SCOLIOSIS RESEARCH SOCIETY

46th ANNUAL MEETING & COURSE

LOUISVILLE KENTUCKY

SEPTEMBER 14-17, 2011

Jointly sponsored by
USF Health and the Scoliosis Research Society

www.srs.org

FINAL PROGRAM

2010 CORPORATE PARTNERS

We are pleased to acknowledge and thank those companies that provided financial support to SRS in 2010. Support levels are based on total contributions throughout the year and include the Annual Meeting, IMAST, Worldwide Conferences, Global Outreach Scholarships, Edgar Dawson Memorial Scholarships, SRS Traveling Fellowships and the Research Endowment Fund. Their support has helped SRS to offer high quality medical meetings and courses throughout the world, fund spinal deformity research, develop new patient materials, and provide educational opportunities for young surgeons and those from developing nations.

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TABLE OF CONTENTS

SCOLIOSIS RESEARCH SOVIETY

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info@srs.org meetings@srs.org www.srs.org

PRESIDENT'S MESSAGE

Dear Colleagues,

It is with great enthusiasm that I welcome everyone to Louisville, Kentucky for the SRS 46th Annual Meeting and Course! Following a tremendously successful meeting in Kyoto, Japan last September, the "crown jewel" meeting of our society is here in this most scenic part of Bluegrass Country in the USA. I would like to personally thank local hosts John Dimar and Mohammad Majd along with Steve Glassman, our outgoing Education Council Chair, for their tremendous help in organizing the many venues, locales and other aspects of our visit. I think you will reap the fruits of their labor as you participate in a most successful educational, social, recreational and enjoyable meeting.

Obviously, the educational offerings are the cornerstone of this meeting, and Program Chair Laurel Blakemore and her committee have assembled another outstanding collection of top-rated abstracts encompassing all areas of spinal deformity research and treatment. Keeping to our theme of globalization, approximately 40% of the accepted abstracts are from international countries, and over 40% of all moderators are OUS members as well. Maintaining the long-standing tradition of an entire single-session meeting, 116 podium presentations of the highest scientific quality will be delivered. In addition, nine lunchtime symposia (three each day of the meeting), and three Instructional Course Lectures will compliment the free paper sessions. Please also make plans to attend the Pre-Meeting Course Wednesday titled, "Techniques for Optimizing Safety and Outcomes in Spinal Deformity Surgery," which is a theme of my presidency. I appreciate the effort Education Committee Chairman Joe Perra, along with co-chairs Mark Dekutoski and John Dimar have put into this comprehensive course covering both pediatric and adult topics. As a new offering, five separate and simultaneous group Case Discussion sessions will provide a more intimate delivery of specific deformity themes, which will round out the Pre-Meeting Course agenda prior to the Opening Ceremonies.

Highlights of our invited speakers include, during the Opening Ceremonies, a special talk on how the delivery of Health Care for Spinal Deformity patients will change in the future given by our SRS emeritus fellow Steven Ondra, current Senior Policy Advisor for Health Affairs in Washington, DC. After that potentially sobering talk, we will certainly be ready to listen to our Howard Steel lecture given by Mr. Bill Samuels, President and CEO of Maker's Mark, one of the leading makers and distributors of bourbon in the entire world! This will surely bring a festive spirit to the reception that follows where old and new friends can meet and greet.

I am extremely proud to have Keith Bridwell, my first mentor and colleague for 20 years, as well as the 33rd SRS President as my Harrington Lecturer speaking on the "Past, Present, and Future of the Scoliosis Research Society: What do the Past Presidents Think?" Rounding out the list of Past President awards include the presentation of the Blount Award to Jim Ogilvie, and Lifetime Achievement Awards to Ronald DeWald and Dennis Drummond. What an unbeatable list of past-presidential talent!

On the social front, golf will be available again on Thursday afternoon, along with a variety of tours exposing the beautiful city of Louisville and the surrounding countryside. A not-to-miss farewell event is our visit to the Kentucky Derby Museum on Friday night! Home of the "Greatest Horse Race in the World," we will be enmeshed in "derby world" in this magnificent museum treasure. Be sure to take advantage of actually going into Churchill Downs to see the racetrack as tours will be running throughout the night along with pictures available with a beautiful thoroughbred. And if you feel lucky, come bet on the ponies while benefitting our new SRS investment fund! This will truly be an enjoyable and memorable event.

As this meeting brings an end to my presidency, I must thank all of those who help promote the mission of our society on a regular basis from our committee members, committee chairs, council chairs, Board of Directors and especially the three other Presidential Line members, Steve Richards, Kamal Ibrahim and Rick McCarthy, who have helped me so much this year. Lastly, Tressa Goulding and her incredibly dedicated staff must receive special thanks for their daily efforts to move this society forward. This truly is the greatest spine society in the world focused on the mission of improving the care of all patients with spinal deformity. Thank you for the honor and privilege of serving as your president.

With warm regards,

Lawrence G. Lenke, MD
SRS President

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Steven D. Glassman, MD
Mohammad Majd, MD

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Michael J. Yaszemski, MD, PhD – Past Co-Chair
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R. Haluk Berk, MD
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Mark Dekutoski, MD – Chair-Elect
Laurel C. Blakemore, MD – Program Chair
Ahmet Alanay, MD
John R. Dimar, II, MD
Brian Hsu, MD
Kamal N. Ibrahim, MD, FRCS(C), MA
Eric T. Jones, MD
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Amer Samdani, MD
Paul D. Sponseller, MD
Daniel W. Green, MS, MD, FACS
Adam L. Wollowick, MD

SCOLIOSIS RESEARCH SOCIETY

GENERAL INFORMATION

The Scoliosis Research Society gratefully acknowledges Medtronic for their support of the Annual Meeting Newsletter, Welcome Reception, Farewell Reception, Instructional Course Lectures, Wireless Internet and Beverage Breaks.

Medtronic

GENERAL MEETING INFORMATION

ABSTRACT VOLUME

All abstracts accepted for presentation at the 46th Annual Meeting have been published in the Final Program (pages 55-153). Each attendee will receive one copy of the program along with their registration materials. Abstracts have also been posted online at www.srs.org.

ADMISSION TO SESSIONS

Official name badges will be required for admission to all sessions. All Annual Meeting attendees receive a name badge with their registration materials. Name badges should be worn at all time inside the Galt House Hotel & Suites, as badges will be used to control access to sessions and activities. Attendees are cautioned against wearing their name badges while away from the venue, as badges draw unwanted attention to your status as visitors to the city.

ADMISSION BY TICKETS

The Instructional Course Lectures on Thursday, September 15 require a ticket for admission. Tickets for these sessions are not included in the meeting's regular registration fees, but are available for an additional $30. Tickets will be collected at the door by ushers. A limited number of tickets may be available at the Registration Desk. In addition, tickets will be required for admission to the Farewell Reception. The Farewell Reception will take place at the Kentucky Derby Museum, at an additional $25 fee per ticket for registered delegates and registered guests. If you pre-registered, tickets may be found in your registration packets. A limited number of tickets may be available at the Registration Desk. Tickets are required for optional tours and activities, and the cost of tour tickets is in addition to the delegate or guest registration fee. If you pre-registered for a tour, tickets may be found in your registration packet. There may be a limited number of tickets for tours available at the Registration Desk, in the event a delegate or guest has chosen not to attend a tour.

ATTIRE

Business casual (polo or dress shirts, sport coats) is appropriate for meeting sessions and for all Annual Meeting & Course sessions and events.

BUSINESS CENTER

The Galt House Hotel & Suites offers self-serve, pay-per-use, business services, available for the duration of the Annual Meeting. Services include printing, copying, and faxing.

CELL PHONE PROTOCOL

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

EMERGENCY & FIRST AID

The Galt House Hotel & Suites is fully prepared to handle emergency requests and first aid. Contact an SRS staff person for support. Remember to note all emergency exits within the venue.

EVALUATIONS

Please take time to complete the online evaluation forms provided for each session you attend. Evaluations and comments will be collected as part of the CME Certificate program. Delegates will be asked to complete evaluation forms for the sessions they attended, as part of the process of collecting a CME Certificate. Your input and comments are essential in planning future Annual Meetings.

GUEST HOSPITALITY SUITE & ACTIVITIES

Location: Clements Room, Suite Tower

Registered guests of Annual Meeting & Course delegates are welcome to meet and plan their days over a continental breakfast, courtesy of SRS. The Guest Hospitality Suite is open Thursday, September 15 through Saturday, September 17 from 6:30 – 9:00am in the Clements Room in the Suite Tower of the Galt House Hotel & Suites.

SRS is also pleased to announce the following activities available only to registered guests:

- Breakfast with a Louisvillian

  On Thursday, September 15, guests are invited to share breakfast with the locals and learn about the hidden hot spots in Louisville! A representative from the Louisville Convention & Visitors Bureau will be available in the Guest Hospitality Suite from 7:30 – 9:00am to help guests make the most of their days in the city. Learn about the hottest restaurants, trendiest shopping areas, and ask any question you may have about things to see and do in and around Louisville.
- Derby Fashion Face-Off

  Annual Meeting delegates and guests will celebrate the close of the meeting on Friday evening with a reception at the Kentucky Derby Museum. Fans of the Derby know that one of the race day trademarks at Churchill Downs are the unbelievable hats worn by the women attending the race. Guests will have a chance to design and create their own Derby hat with materials provided in the Guest Hospitality Suite on Thursday, September 15 and Friday, September 16.

  Contestants will be photographed wearing their hat on Friday at 8:30am and their photos will be posted during the Farewell Reception that evening where delegates will "vote" for their favorite.

  $1 = one vote! All proceeds will benefit the SRS Research, Education and Outreach Fund, and the designer of the winning hat will receive a prize.

Guests must be registered with SRS to access the Hospitality Suite and take part in these activities.

GENERAL MEETING INFORMATION (continued...)

INTERNET KIOSKS

Location: Wetherby Hall Foyer, Suite Tower

Attendees can search the Internet and check e-mail at the Internet Kiosks, supported by a grant from K2M.

Wednesday, September 14	6:30am – 5:00pm
Thursday, September 15	6:30am – 3:00pm
Friday, September 16	6:30am – 5:15pm
Saturday, September 17	6:30am – 12:35pm

Wireless Internet access is available in the public spaces of the Galt House, as well as all guest rooms, supported by a grant from Medtronic.

LANGUAGE

English will be the official language of the SRS Annual Meeting & Course.

LOST & FOUND

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

MEMBERS BUSINESS MEETINGS

Location: Archibald Cochrane, Rivue Tower

All SRS members are invited and encouraged to attend the Members Business Meetings, held Thursday, September 15 through Saturday, September 17 from 6:30 – 7:45am in the Archibald Cochrane Room, in the Rivue Tower of the Galt House Hotel & Suites. Agendas will include reports from the various SRS committees, presentations by the 2011 Travelling Fellows and Edgar Dawson Scholarship recipients, and updates on SRS activities and programs. A hot breakfast will be served.

MESSAGES

A self-service message board (non-electronic) will be available in the Registration Area for attendees to post notes or leave messages for other attendees. Please remember to check for any messages that may be left for you. This message center is supported by a grant from K2M.

NON-MEMBERS CONTINENTAL BREAKFAST

Location: Wetherby Hall Foyer

All non-member delegates to the SRS Annual Meeting are invited to meet with their colleagues, view posters and network over coffee and a continental breakfast served Thursday, September 15 through Saturday, September 17 from 6:30 – 7:45am in the Wetherby Hall Foyer.

PHOTOGRAPHY POLICY

SRS will be taking photographs throughout the Annual Meeting & Course. SRS will use these photos in publications and to produce related literature and products for public release. Individuals photographed will not receive compensation for the use and release of these photos and will be deemed to have consented to the use and release of photos in which they appear. If you are opposed to being photographed, please immediately notify the photographer or an SRS staff member if your picture is taken. Thank you for your cooperation.

POSTER HALL

Location: Wetherby Hall Foyer, Suite Tower

Wednesday, September 14	6:30am – 5:00pm
Thursday, September 15	6:30am – 3:00pm
Friday, September 16	6:30am – 5:15pm
Saturday, September 17	6:30am – 12:35pm

E-Posters may be viewed on monitors located in the Wetherby Hall Foyer, in the Suite Tower courtesy of K2M and Stryker Spine, or from your own laptop using the CD-ROM provided with your registration materials, courtesy of Stryker Spine.

REGISTRATION DESK

Location: Suite Tower, Ballroom Level

Tuesday, September 13	2:00 – 6:00pm
Wednesday, September 14	6:30am – 5:00pm
Thursday, September 15	6:30am – 3:00pm
Friday, September 16	6:30am – 5:15pm
Saturday, September 17	6:30am – 12:35pm

SMOKING POLICY

Smoking is not permitted during any meeting activity or event.

SPEAKER PRESENTATION UPLOAD

Location: Grand Ballroom, Suite Tower

All podium presentations must have been uploaded to the Online Speaker Ready Room and reviewed by the SRS CME Committee in advance of the meeting. However, if presenters wish to make small changes to their presentations onsite, they may do so at the back of the Grand Ballroom, in the general session room. IMPORTANT: Only small changes will be allowed. New presentation files may not be uploaded to replace the files that have been reviewed by the CME Committee. Final presentations must be uploaded at least 24 hours in advance of the scheduled presentation time.

Wednesday, September 14	6:30am – 5:00pm
Thursday, September 15	6:30am – 3:00pm
Friday, September 16	6:30am – 5:15pm
Saturday, September 17	6:30 – 11:00am

GENERAL MEETING INFORMATION (continued...)

SPECIAL NEEDS

If you have any health issues for which you may require special accommodations or assistance, please notify the SRS staff at the Registration Desk. We will make every effort to accommodate any special needs.

TOUR INFORMATION

Delegates and guests, including adults and children ages 10 and up, are able to attend optional tours. Tickets are required to participate in the tours and must have been requested before August 1. Any tour tickets purchased will be included with the delegate or guest's registration packet. Additional tour tickets may be available at the Registration Desk, in the event a delegate or guest has chosen not to attend a tour. For more information on tours, including a complete schedule, please see page 17.

VENUE INFORMATION

The Galt House Hotel & Suites is the location for the 46th Annual Meeting & Course:
140 N 4th Street
Louisville, Kentucky 40202
(502) 589-5200
www.galthouse.com

SRS ANNUAL MEETING MOBILE APP

A new mobile and online app will be available to all delegates during the 46th Annual Meeting & Course. The app is designed to provide all the information about the Annual Meeting & Course and Louisville 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/srs46am

or scan the QR code below with your smart phone.

The app will feature:

- Detailed meeting agenda that allows you to create your personalized schedule
- Interactive session polls, used for live Q&A sessions during the Instructional Course Lectures (ICLs) & Pre-Meeting Course
- Maps of the Galt House and meeting space
- An alert system for real-time updates
- A searchable speaker's list, indicating the times and locations of each speaker's presentations
- An information booth featuring the official SRS social events and things to do and see in Louisville

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.

CME INFORMATION

MEETING DESCRIPTION

The Scoliosis Research Society Annual Meeting & Course is a forum for the realization of the Society's mission and goals, the improvement of patient care for those with spinal deformities. Over 100 papers will be presented on an array of topics, including adolescent idiopathic scoliosis, growing spine, kyphosis, adult deformity, trauma, neuromuscular scoliosis and tumors.

LEARNING OBJECTIVES

At the conclusion of the SRS 46th Annual Meeting & Course, participants should be able to:

1) Recognize and address factors which may contribute to higher complication rates or risk of reoperation in children and adults with spinal deformities
2) Incorporate pre- and peri-operative steps that may help to avoid complications in spinal deformity surgery in children, adolescents and adults
3) Assess clinical and radiographic factors that contribute to positive or negative outcomes in spinal deformity surgery
4) Improve treatment plans for patients with spinal deformity through a better understanding of long term results from various options
5) Demonstrate understanding of the relationship between spinal deformity treatments and quality of life, including body image in adolescent scoliosis, as perceived by patients

TARGET AUDIENCE

Presentations at the SRS Annual Meeting and Course will have value for physicians and allied health personnel who treat spinal deformities at all levels and in all ages of patients. Medical students, residents, fellows and researchers with an interest in spinal deformities will also benefit from the materials presented.

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 joint sponsorship of USF Health and SRS. USF Health is accredited by the ACCME to provide continuing medical education for physicians.

USF Health designates this live activity for a maximum of 25.5 *AMA PRA Category 1 Credits™* (6.25 for the Pre-Meeting Course and 19.25 for the Annual Meeting). 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 USF Health and SRS to insure balance, independence, objectivity, and scientific rigor in all of their educational activities. In accordance with this policy, USF Health and SRS identify 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 USF Health and SRS to ensure that all scientific research referred to, reported, or used in a CME activity conforms to the generally accepted standards of experimental design, data collection, and analysis. Complete faculty disclosures will be included in the Final Program.

FDA STATEMENT (UNITED STATES)

Some drugs and medical devices discussed 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 the Annual Meeting & Course 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 the Annual Meeting & Course 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 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 and USF Health disclaim any and all liability for injury or other damages resulting to any individual attending a scientific meeting and for all claims that may arise out of the use of techniques demonstrated therein by such individuals, whether these claims shall be asserted by a physician or any other person.

CME CERTIFICATES

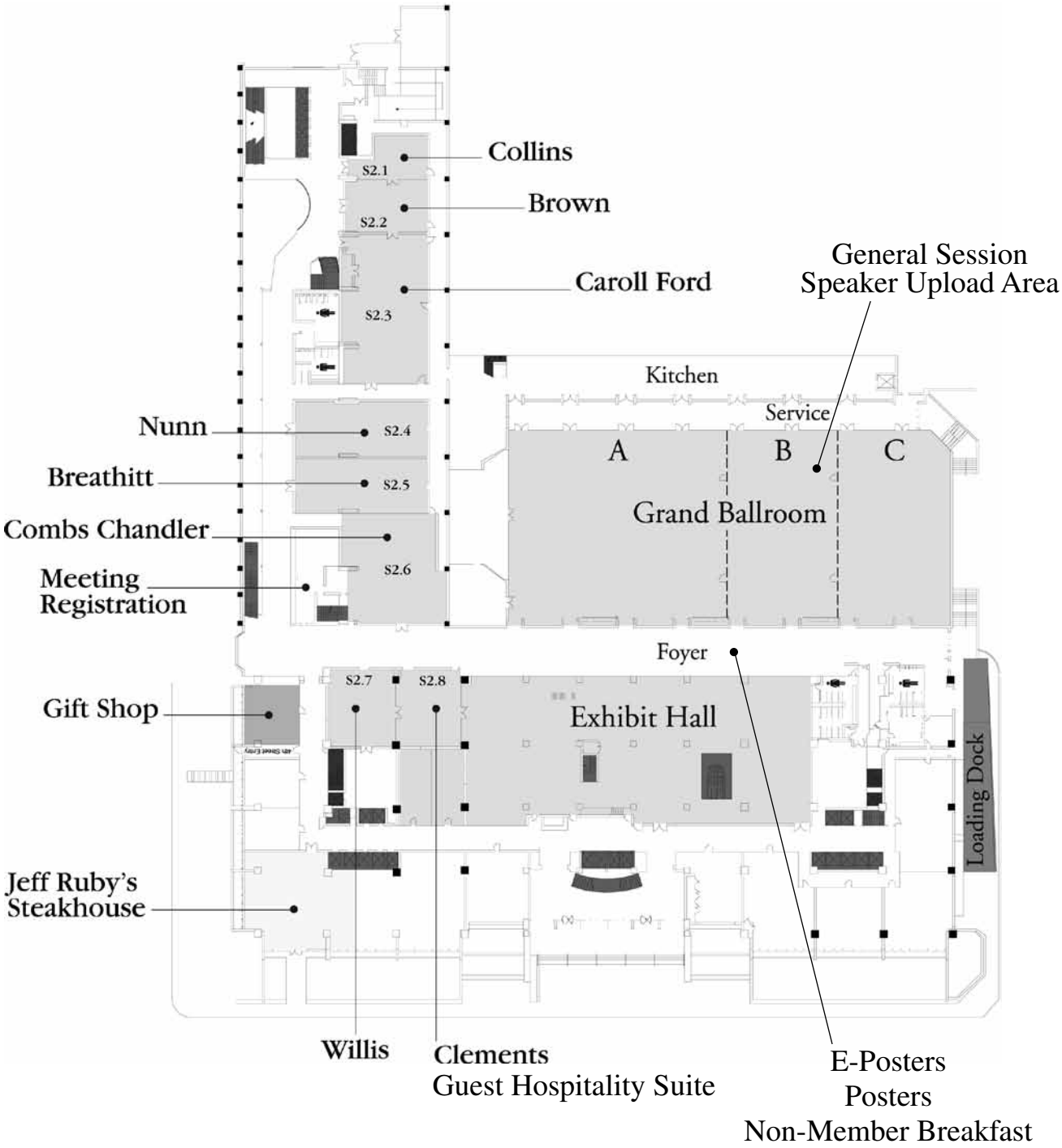
CME Certificates will be available immediately upon the close of the meeting at www.srs.org/professionals/meetings/am11.

Delegates should log on to the website listed above and enter their last name and the ID# listed at the top of your Annual Meeting registration confirmation form. The system will then ask delegates to indicate which sessions they attended, to complete evaluation forms for each of those sessions, and then generate a PDF certificate which may be printed or saved. Session attendance and evaluation information are saved in the database, and certificates may be assessed 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. If you have any questions, please visit the registration desk, or email the SRS office at meetings@srs.org.

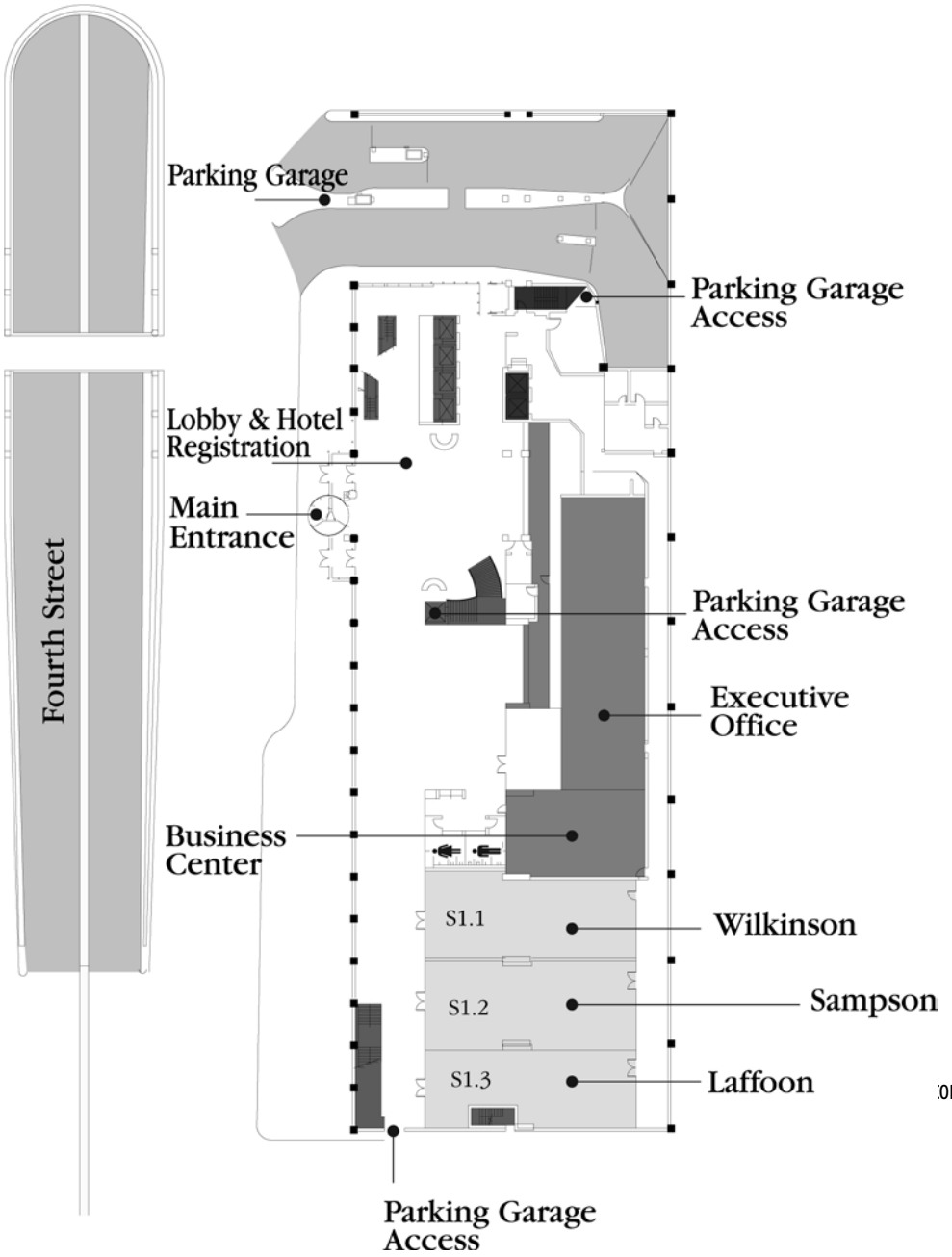
GALT HOUSE FLOORPLAN

SUITE TOWER, BALLROOM LEVEL



GALT HOUSE FLOORPLAN (continued...)

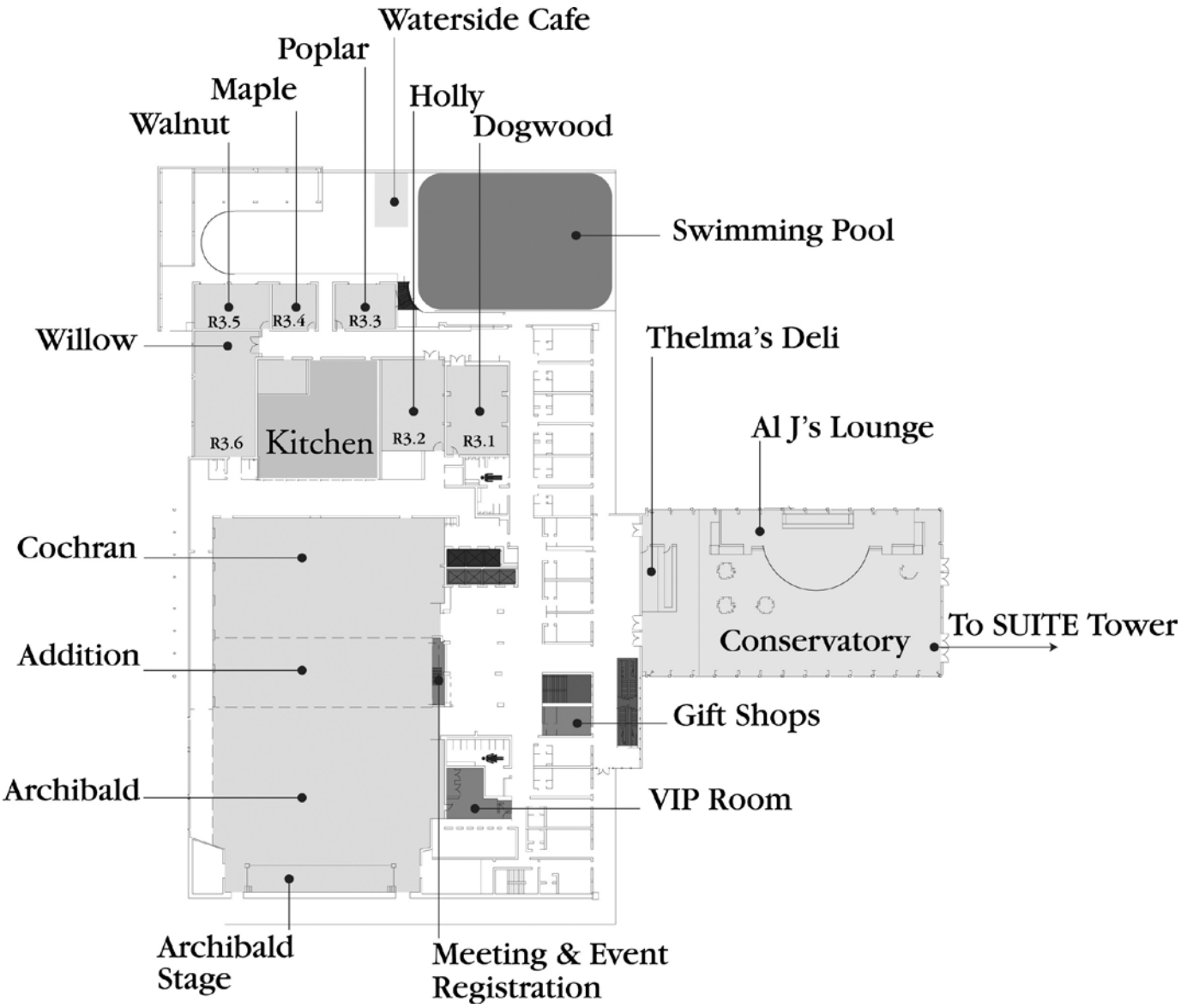
SUITE TOWER, LOBBY LEVEL



(continued on page 10...)

GALT HOUSE FLOORPLAN (continued...)

RIVUE TOWER



MEETING OUTLINE

(subject to change)

MONDAY, SEPTEMBER 12, 2011		
7:00am - 5:00pm	Board of Directors Meeting	Nunn Room

TUESDAY, SEPTEMBER 13, 2011		
7:00am - 5:00pm	SRS Committee Meetings	Combs Chandler; Nunn, Breathitt, Willis, Clements Rooms
1:00 - 5:00pm	Hibbs Society Meeting*	Caroll Ford
2:00 - 6:00pm	Poster Set-Up	Wetherby Hall Foyer
2:00 - 6:00pm	Registration Open	2nd Floor Registration
7:00 - 10:00pm	SRS Leadership Dinner (by invitation only)	Muhammad Ali Center

WEDNESDAY, SEPTEMBER 14, 2011		
6:30am - 5:00pm	Registration Open	2nd Floor Registration
6:30am - 5:00pm	Internet Kiosks, E-Posters Open	Wetherby Hall Foyer
8:00am - 3:30pm	Pre-Meeting Course (supported by grants from Stryker Spine and Synthes Spine)	Grand Ballroom ABC; Archibald Cochrane (Rivue Tower)
11:30am - 12:30pm	Lunchtime Symposia*	Grand Ballroom ABC; Combs Chandler; Caroll Ford
3:45 - 5:00pm	Case Discussions	Combs Chandler; Caroll Ford; Breathitt, Wilkinson, Sampson
6:00 - 7:30pm	Opening Ceremonies	Grand Ballroom ABC
7:30 - 9:00pm	Welcome Reception (supported by grants from Medtronic and Synthes Spine)	Grand Ballroom & Wetherby Hall Foyers

THURSDAY, SEPTEMBER 15, 2011		
6:30am - 3:00pm	Registration Open	2nd Floor Registration
6:30am - 3:00pm	Internet Kiosks, E-Posters Open	Wetherby Hall Foyer
6:30 - 7:45am	Members Business Meeting	Archibald Cochrane (Rivue Tower)
6:30 - 7:45am	Non-Members Continental Breakfast	Grand Ballroom & Wetherby Hall Foyers
6:30 - 9:00am	Guest Hospitality Suite	Clements Room
8:00am - 12:30pm	Scientific Program	Grand Ballroom ABC
12:30 - 3:00pm	Instructional Course Lectures	Grand Ballroom ABC; Archibald Cochrane (Rivue Tower); Caroll Ford

*denotes sessions for which CME credit is not available.

MEETING OUTLINE (continued...)

FRIDAY, SEPTEMBER 16, 2011		
6:30am - 5:15pm	Registration Open	2nd Floor Registration
6:30am - 5:15pm	Internet Kiosks, E-Posters Open	Wetherby Hall Foyer
6:30 - 7:45am	Members Business Meeting	Archibald Cochrane (Rivue Tower)
6:30 - 7:45am	Non-Members Continental Breakfast & Information Session	Grand Ballroom; Wetherby Hall Foyers
6:30 - 9:00am	Guest Hospitality Suite	Clements Room
8:00am - 12:35pm	Scientific Program	Grand Ballroom ABC
12:35 - 1:25pm	Lunchtime Symposia*	Grand Ballroom ABC; Combs Chandler; Caroll Ford
1:25 - 5:15pm	Scientific Program	Grand Ballroom ABC
7:00 - 10:00pm	Farewell Reception (supported by a grant from Medtronic)	Kentucky Derby Museum
	Shuttles depart from hotel lobby at 6:30pm; Return shuttles run 9:00 -10:00pm	

SATURDAY, SEPTEMBER 17, 2011		
6:30am - 12:35pm	Registration Open	2nd Floor Registration
6:30am - 12:35pm	Internet Kiosks, E-Posters Open	Wetherby Hall Foyer
6:30 - 7:45am	Members Business Meeting	Archibald Cochrane (Rivue Tower)
6:30 - 7:45am	Non-Members Continental Breakfast	Grand Ballroom; Wetherby Hall Foyers
6:30 - 9:00am	Guest Hospitality Suite	Clements Room
8:00am - 12:30pm	Scientific Program	Grand Ballroom ABC
12:45pm	Meeting Adjourns	
1:00 - 3:30pm	Board of Directors Meeting	Nunn Room

*denotes sessions for which CME credit is not available.

GUEST LECTURERS & AWARD RECIPIENTS

PRESIDENTIAL GUEST SPEAKER

Wednesday, September 14, 2011

Stephen L. Ondra, MD
Senior Policy Advisor for Health Affairs, Washington, DC

"Transforming Healthcare: Fitting Together the Pieces of the Puzzle"

Dr. Stephen Ondra, MD, was appointed as Senior Policy Advisor for Health Affairs in the Department of Veterans Affairs (VA) by President Barak Obama on May 10, 2009. Prior to that, he served on the Veterans Affairs group in the Obama-Biden Presidential Transition Team, as well as on the Obama-Biden Campaign Health Policy and Veteran's Policy committees.

Dr. Ondra first entered government service as a Cadet at the U.S. Military Academy. After receiving injuries in a training accident, Dr. Ondra completed pre-medical studies at Illinois Wesleyan University. By his graduation in 1984, Dr. Ondra had recovered sufficiently from his injuries to allow him to re-enter Army service while earning his doctorate at Rush Medical College in Chicago, Ill. He completed his residency training at Walter Reed Army Medical Center in Washington, D.C., where he received specialized instruction in spine surgery and reconstruction in both the neurosurgery and orthopedic specialties.

Dr. Ondra was deployed to Saudi Arabia from 1990 to 1991 in support of Operations Desert Shield and Desert Storm. His service was recognized with a Bronze Star and Army Commendation Medal. Following his deployment, he was assigned to Walter Reed and became the Director of Spine and Skull-base Surgery.

After leaving military service in 1994, Dr. Ondra joined the Clinical Faculty at the University of Michigan. In 1996, he moved to Illinois' Northwestern University, where he served as the Residency Program Director Vice Chair, Director of Spine Surgery, Director of the Spinal Deformity Fellowship, Director of Spine Research, and Medical Director of the Neuro-Spine Intensive Care Units. He also chaired the Medical Device and Technology Committee at Northwestern Memorial Hospital. In 2006, he was promoted to Professor of Neurological Surgery at Northwestern.

In parallel to his medical work in both the military and civilian worlds, Dr. Ondra has worked with several Government agencies. He chaired the Scientific Advisory Board for the Defense Spinal Cord and Column Injury Project for the Department of Defense, and served on the Medical Coverage Advisory Committee with the Centers for Medicare and Medicaid Services at the Department of Health and Human Services. His medical expertise has allowed him to advise and discuss health policy matters with members of Congress, Cabinet Members and foreign government leaders.

Dr. Ondra is an Emeritus Member of the Scoliosis Research Society.

HOWARD STEEL LECTURE

Wednesday, September 14, 2011

Bill Samuels, Jr.
President and CEO - Maker's Mark

Bill Samuels Jr. is the President of Maker's Mark Distillery in Loretto, Kentucky. He is the seventh generation in a long line of bourbon-makers, and uses his father's innovative recipe, continuing the tradition of small, closely-supervised production to make sure there is a part of himself and his family in every bottle. It is only natural that Bill, Jr. wound up taking over the family business. However, young Bill had big ideas about playing basketball and becoming a rocket scientist and a lawyer. So, he did all three.

Bill Jr. played basketball in high school and then he proceeded to college at Case Western Reserve University where he studied rocket science and solid propellants. When solid propellants became obsolete, law school called, and he headed to Vanderbilt University. While there, Bill Jr. formed a good relationship with Hap Motlow, Jack Daniel's whiskey chairman, who had offices across the street from the school. When the summers came, Samuels worked in Washington, D.C. in the U.S. patent office.

When he finished law school, he returned to Kentucky to work "temporarily" for his father. Thirteen years later, he was still with the company, which struggled, but never compromised its integrity. The company took off in 1980, when the Wall Street Journal ran a front-page article about the Marker's Mark Distillery, and the phone rang off the hook. Maker's Mark rapidly became known for its irreverent ads (written personally by Bill, Jr.) and its smooth, soft taste. The Marker's Mark Distillery was designated a National Historic Landmark in 1980, becoming the first distillery in American to be recognized as a national treasure.

GUEST LECTURERS & AWARD RECIPIENTS (continued...)

WALTER P. BLOUNT HUMANITARIAN AWARD RECIPIENT

The 2011 Walter P. Blount Humanitarian Award will be presented on Wednesday, September 14, acknowledging outstanding service to those with spinal deformity, and for generosity to the profession and society.

James W. Ogilvie, MD

Dr. James W. Ogilvie is co-founder and Chief Medical Advisor of Axial Biotech, Inc. a genetics research laboratory. He graduated from Yale School of Medicine and is a past president of the Scoliosis Research Society and has been an associate editor of *Spine* since 1987. Dr. Ogilvie has served as a staff surgeon at Shriners Hospital for Children, professor and vice-chair of the University of Minnesota-Department of Orthopaedic Surgery, and served on the staff of the Twin Cities Spine Center at Abbott Northwestern Hospital.

In 1985, Dr. Ogilvie began traveling to Asia to provide care for spinal deformity patients there. Since then, he has averaged 1-3 trips per year to China and Mongolia, often using his own funds, to continue that care and to train local physicians.

Throughout his career, Dr. Ogilvie has received multiple NIH and industry grants during his years of practice, and has authored dozens of peer reviewed scientific papers, book chapters and abstracts. Along with this, Dr. Ogilvie has been issued patents pertaining to methods and instrumentation for spine surgery. He currently lives in the mountains outside of Salt Lake City with his wife Susan while two of his sons are faculty surgeons at the University of Minnesota.

HARRINGTON LECTURE

Thursday, September 15, 2011

Keith H. Bridwell, MD

Past, Present and Future Course of the Scoliosis Research Society: What Do the Past Presidents Think?

Keith Bridwell, MD is Chief of Spine Surgery in the Department of Orthopaedic Surgery at Washington University School of Medicine, St. Louis, and is the J. Albert Key Professor of Orthopaedic Surgery at Washington University School of Medicine. He is the founder and Director of the Washington University (St. Louis) Spine Fellowship program, which was initiated in 1991 and to date, has trained 51 fellows with four currently in training.

Following a medical degree at Washington University Medical School in 1977, Dr. Bridwell did his orthopaedic internship and orthopaedic surgery residency at Washington University School of Medicine. In 1982 he completed a spinal deformity research fellowship at Rush Medical College, the University of Illinois, and Chicago Shriners Hospital for Children. In 1985, Dr. Bridwell received board certification from the American Board of Orthopaedic Surgery.

Dr. Bridwell is also an active member of the American Academy of Orthopaedic Surgeons, the North American Spine Society, the Scoliosis Research Society and the American Orthopaedic Association and former president of the SRS.

Since 1982, Dr. Bridwell has been an active researcher in the spine field contributing over 50 chapters to medical books, more than 260 articles to scientific peer-review journals, and almost 500 scientific abstracts and presentations. He is also co-editor-in-chief with Dr. Ronald L. DeWald of The Textbook of Spinal Surgery and deputy editor for *Spine*.

GUEST LECTURERS & AWARD RECIPIENTS (continued...)

The 2011 Lifetime Achievement Awards will be presented on Saturday, September 17. The Lifetime Achievement Award Recipients were chosen from among the SRS membership, based on long and distinguished service to the Society and spinal deformity research and care.

Ronald L. DeWald, MD

Ronald L. DeWald, MD is a founding member and past president of the SRS (1988). While president he started the first instructional course in conjunction with the Annual Meeting. Dr. DeWald served on many committees and was the editor in chief of the textbook Spinal Deformities the Comprehensive Text, an SRS textbook which is the precursor to the current e-text. He also was a senior traveling fellow in 1997 and among the first group to go to the Orient.

In addition to his work with SRS, Dr. DeWald has been an orthopedic surgical board examiner for 15 years. During his career, he has served as president of his medical staff at the Chicago Orthopedic Society and the Illinois Orthopedic Society.

Dr. DeWald started the first year long spinal deformity fellowship, accredited by ACGME. While he was director over 60 fellows matriculated through the program which included adult and pediatric experience.

Dr. DeWald is also Emeritus Professor of Orthopedic Surgery at Rush University in Chicago, Il. At the University, there is a Ronald L. DeWald endowed Chair in Spinal Deformities that was established in 1996 being the 76th chair endowed at Rush. This is the only endowed Chair in Spinal Deformities in the United States. Dr. Gunner Anderson is the chairperson at this time.

Dr. DeWald says the only regret in his career was that he was unable to convince his peers that sub-specialty certification in spinal deformity surgery would be a worthwhile goal.

Denis S. Drummond, MD

Denis S. Drummond, MD, FRS(C) is a pediatric orthopaedic surgeon. He is the past director of orthopaedic surgery at the Children's Hospital of Philadelphia and Emeritus Professor at the University of Pennsylvania School of Medicine. His special interests include the pediatric spine and he has extensive experience in the correction of spine deformity and the surgical management of congenital and traumatic pathologies of the pediatric cervical spine. He was an active member of the Scoliosis Research Society, including eight consecutive years serving as a director, Secretary and President. He has also been active in the Pediatric Orthopaedic Societies, as president of the Pediatric Orthopaedic Study Group, one of the two founding groups of the Pediatric Orthopaedic Society of North America (POSNA). At that time, he also served as Chair of the committee that worked through the merger process between the two founding groups.

Dr. Drummond has a long interest in research, publishing more than 178 original research studies to refereed journals and numerous contributions to textbooks including 42 chapters and editorial contributions. In addition, he has presented or coauthored 91 presentations to both national and international societies, and 94 lectures at courses throughout the world. He has presented his work as a visiting professor or invited lecturer 51 times and has received 21 grants to fund his research.

He still serves on the editorial board for three national or international journals. For the last five years he has acted as Director of Clinical Research for the division of Orthopaedic Surgery at his hospital. Dr. Drummond has also shown an interest in new technology for spinal surgery and is a co-holder of five patents. Finally, throughout his career he has received several awards for teaching and other academic work.

SOCIAL EVENTS

OPENING CEREMONIES & WELCOME RECEPTION

Wednesday, September 14

Open to all registered delegates and their registered guests at no additional fee. Name badges are required.

The Annual Meeting will officially begin with Opening Ceremonies and this year's Howard Steel Lecture, presented by Bill Samuels, Jr., President of Maker's Mark Distillery and a "Call to the Post," by famed Kentucky Derby bugler Steve Buttleman. The evening will include an introduction of the SRS officers and honored presidents from other spine societies. All guests are invited and encouraged to attend the Opening Ceremonies. Following the Opening Ceremonies, we'll move to a hosted reception featuring heavy hors d'oeuvres, cocktails, and plenty of lively conversation and reunions with colleagues and friends. The Welcome Reception is supported, in part, by grants from Medtronic and Synthes Spine.

FAREWELL RECEPTION

Friday, September 16

Open to all registered delegates and their registered guests. Tickets are $25 each and must be purchased in advance. A limited number of tickets may be available onsite, but SRS strongly urges delegates and guests to purchase tickets at the time of registration. Name badges are required.

The 46th Annual Meeting culminates with a truly unique evening at the Kentucky Derby Museum. Delegates and guests will enjoy the local culinary flair, while taking in the epic history and ceremony that surrounds the "Run for the Roses!" SRS has a "Triple Crown" of activities planned, including tours of world-famous Churchill Downs, mock-betting (with proceeds benefiting the new SRS Investment Fund), photo opportunities with a real thoroughbred, and conclusion of the Derby Fashion Face-Off! Shuttles will depart the the Galt House Hotel & Suites every 15 minutes from 6:30 - 7:30pm and will return between 9:00 - 10:00pm. Be sure to purchase your tickets with your registration – they'll go quickly and availability is limited! Supported, in part, by a grant from Medtronic.

TOURS

Tours depart from the lobby of the Galt House Hotel & Suites promptly at the times indicated below. Please arrive ten minutes before scheduled departure and bring the tickets included with your registration materials.

HISTORIC LOUISVILLE TOUR

Thursday, September 15; 2:00 – 5:00pm

SHOP HOP

Thursday, September 15; 9:00am – 12:30pm

GOLF TOURNAMENT

Thursday, September 15; 12:30 – 6:30pm

MOONSHINE & MADNESS HAUNTED HIGHLANDS GHOST TOUR

Thursday, September 15; 6:30 – 9:00pm

SCOLIOSIS RESEARCH SOCIETY

CONFLICT OF INTEREST DISCLOSURES


SCOLIOSIS RESEARCH SOCIETY
FOUNDED 1966

CONFLICT OF INTEREST DISCLOSURES

If noted, the relationships disclosed are as follows:
(a) Grant/Research Support (b) Consultant (c) Stock/Shareholder (d) Salary, Contractual Services (e) Advisory Board or Panel (f) Speaker's Bureau (g) Other Financial or Material Support

NAME	COUNTRY	RELATIONSHIP DISCLOSURE
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William Donaldson, MD	United States	(a) Stryker
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Noriaki Kawakami, MD	Japan	(b) Medtronic; (g) Showa
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Timothy Oswald, MD	United States	(b) Medtronic
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Daniel J. Sucato, MD, MS	United States	(g) Medtronic
Suken A. Shah, MD	United States	(a) DePuy Spine, Inc.; Axial Biotech, Inc; (b) DePuy Spine, Inc.; (c) Globus Medical; (e) K Spine, Inc.; (g) DePuy Spine, Inc.
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Michael Flippin, MD	United States	(e) Orthopaedics
Paul Glazer, MD	United States	(c) Pioneer, Promethean Surgical Devices; (f) DePuy Spine, A Johnson & Johnson Company; Medtronic; (e) The Spine Journal; (g) Biomet
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Michelle C. Marks, PT, MA	United States	(a) DePuy Spine
Mohamed Mossaad, MD	Egypt	No Relationships
Praveen Mummaneni, MD	United States	(b) DePuy Spine; (g) Quality Medical Publishers, DePuy Spine
Michael F. O'Brien, MD	United States	(a) DePuy Spine; (b) Medtronic Sofamor Danek, Osteotech, DePuy Spine; (g) Medtronic Sofamor Danek, Axial Biotech, DePuy Spine
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Mark Dekutoski, MD	United States	(a) AO Foundation; Mayo Foundation; AOSNA Fellowship; (b) Mayo Medtronic Percutaneous Deformity; (d) Synthes –Education; (e) AOSNA Board; (g) Mayo Medtronic Perc Trauma; Mayo Medtronic Perc Deformity
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Shay Bess, MD	United States	(a) Depuy Spine; (b) DePuy Spine; (e) Allosource; (f) DePuy Spine; (g) Pioneer Spine
Oheneba Boachie-Adjei, MD	United States	(a) DePuy Spine, K2M, Osteotech; (b) DePuy Spine, K2M, Osteotech, Trans1; (c) K2M; (f) DePuy Spine, K2M, Trans1; (g) Trans1
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Nathan H. Lebwohl, MD	United States	(b) DePuy Spine; Salient Technologies; (f) DePuy Spine, Trans1; (e) Journal of Neuroadiology; Orthopedic Knowledge Online; (g) DePuy Spine
Lawrence G. Lenke, MD	United States	(a) Axial Biotech, DePuy; (g) Medtronic, Quality Medical Publishing
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Hilali H. Noordeen, FRCS	United Kingdom	(a) K2M; (b) K2M, Ellipse Technologies; (e) K2M
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Eli Baron, MD	United States	(f) TranS1

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John S. Blanco, MD	United States	No Relationships
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Benjamin Blondel, MD	United States	No Relationships
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Alberto Caballero, MD	Spain	No Relationships
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Frank P. Cammisa, MD	United States	No Relationships
Chelsea E. Canan, BA	United States	No Relationships
Robyn A. Capobianco, MA	United States	(c) Baxano Inc
Joseph H. Carreau, MD	United States	No Relationships
Leah Y. Carreon, MD, MSc	United States	No Relationships
Alan Carstens, MBChB, FRACS	Australia	No Relationships
Soo Min Cha	Republic of Korea	No Relationships
Michael S. Chang, MD	United States	No Relationships
Edward Chay	United States	No Relationships
Zi-Qiang Chen, MD	China	No Relationships

CONFLICT OF INTEREST DISCLOSURES (continued...)

(a) Grant/Research Support (b) Consultant (c) Stock/Shareholder (d) Salary, Contractual Services (e) Advisory Board or Panel (f) Speaker's Bureau (g) Other Financial or Material Support

NAME	COUNTRY	RELATIONSHIP DISCLOSURE
Ivan Cheng, MD	United States	(a) Medtronic; (b) Stryker Spine; (e) Nuvasive; (f) Synthes Spine
Jack C. Cheng, MD	Hong Kong	No Relationships
Rakesh Chettier, MS	United States	(d) Axial Biotech
Kenneth MC Cheung, MD	Hong Kong	(a) Synthes; Ellipse Technologies; (b) Ellipse Technologies
Wai Yuen Cheung, MD	China	No Relationships
Rosetta Chiavacci, BSN	United States	No Relationships
Kazuhiro Chiba, MD, PhD	Japan	No Relationships
Samuel K. Cho, MD	United States	No Relationships
Woojin Cho, MD, PhD	United States	No Relationships
Dae Jung Choi	Republic of Korea	No Relationships
Seung-Hyun Choi	Republic of Korea	No Relationships
Theodore J. Choma, MD	United States	(b) Stryker Spine
Jean-Luc Clement, MD	France	(b) Medicrea
David H. Clements, MD	United States	(a) DePuy Spine; (b) DePuy Spine; (g) DePuy Spine
Stephanie R. Cody, BS	United States	No Relationships
Jeffrey D. Coe, MD	United States	(a) NuVasive; Medtronic; (b) NuVasive; Synthes Spine; (g) Synthes Spine
Nicholas D. Colacchio, BA	United States	No Relationships
Jorge Collazos, MD, PhD	Spain	No Relationships
Complex Spine Study Group	United States	(a) K2M
Ian Corcoran-Schwartz	United States	No Relationships
Jacqueline Corona, MD	United States	No Relationships
Carlos Correa	Spain	No Relationships
Lisa Covington, RN, MPH	United States	No Relationships
Dennis Crandall, MD	United States	(a) Medtronic; (b) Medtronic; (c) CoAlign; KSpine; (e) CoAlign; KSpine; (g) Medtronic
Alvin H. Crawford, MD	United States	(a) DePuy Spine; (b) DePuy Spine
Charles H. Crawford, MD	United States	(b) Medtronic; (f) Synthes
Terrence Crowder, MD	United States	No Relationships
Matthew E. Cunningham, MD, PhD	United States	No Relationships
E. Patrick Curry, MD	United States	No Relationships
Kirk W. Dabney, MD	United States	No Relationships
Jason Datta, MD	United States	(a) Medtronic
Gema De Blas, MD, PhD	Spain	No Relationships
Donald A. Deinlein, MD	United States	(a) K2M; (b) K2M; (f) Medtronic
Maria Soledad del Cura	Spain	No Relationships
H Gokhan Demirkiran, MD	Turkey	No Relationships
Satoru Demura, MD	Japan	No Relationships
Jay T. deVenny, MBA	United States	No Relationships
Vedat Deviren, MD	United States	(b) Nuvasive; Stryker; (g) Nuvasive
Christopher J. DeWald, MD	United States	No Relationships
Arjun Dhawale	Canada	No Relationships
Mario Di Silvestre, MD	Italy	No Relationships
Mohammad Diab	United States	(a) Medtronic
Beverly E. Diamond, PhD	United States	No Relationships
Douglas D. Dickson, MD	United States	No Relationships
Anton E. Dmitriev, PhD	United States	No Relationships
Josh Doan, MEng	United States	No Relationships
Lori A. Dolan, PhD	United States	No Relationships
Fernando Dominguez	Spain	No Relationships
Gordon Donald, MD	United States	(b) K2M; (f) Orthovita; (g) K2M

CONFLICT OF INTEREST DISCLOSURES (continued...)

(a) Grant/Research Support (b) Consultant (c) Stock/Shareholder (d) Salary, Contractual Services (e) Advisory Board or Panel (f) Speaker's Bureau (g) Other Financial or Material Support

NAME	COUNTRY	RELATIONSHIP DISCLOSURE
John P. Dormans, MD	United States	(a) Synthes; Medtronic; (e) Journal of Pediatric Orthopaedics; (g) Elsevier; Mosby; Brookes Publishing
Ian G. Dorward, MD	United States	No Relationships
Denis S. Drummond, MD	United States	No Relationships
Gregory J. Duncan, BSc	Canada	No Relationships
Simon P. Durcan, MD	United States	No Relationships
Atiq Durrani, MD	United States	No Relationships
Shaalee Dworski	Canada	No Relationships
Mostafa H. El Dafrawy, MD	United States	No Relationships
Mohammad M. El-Sharkawi, MD	Egypt	No Relationships
Caroline Elie	France	No Relationships
Yasser ElMiligui, MD, FRCS	Egypt	No Relationships
John B. Emans, MD	United States	(b) Medtronic; Synthes; (e) Journal of Childrens Orthopaedics; (g) Synthes
Meric Enercan	Turkey	No Relationships
Yoshio Enyo	Japan	No Relationships
Mark A. Erickson, MD	United States	(a) Medtronic
Thomas Errico	United States	(a) Paradigm; Stryker; Synthes; (b) Stryker; (g) K2M; Fastenetix
Peter D. Fabricant, MD	United States	No Relationships
Jean-Pierre C. Farcy, MD	United States	No Relationships
Erin Farrelly, MD	United States	No Relationships
Charla R. Fischer, MD	United States	No Relationships
Neil Fleming, PhD	United States	No Relationships
Nicholas Fletcher, MD	United States	No Relationships
John M. Flynn, MD	United States	(e) Orthopedics Today; Pediatric Orthopaedic Society of North America; Scoliosis Research Society; AAOS; (g) Biomet; Wolters-Kluwer Health - Lippincott Williams & Wilkins
Daniel Y. Fong, PhD	Hong Kong	No Relationships
Anita Franco, MSc	Canada	No Relationships
Chantelle Freeman, BS	United States	No Relationships
Idy C. Fu	Hong Kong	No Relationships
Kai-Ming Fu, MD, PhD	United States	No Relationships
Kenta Fujiwara	Japan	No Relationships
Peter G. Gabos, MD	United States	No Relationships
Robert W. Gaines, MD	United States	No Relationships
Melanie Gambassi, NP	United States	No Relationships
Yubo Gao	United States	No Relationships
Hitesh Garg, MD	United States	No Relationships
Sumeet Garg, MD	United States	No Relationships
Rachel E. Gaume, BS	United States	No Relationships
Hani Ghazi, ME	United States	No Relationships
Paul A. Giorgio	United States	No Relationships
Joseph P. Gjolaj, MD	United States	No Relationships
Diana A. Glaser, PhD	United States	(a) POSNA; DePuy; Naval Medical Center, San Diego; K2M; GSF; Biospace; Alphatec; KCI
Steven D. Glassman, MD	United States	(a) Petersdorf Fund; (b) Medtronic Sofamor Danek; (e) Medtronic Sofamor Danek; (g) Medtronic Sofamor Danek
Christophe Glorion	France	No Relationships
Gnanapragasam Gnanapradeep, MD	United States	No Relationships
Jaspaul Gogia, MD	United States	No Relationships
Michael J. Goldberg, MD	United States	No Relationships
Jeffrey A. Goldstein, MD	United States	(b) Synthes Spine, Medtronic, NuVasive; (c) K2M, Johnson and Johnson
Sergey Goldstein, MD	Canada	No Relationships
Jaime A. Gomez, MD	United States	No Relationships

CONFLICT OF INTEREST DISCLOSURES (continued...)

(a) Grant/Research Support (b) Consultant (c) Stock/Shareholder (d) Salary, Contractual Services (e) Advisory Board or Panel (f) Speaker's Bureau (g) Other Financial or Material Support

NAME	COUNTRY	RELATIONSHIP DISCLOSURE
Michael J. Goytan, MD, FRCSC	Canada	No Relationships
Struan F. Grant, PhD	United States	No Relationships
Daniel W. Green, MS, MD, FACS	United States	(g) Pega Medical
Megan Gresh, MD	United States	No Relationships
Guy Grimard, MD	Canada	No Relationships
Seth A. Grossman, MD	United States	No Relationships
Growing Spine Study Group	United States	(a) Growing Spine Foundation
Jordan Gruskay, BA	United States	No Relationships
Kenneth J. Guidera, MD	United States	No Relationships
Tenner J. Guillaume, MD	United States	No Relationships
Chaofeng Guo	China	No Relationships
Munish C. Gupta, MD	United States	(a) Medtronic; (b) DePuy; Osteotech; Lanx; (e) DePuy; (f) DePuy; Osteotech; Trans1; Synthes
Sachin Gupta	United States	No Relationships
Lawrence L. Haber, MD	United States	No Relationships
Hakon Hakonarson	United States	No Relationships
Ryan J. Halpin, MD	United States	No Relationships
Qusai Hammouri, MD	United States	No Relationships
Azmi Hamzaoglu, MD	Turkey	(b) Medtronic, DePuy Spine
Ebbe S. Hansen, MD, DMSc	Denmark	No Relationships
Harms Study Group	United States	(a) DePuy Spine
Adil Harroud	Canada	No Relationships
Robert A. Hart, MD	United States	(a) DePuy; Medtronic; OREF; Synthes; (b) DePuy; (c) SpineConnect; (f) DePuy; Synthes; (g) SeaSpine
Hamid Hassanzadeh, MD	United States	No Relationships
Paul Haynes, MD	United States	No Relationships
Kimberly Heckmann, BSN	United States	No Relationships
Ilkka Helenius, MD, PhD	Finland	(a) Baxter Finland; Synthes; Pediatric Research Foundation; (b) Medtronic International
Joshua E. Heller, MD	United States	No Relationships
Michael W. Hennessy, MD	United States	No Relationships
Eduardo Hevia, MD	Spain	No Relationships
Alan Hilibrand, MD	United States	(c) Nudisc, Pioneer, PSD, Vertiflex, Lifespine, Benvenue, Paradigm Spine; (e) Amedica; (g) Biomet, Amedica, Alphatec, Aesculap, Stryker, Zimmer
Arja Hiller, MD, PhD	Finland	No Relationships
Toru Hirano	Japan	No Relationships
Chang Hwa Hong	Republic of Korea	No Relationships
Jonathan J. Horn	United States	No Relationships
Naobumi Hosogane, MD	Japan	No Relationships
Richard Hostin, MD	United States	No Relationships
Guangxun Hu, MD	United States	No Relationships
Serena S. Hu, MD	United States	(a) DePuy; (b) Medtronic
Joshua D. Hughes	United States	No Relationships
Man Hung, PhD	United States	No Relationships
Vivian WY Hung	Hong Kong	No Relationships
Raymond W. Hwang, MD, MEng, MBA	United States	No Relationships
Joshua E. Hyman, MD	United States	No Relationships
Ryan M. Ilgenfritz, MD	United States	No Relationships
Brice Ilharreborde, MD	France	No Relationships
Shiro Imagama, MD	Japan	No Relationships
Satoshi Inami	Japan	No Relationships
International Spine Study Group	United States	(a) DePuy Spine

CONFLICT OF INTEREST DISCLOSURES (continued...)

(a) Grant/Research Support (b) Consultant (c) Stock/Shareholder (d) Salary, Contractual Services (e) Advisory Board or Panel (f) Speaker's Bureau (g) Other Financial or Material Support

NAME	COUNTRY	RELATIONSHIP DISCLOSURE
Yoshihiro Inui	Japan	No Relationships
Lisa S. Ipp, MD	United States	No Relationships
Ken Ishii, MD, PhD	Japan	No Relationships
Yuyu Ishimoto	Japan	No Relationships
Manabu Ito, MD, PhD	Japan	(a) Robert Reid,Inc.; Synthes
Chizuo Iwai	Japan	No Relationships
Henry J. Iwinski, MD	United States	No Relationships
Maree T. Izatt, BPhty	Australia	No Relationships
Amit Jain	United States	No Relationships
Viral Jain	United States	No Relationships
Jae-Min Jeon	Republic of Korea	No Relationships
Daniel Jiménez	Spain	No Relationships
Siddharth B. Joglekar	United States	No Relationships
J. Patrick Johnson, MD	United States	(b) Pioneer Medical; SpineWave; Alphatech ; FlexUspine; (c) Pioneer Medical; SpineWave; FlexUspine; Alphatech; (f) Biomet
Charles E. Johnston, MD	United States	(a) Medtronic; (g) Medtronic; Saunders/Mosby Elsevier
Julie Joncas	Canada	No Relationships
Yong Bum Joo	Republic of Korea	No Relationships
Cristina M. Justice, PhD	United States	No Relationships
Nima Kabirian, MD	United States	No Relationships
Sheila Kahwaty, PA-C	United States	No Relationships
Glen Kajiyama, BA	United States	No Relationships
Matthew M. Kang, MD	United States	No Relationships
Sinan Karaca	Turkey	No Relationships
Emre Karadeniz	Turkey	No Relationships
Selhan Karadereler	Turkey	No Relationships
Nakayuki Kato	Japan	No Relationships
Kazuki Kawakami	Japan	No Relationships
Noriaki Kawakami, MD	Japan	(b) Medtronic; (g) Showa
Khaled Kebaish	United States	(a) DePuy Spine; (b) K2M, DePuy Spine; (c) K2M
Michael P. Kelly, MD	United States	No Relationships
Babak Khandehroo, MD	United States	No Relationships
Oner Khera, MD	United States	No Relationships
Jin-Hyok Kim	Republic of Korea	No Relationships
Sung-Soo Kim, MD	Republic of Korea	No Relationships
Terrence T. Kim, MD	United States	(b) Biomet/EBI
Yongjung J. Kim, MD	United States	No Relationships
Youngbae B. Kim, MD, PhD	Republic of Korea	No Relationships
Akilah B. King, BA	United States	No Relationships
Joshua B. Klatt, MD	United States	No Relationships
Dennis R. Knapp, MD	United States	No Relationships
Reginald Q. Knight, MD, MHA	United States	(a) Benvenue; (b) Medtronic; Stryker; (e) Spine Universe; (g) Stryker
Linda Koester, BS	United States	No Relationships
Wael Koptan, MD	Egypt	No Relationships
Tyler Koski, MD	United States	(b) Medtronic; (d) DePuy, Stryker
John P. Kostuik, MD	United States	(c) K2M; (d) K2M
Toshiaki Kotani, MD, PhD	Japan	No Relationships
Rustam Kudyakov, MD, MPH	United States	No Relationships
Preethi M. Kulkarni, MD	United States	No Relationships

CONFLICT OF INTEREST DISCLOSURES (continued...)

(a) Grant/Research Support (b) Consultant (c) Stock/Shareholder (d) Salary, Contractual Services (e) Advisory Board or Panel (f) Speaker's Bureau (g) Other Financial or Material Support

NAME	COUNTRY	RELATIONSHIP DISCLOSURE
Evelyn E. Kuong	Hong Kong	No Relationships
Brian K. Kwon, MD, PhD, FRCSC	Canada	(b) Medtronic
Hubert Labelle, MD	Canada	No Relationships
Robert D. Labrom, MD	Australia	No Relationships
Virginie Lafage, PhD	United States	(c) Nemaris, Inc
Tsz-ping Lam, MB,BS	China	No Relationships
A. Noelle Larson, MD	United States	No Relationships
Darren R. Lebl, MD	United States	No Relationships
Charles Gerald T. Ledonio, MD	United States	No Relationships
Christopher Lee, BS	United States	No Relationships
Dong-Ho Lee, MD, PhD	Republic of Korea	No Relationships
June Kyu Lee	Republic of Korea	No Relationships
Kwong-man Lee, PhD	Hong Kong	No Relationships
Ronald A. Lehman, MD	United States	No Relationships
Lawrence G. Lenke, MD	United States	(a) Axial Biotech, DePuy; (g) Medtronic, Quality Medical Publishing
Julien Leroux	France	No Relationships
Allen Leung, MD	United States	No Relationships
Stephen Lewis	Canada	(b) Medtronic, Stryker
Ming Li	China	No Relationships
Dong-Ju Lim	Republic of Korea	No Relationships
Tracy Lin	United States	No Relationships
Jie Liu, MD	Canada	No Relationships
Zhen Liu	China	No Relationships
Francesco Lolli	Italy	No Relationships
Baron S. Lonner	United States	(a) DePuy; (b) DePuy; (c) K2M; Axial Biotech; Paradigm; (f) DePuy; Spine Wave; Axial Biotech
John Lonstein	United States	No Relationships
Rafael Lorente, PhD	Spain	No Relationships
John P. Lubicky, MD	United States	No Relationships
Scott J. Luhmann, MD	United States	No Relationships
Keith D. Luk, MD	China	No Relationships
Jon D. Lurie, MD	United States	No Relationships
Weiwei Ma, MD	China	No Relationships
Jean-Marc Mac-Thiong, MD, PhD	Canada	(a) Fonds de Recherche en Santé du Québec, National Sciences and Engineering Research Council of Canada, Canadian Institutes of Health Research, DePuy Spine; (g) MMcS Medical, Inc
W.G. Stuart Mackenzie, BS, MS II	United States	No Relationships
Sofia Magana, BSc	Canada	No Relationships
Kin C. Mak, MBBS, FRCS	Hong Kong	No Relationships
Elena Maredi	Italy	No Relationships
Michelle C. Marks, PT, MA	United States	(a) DePuy Spine
Konstantinos Martikos	Italy	No Relationships
Jonathan R. Mason, MD	United States	No Relationships
Karim Z. Masrouha, MD	United States	No Relationships
Hiroko Matsumoto, MA	United States	(a) AOSpine; Chest Wall Spinal Deformity Foundation
Morio Matsumoto, MD	Japan	(b) Medtronic Japan
Andrew S. Matthys, BA	United States	No Relationships
Robert E. Mayle, MD	United States	No Relationships
Keyvan Mazda	France	No Relationships
Jamal McClendon, MD	United States	No Relationships
Anna McClung, RN	United States	No Relationships

CONFLICT OF INTEREST DISCLOSURES (continued...)

(a) Grant/Research Support (b) Consultant (c) Stock/Shareholder (d) Salary, Contractual Services (e) Advisory Board or Panel (f) Speaker's Bureau (g) Other Financial or Material Support

NAME	COUNTRY	RELATIONSHIP DISCLOSURE
Scott McKay	United States	No Relationships
Ryan McLemore, PhD	United States	No Relationships
Amir A. Mehbod, MD	United States	(b) Stryker; (g) Stryker
Hossein Mehdian, MD, MS(Orth) FRCS(Ed)	United Kingdom	No Relationships
Sergio A. Mendoza-Lattes, MD	United States	No Relationships
Olli Meretoja, MD, PhD	Finland	No Relationships
Addisu Mesfin, MD	United States	No Relationships
Andreas Meyer-Heim, MD	Switzerland	No Relationships
Kathleen N. Meyers, MS	United States	No Relationships
Devdatt Mhatre	United States	No Relationships
Jennie B. Mickelson, BS	United States	No Relationships
Cary H. Mielke, MD	United States	No Relationships
Todd A. Milbrandt, MD, MS	United States	(e) POSNA; Lippencott Publishing
Christopher R. Miller, MD	United States	No Relationships
Daniel J. Miller, BS	United States	(a) Doris Duke Charitable Foundation
Freeman Miller, MD	United States	No Relationships
Nancy H. Miller, MD	United States	No Relationships
Robert A. Miller, BS	United States	No Relationships
Kan Min, MD	Switzerland	No Relationships
Woo-Kie Min, MD, PhD	Republic of Korea	No Relationships
Shohei Minami	Japan	No Relationships
Rachel Mistur, MS	United States	(b) Trans1
Hiroshi Miyamoto, MD	Japan	No Relationships
Takeshi Miyamoto	Japan	No Relationships
Firoz Miyanji, MD, FRCSC	Canada	(a) DePuy Spine; (b) DePuy Spine; Medtronic
Kazuyoshi MIyasaka, MD	Japan	No Relationships
Bertrand Moal, MS	United States	No Relationships
Urvij M. Modhia, MD	United States	No Relationships
Hitesh N. Modi, MS, PhD	Canada	No Relationships
Robert W. Molinari, MD	United States	No Relationships
William J. Molinari, MD	United States	No Relationships
Shafagh Monazzam, MD	United States	No Relationships
Elena Montes	Spain	No Relationships
Dianna C. Morales, BA	United States	No Relationships
Alain Moreau, PhD	Canada	(a) Paradigm Spine; (e) Paradigm Spine; (g) Paradigm Spine
Sebastien Moreau	France	No Relationships
Michael Mukhin, BS	United States	No Relationships
Gregory M. Mundis, MD	United States	(a) Nuvasive; K2M; DePuy; (b) Nuvasive; K2M; (f) Nuvasive; K2M
Jennifer Murphy, BA	United States	No Relationships
Nanette Myers, MBA	United States	No Relationships
Karen S. Myung, MD, PhD	United States	No Relationships
Colin E. Nabb, BS	United States	No Relationships
Keiji Nagata	Japan	No Relationships
Masaya Nakamura	Japan	No Relationships
Yutaka Nakamura, MD, PhD	Japan	No Relationships
Takashi Namikawa, MD, PhD	Japan	No Relationships
Unni G. Narayanan, MBBS, MSc, FRCS(C)	Canada	No Relationships
J. Narsh-Babu	India	No Relationships
Rachel C. Nash	United States	No Relationships

CONFLICT OF INTEREST DISCLOSURES (continued...)

(a) Grant/Research Support (b) Consultant (c) Stock/Shareholder (d) Salary, Contractual Services (e) Advisory Board or Panel (f) Speaker's Bureau (g) Other Financial or Material Support

NAME	COUNTRY	RELATIONSHIP DISCLOSURE
Fadi F. Nasr, MD	United States	No Relationships
Geraldine I. Neiss, PhD	United States	No Relationships
Lesa M. Nelson, BS	United States	(d) Axial Biotech, Inc
Philip Neubauer, MD	United States	No Relationships
Brian Neuman, MD	United States	No Relationships
Pertti J. Neuvonen, MD, PhD	Finland	No Relationships
Peter O. Newton, MD	United States	(a) DePuy Spine, Biospace Med; (b) DePuy Spine; (c) NuVasive; (g) DePuy Spine
Bobby KW Ng, MD	Hong Kong	No Relationships
Yasuo Niki, MD	Japan	No Relationships
Yuan Ning	China	No Relationships
Ayato Nohara	Japan	No Relationships
Yutaka Nohara, MD	Japan	No Relationships
Hilali H. Noordeen, FRCS	United Kingdom	(a) K2M; (b) K2M, Ellipse Technologies; (e) K2M
Wendy Novicoff, PhD	United States	No Relationships
Elisa Nurmi, MD	Finland	No Relationships
Brian A. O'Shaughnessy, MD	United States	(b) Medtronic; DePuy; Globus; (c) Medtronic
Michael F. O'Brien, MD	United States	(a) DePuy Spine; (b) Medtronic Sofamor Danek, Osteotech, DePuy Spine; (g) Medtronic Sofamor Danek, Axial Biotech, DePuy Spine
Thierry Odent, MD, PhD	France	No Relationships
James W. Ogilvie, MD	United States	(b) Axial Biotech; (c)Nuvasive; (d) Axial Biotech; (f) DePuy Spine; (g) Medtronic
Gerald Ogola, MS	United States	No Relationships
Tetsuya Ohara	Japan	No Relationships
Eijiro Okada, MD	United States	No Relationships
Z Deniz Olgun, MD	Turkey	No Relationships
Rayshad Oshtory, MD, MBA	United States	No Relationships
Cagatay Ozturk, MD	Turkey	No Relationships
Anne M. Padberg, MS	United States	No Relationships
Jean-Paul Padovani	France	No Relationships
Joshua M. Pahys, MD	United States	No Relationships
Olli T. Pajulo, MD, PhD	Finland	No Relationships
Stefan Parent, MD, PhD	Canada	(a) DePuy Spine
Don Y. Park, MD	United States	No Relationships
Hoon-seok Park	Republic of Korea	No Relationships
Justin Park, MD	United States	No Relationships
Robert S. Pashman, MD	United States	No Relationships
Alok Patel, BS	United States	No Relationships
Ashish Patel, MD	United States	No Relationships
Neeraj M. Patel, MBS	United States	No Relationships
Jeff Pawelek	United States	No Relationships
Georges-françois Penneçot	France	No Relationships
Cesar Perez-Caballero	Spain	No Relationships
Joseph H. Perra, MD	United States	(a) DePuy, Medtronic; (b) Medtronic; (e) Abbott NW Hospital, Allina Healthcare System; (f) Stryker; (g) Medtronic
Maty Petcharaporn, BS	United States	No Relationships
Ferris M. Pfeiffer, PhD	United States	No Relationships
Gabriel Piza Vallespir, MD, PhD	Spain	No Relationships
Benoit Poitras, MD	Canada	No Relationships
David W. Polly, MD	United States	(b) Medtronic
Karthikeyan Ponnusamy	United States	No Relationships
Tomasz Potaczek, MD	Poland	No Relationships

CONFLICT OF INTEREST DISCLOSURES (continued...)

(a) Grant/Research Support (b) Consultant (c) Stock/Shareholder (d) Salary, Contractual Services (e) Advisory Board or Panel (f) Speaker's Bureau (g) Other Financial or Material Support

NAME	COUNTRY	RELATIONSHIP DISCLOSURE
Andrew Pugely	United States	No Relationships
Rehan Puri, MD	United States	No Relationships
Bangping Qian	China	No Relationships
Guixing Qiu	China	No Relationships
Yong Qiu, MD	China	No Relationships
Kristen E. Radcliff, MD	United States	No Relationships
Ra'Kerry K. Rahman, MD	United States	No Relationships
Mohamed O. Ramadan, MD, MSc	United States	No Relationships
V. James Raso, MASc	Canada	No Relationships
Karl E. Rathjen, MD	United States	No Relationships
Abhishek Ray, MD	United States	No Relationships
Barry L. Raynor	United States	No Relationships
Ignacio Regidor, MD, PhD	Spain	No Relationships
Christopher Reilly	Canada	(a) DePuy
Norma Rendon Sampson, MS	United States	No Relationships
Dustin Revella, BA	United States	No Relationships
Jan Revella, RN	United States	No Relationships
Pedro A. Ricart-Hoffiz, MD	United States	No Relationships
B. Stephens Richards, MD	United States	(c) Pfizer; (g) Wolters Kluwer Health (Lippincott Williams & Wilkins)
Kathleen M. Richter, MS, MFA, ELS	United States	No Relationships
K. Daniel Riew, MD	United States	(a) Medtronic; (b) Biomet; (c) Spinal Kinetics; Paradigm; Amedica; PSD; Nexgen Spine; Spineology; Vertiflex; Expanding Orthopedics; Benvenue Medical, Inc; Osprey; (e) KASS; CSRS; (g) Medtronic Sofomar Danek; Osprey
Jeffrey A. Rihn, MD	United States	No Relationships
Guillaume Riouallon	France	No Relationships
Kenneth J. Rogers, PhD	United States	No Relationships
Sarah P. Rogers, MPH	United States	No Relationships
Michael S. Roh, MD	United States	No Relationships
Benjamin D. Roye, MD, MPH	United States	No Relationships
David P. Roye, MD	United States	(a) CWSDRF, OREF, Biomet, Medtronic, AOSpine/Synthes; (g) CWSDSG, Medtronic, Biomet
Lisa Saiman, MD, MPH	United States	No Relationships
Toshiki Saito	Japan	No Relationships
Pooria Salari, MD	United States	No Relationships
Dino Samartzis, DSc, PhD, MSc	Hong Kong	No Relationships
Amer F. Samdani, MD	United States	(b) DePuy; Synthes; SpineVision; (f) DePuy; Synthes; SpineVision
Mika Sampo	Finland	No Relationships
James O. Sanders, MD	United States	(a) Medtronic; POSNA; Chest Wall and Spinal Deformity Study Group Foundation; (c) Abbott
Wudbhav Sankar, MD	United States	No Relationships
Ignacio Sanpera, MD, PhD	Spain	No Relationships
Edward Rainier G. Santos, MD	United States	(a) Medtronic; (f) Synthes
Neil Saran, MD, MHSc, FRCSC	Canada	No Relationships
Vishal Sarwahi, MD	United States	(a) DePuy Spine Inc; K2M; Stryker Inc
Anthony A. Scaduto, MD	United States	No Relationships
Jonathan R. Schiller, MD	United States	No Relationships
Kenneth Schmidt, MD	United States	No Relationships
Frank J. Schwab, MD	United States	(a) Medtronic, DePuy Spine; (b) Medtronic, DePuy Spine; (c) Nemaris
Daniel M. Schwartz, PhD	United States	No Relationships
Jennifer K. Sehn, BS	United States	No Relationships
Kenji Seki, MD, PhD	Japan	No Relationships
Jonathan N. Sembrano, MD	United States	(a) NuVasive

CONFLICT OF INTEREST DISCLOSURES (continued...)

(a) Grant/Research Support (b) Consultant (c) Stock/Shareholder (d) Salary, Contractual Services (e) Advisory Board or Panel (f) Speaker's Bureau (g) Other Financial or Material Support

NAME	COUNTRY	RELATIONSHIP DISCLOSURE
Dilip K. Sengupta, MD	United States	No Relationships
Hassan Serhan, PhD	United States	(c) Johnson & Johnson; (d) Johnson & Johnson
Joni Serlo, MD	Finland	(a) Nora and Kullervo Väre Foundation; Foundation for Paediatric Research
Anthony K. Sestokas, PhD	United States	No Relationships
Christopher I. Shaffrey, MD	United States	(a) NIH, Department of Defense, AOSpine, NACTN; (b) DePuy, Biomet; (g) Medtronic
Fady S. Shafik	Egypt	No Relationships
Suken A. Shah, MD	United States	(a) DePuy Spine, Inc., Axial Biotech, Inc; (b) DePuy Spine, Inc.; (c) Globus Medical; (e) K Spine, Inc.; (g) DePuy Spine, Inc
James Shaha	United States	No Relationships
Nael Shanti, MD	United States	No Relationships
Xiang Shao	China	No Relationships
Evan D. Sheha, BS	United States	No Relationships
Francis H. Shen, MD	United States	(a) OREF; OTA; (b) DePuy Spine; Synthes Spine; Globus Medical; (e) MTF; (f) Synthes Spine; DePuy Spine
Jianxiong Shen, MD	China	No Relationships
Adam L. Shimer, MD	United States	No Relationships
Harry L. Shufflebarger, MD	United States	(a) DePuy Spine, Axial Biotech; (b) DePuy Spine; (e) DePuy Spine; (g) DePuy Spine
Brenda A. Sides, MA	United States	No Relationships
Gordon E. Sims, BS	United States	No Relationships
David L. Skaggs, MD	United States	(b) Medtronic; Stryker; (e) POSNA; Growing Spine Study Group; (f) Medtronic; Stryker; AO North America; (g) Biomet; Lippincott
Richard L. Skolasky, ScD	United States	No Relationships
Bronwyn Slobogean	Canada	No Relationships
Harvey E. Smith, MD	United States	(d) DePuy Spine
John T. Smith, MD	United States	(b) Synthes Spine; (g) Synthes Spine
Justin S. Smith, MD, PhD	United States	(a) DePuy; (b) Biomet, DePuy, Medtronic, Axial Biotech; (e) Medtronic
Robert L. Smith, PhD	United States	No Relationships
Timothy R. Smith, MD	United States	No Relationships
Jonathon M. Spanyer, MD	United States	No Relationships
Joe Sparling	Canada	No Relationships
Hillard Spencer	United States	No Relationships
David A. Spiegel, MD	United States	No Relationships
Jeffrey M. Spivak, MD	United States	No Relationships
Paul Sponseller	United States	(a) DePuy Spine; (b) DePuy Spine; (e) Oakstone Medical Publishers; (g) DePuy Spine; Globus
Kevin F. Spratt, PhD	United States	No Relationships
Jeremy J. Stallbaumer, MD	United States	No Relationships
Bradley Stephens, MD	United States	No Relationships
Geoffrey E. Stoker, BS	United States	No Relationships
Joseph Stone, MD	United States	No Relationships
Peter Sturm, MD	United States	(a) DePuy Spine; (b) DePuy Spine; (c) Pioneer Surgical
Daniel J. Sucato, MD, MS	United States	(g) Medtronic
Etan P. Sugarman, MSIV	United States	No Relationships
William Suggs, MD	United States	No Relationships
Patrick A. Sugrue, MD	United States	No Relationships
Se-Il Suk, MD	Republic of Korea	No Relationships
Guang-quan Sun	Hong Kong	No Relationships
Cheekatla Suresh	India	No Relationships
Teppei Suzuki	Japan	No Relationships
Ch. V. Swamy	India	No Relationships
Kandice Swindle	United States	No Relationships

CONFLICT OF INTEREST DISCLOSURES (continued...)

(a) Grant/Research Support (b) Consultant (c) Stock/Shareholder (d) Salary, Contractual Services (e) Advisory Board or Panel (f) Speaker's Bureau (g) Other Financial or Material Support

NAME	COUNTRY	RELATIONSHIP DISCLOSURE
Aviva Symes	United States	No Relationships
Kazuhisa Takahashi	Japan	No Relationships
Richelle C. Takemoto, MD	United States	No Relationships
Steven Takemoto, PhD	United States	No Relationships
Katsushi Takeshita	Japan	No Relationships
Daisaku Takeuchi	Japan	No Relationships
Vishwas R. Talwalkar, MD	United States	No Relationships
Hiroshi Taneichi, MD	Japan	No Relationships
Maija Tarkkanen	Finland	No Relationships
Bobby Tay, MD	United States	(a) AOSpine; Omega; OREF; (b) BioMet; Stryker
Jamie S. Terran, BS	United States	No Relationships
Wolfram Tetzlaff, MD, PhD	Canada	No Relationships
Mehmet Tezer	Turkey	No Relationships
Dinesh Thawrani, MD	United States	No Relationships
Beverly Thornhill, MD	United States	No Relationships
Michael To, FRCSEd (Ortho); FHKCOS; FHKAM (Ortho)	Hong Kong	No Relationships
Lauren A. Tomlinson, BS	United States	No Relationships
Tor D. Tosteson, ScD	United States	No Relationships
Charles-William Toueg, MD	Canada	No Relationships
Yoshiaki Toyama	Japan	No Relationships
Ensor E. Transfeldt, MD	United States	No Relationships
Clifford B. Tribus, MD	United States	(b) Stryker Spine; (c) Amedica; (g) Stryker Spine; ESM Technologies LLC; Amedica
Per D. Trobisch, MD	United States	No Relationships
Taichi Tsuji	Japan	No Relationships
Shunji Tsutsui	Japan	No Relationships
Lyubov Tsytsikova, BSc	United States	No Relationships
Ejovi Ughwanogho, MD	United States	No Relationships
Benjamin Ungar	United States	No Relationships
Koki Uno, MD, PhD	Japan	No Relationships
Alexander R. Vaccaro, MD, PhD	United States	(b) Gerson Lehrman Group, Guidepoint Global, Medacorp; (c) Replication Medica, K2M, Paradigm Spine, Stout Medical Spine Medica, Computational Biodynamics, Progressive Spinal Technologies, Spinology, Orthovita, Vertiflex, Small Bone Innovations, Disk Motion Technology, NeuCore, Cross Current, Syndicom, In Vivo, Flagship Surgical, Advanced Spinal Intellectual Properties, Cytonics, Bonovo Orthopaedics, Electrolux, Gamma Spine, Location Based Intelligence, FlowPharma, R.I.S.; (g) DePuy, Medtronics, Biomet Spine, Osteotech, Globus, Aesculap, NuVasive
Michael G. Vitale, MD, MPH	United States	(a) Synthes Spine; AO Spine; POSNA; (b) Stryker Spine; Biomet Spine; (e) CWSDSG; (g) Biomet Spine
Francesco Vommaro	Italy	No Relationships
Janet L. Walker, MD	United States	No Relationships
Eric Wall, MD	United States	(b) OrthoPediatric Sports; Stryker Trauma; OrthoPediatric Spine; (g) Spine Form, LLC
Michael J. Wallendorf, PhD	United States	No Relationships
Bin Wang, MD	China	No Relationships
Miao Wang, MD	Denmark	No Relationships
Yan Wang, MD	China	No Relationships
Yipeng Wang, MD	China	No Relationships
Yu Wang, MD, PhD	Denmark	No Relationships
Yuxiang Wang, MD	China	No Relationships
Zijia Wang, MD	China	No Relationships
Kenneth Ward, MD	United States	(c) Axial Biotech; (d) Axial Biotech
Kota Watanabe	Japan	(b) Medtronic, Japan

CONFLICT OF INTEREST DISCLOSURES (continued...)

(a) Grant/Research Support (b) Consultant (c) Stock/Shareholder (d) Salary, Contractual Services (e) Advisory Board or Panel (f) Speaker's Bureau (g) Other Financial or Material Support

NAME	COUNTRY	RELATIONSHIP DISCLOSURE
Atsunori Watanuki	Japan	No Relationships
Michael H. Weber, MD, PhD	United States	No Relationships
James N. Weinstein, DO, MS	United States	No Relationships
Stuart L. Weinstein, MD	United States	No Relationships
Roger F. Widmann, MD	United States	No Relationships
Cheryl R. Wiggins, AuD	United States	No Relationships
Brendan A. Williams, BA	United States	No Relationships
Adam Wilson, MD	United States	No Relationships
Robert B. Winter, MD	United States	No Relationships
Brain S. Winters, MD	United States	No Relationships
Adam L. Wollowick, MD	United States	(a) DePuy Spine; Stryker Spine; K2M; (b) DePuy Spine
Erika Womack, MSc	United States	No Relationships
Yatwa Wong	Hong Kong	No Relationships
Margaret L. Wright, BS	United States	No Relationships
Timothy Wright, PhD	United States	No Relationships
Di Leo Wu	Canada	No Relationships
Mitsuru Yagi, MD, PhD	Japan	No Relationships
Hiroshi Yamada	Japan	No Relationships
Takuya Yamamoto	Japan	No Relationships
Ken Yamazaki, MD	Japan	No Relationships
Haruhisa Yanagida, MD	Japan	(a) Japanese Government; Medtronic
Jun Young Yang, MD, PhD	Republic of Korea	No Relationships
Burt Yaszay, MD	United States	(a) DePuy Spine; K2M; KCI; (b) K2M; Synthes; (f) DePuy Spine; (g) Orthopediatrics)
Muharrem Yazici, MD	Turkey	(b) K2M; DePuy
Hiu Yan Yeung, PhD	China	No Relationships
Jin-Seok Yi	Republic of Korea	No Relationships
Annie Po Yee Yim, MSc	Hong Kong	No Relationships
Petya Yorgova	United States	No Relationships
Munehito Yoshida	Japan	No Relationships
Noriko Yoshimura	Japan	No Relationships
Mary T. Yost, BSN	United States	No Relationships
Benjamin Young, BS	United States	(d) PearlDiver Technologies Inc
Bin Yu, MD	China	No Relationships
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Lukas P. Zebala, MD	United States	(b) Pioneer Surgical Technology
Hongqi Zhang, MD	China	No Relationships
Jianguo Zhang	China	No Relationships
Kai Zhang	United States	No Relationships
Wenyan Zhao, MS	United States	No Relationships
Ying-Chuan Zhao	China	No Relationships
Jie Zheng, MS	United States	No Relationships
Feng Zhu	China	No Relationships
X. Zhu, MS	United States	No Relationships
Xiaodong Zhu	China	No Relationships
Zezhang Zhu, MD	China	No Relationships

SCOLIOSIS RESEARCH SOCIETY

EDUCATIONAL PROGRAM


SCOLIOSIS RESEARCH SOCIETY
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EDUCATIONAL PROGRAM

Pre-registration is required for all of the following sessions and space is limited. There is an additional cost of $30 for the Instructional Course Lectures and an additional registration fee of $150 applies to the Hibbs Society Program. Tickets will be collected at the door by ushers. There may be a limited number of tickets available at the Registration Desk.

LUNCHTIME SYMPOSIA

Pre - registration is required for all of the following sessions and space is limited.

WEDNESDAY, SEPTEMBER 14, 2011

11:30am - 12:30pm

Adult Deformity Classification

Location: Grand Ballroom ABC
Chair: Frank Schwab, MD
The Adult Deformity Classification Symposium is being offered by the Adult Spinal Deformity Committee of the SRS. This symposium will address several key points: the outcomes studies as basis for the Classification, details of the hybrid SRS - Schwab Classification and reliability testing. Participants will learn the importance, background and clinical framework for the current standard in the classification of adult spinal deformity. Supported by grants from K2M and Stryker Spine.

AGENDA

Goals of SRS Effort and Relevance of Classification
Frank Schwab, MD

HRQOL Perspective on Design of the New SRS - Schwab Classification
Virginie Lafage, PhD

Validation of the SRS - Schwab Classification
Benjamin Blonde

Clinical Impact and Use of the Classification
Christopher I. Shaffrey, MD

Evidence Based Medicine

Location: Carroll Ford
Chair: James O. Sanders, MD
The Evidence Based Outcomes Committee will provide a lunchtime symposium on evidence based spinal deformity surgery and particularly concentrate on the issues of systematic reviews, clinical practice guidelines, and appropriate use criteria. The symposium will discuss what each of these are and their likely role in the future of medicine, and spinal deformity care in particular.

AGENDA

Systematic Reviews
Evidence Based Clinical Practice Guidelines
Checklists
Appropriate Use Criteria

SRS Website Update

Location: Combs Chandler
Co- Chairs: John F. Sarwark, MD & Michael Roh, MD
This symposium is presented by the Website Committee. The session will cover the committee's various projects and updates that are in progress with the SRS website, and other internet - related activities such as social media.

AGENDA

Introductory Remarks
John F. Sarwark, MD

SRS Website – Major Changes and Future Plans
Anthony Rinella, MD

Social Media – Facebook and Twitter
Michael Roh, MD

Patient Education Website Activities
Jay Shapiro, MD

Discussion and Feedback

EDUCATIONAL PROGRAM (continued...)

FRIDAY. SEPTEMBER 16, 2011
12:30 - 1:30pm

Research Grant Outcomes
Location: Combs Chandler
Chair: Dilip K. Sengupta, MD
The Research Grant Outcomes Symposium is presented by the SRS Research Grant Committee. Grant recipients from 2008 and 2009 will present their projects and the outcome of their research. The grant application and selection process will also be reviewed.

AGENDA
Introduction
Dilip K. Sengupta, MD

Corrleation of Adjacent Segment Degeneration and Qol Outcome: Application an In - vivo Biomechanics to Assess the Effect of Fusion in AIS
Kirkham Wood, MD, 2009 Standard Investigator Recipient

The Contribution of Asymmetric Growth and Vertebral Remodeling to Apical Wedging
David Aronsson, MD, 2008 Standard Investigator Recipient

Single - Blind Comprehensive Cohort Study Incorporating a Randomized Controlled Design on Bracing in AIS: A Feasibility Study
Daniel Y.T. Fong, PhD, 2008 New Investigator Recipient

Monitoring of Nerve Root Injury Using Transcranial Motor - Evoke Potentials in a Pig Model
Shane Burch, MD, 2008 New Investigator Recipient

Impact of Spinal Disorders on Health Related Quality of Life
Sigurd Berven, MD, 2008 Small Exploratory Recipient

Questions and Discussion

Global Outreach Update
Location: Carroll Ford
Chair: Theodore Wagner, MD
The Global Outreach Program has now been an active committee for ten years and continues to redefine itself and establish new active international sites. The goal is to have an educational exchange about the topic of spinal deformity and appropriate surgery, to offer care for an underserved population and to invite other members of the SRS to join these visits.

AGENDA
Introduction
Theodore Wagner, MD

Ghana
Oheneba Boachie - Adjei, MD

Cali, Columbia
Anthony Rinella, MD and Matthew Geck, MD

Sofia, Bulgaria
Steven Mardjetko, MD

Trinidad
Vincent Arlet, MD

Indonesia
Theodore Wagner, MD

ORTHO/LINK
Dheera Ananthakrishnan, MD

Questions

3D Analysis of Scoliosis
Location: Grand Ballroom ABC
Chair: Hubert Labelle, MD
This symposium is organized by the 3D Scoliosis Committee. The objective is to demonstrate how 3D analysis of AIS can change current methods to evaluate and treat scoliosis. The step by step technique to analyze the top view of a scoliotic deformity will be reviewed in detail, and typical pre and post - operative surgical cases of AIS will be used to illustrate how seeing the spine in 3D can influence surgical decision - making.

AGENDA
A Review of Current Technologies and Softwares for 3D Analysis
The Step - by - Step ''Top View" Analysis of Normal and Scoliotic Spines
Pre - and Post - Op 3D Analysis and Case Discussion of Surgical AIS Cases

EDUCATIONAL PROGRAM (continued...)

INSTRUCTIONAL COURSE LECTURES

All Instructional Course Lectures will take place on Thursday, September 15 from 12:30 - 3:30pm. Pre - registration is required for all sessions and space is limited. There is an additional registration fee of $30 for the Instructional Course Lectures.

Growth Sparing Treatment of Early Onset Neuromuscular Spinal Deformity

Location: Grand Ballroom ABC
Chair: Lawrence Karlin, MD

This Instructional Course Lecture is presented by the SRS Growing Spine Committee and invited SRS members who are innovators in the treatment of early onset spinal deformity. The course will provide an overview of the challenges presented by children with early onset neuromuscular spinal deformity, and a survey of the current treatment options: cast/orthotic, growing rods, VEPTR, hybrid growing rods, Shilla, magnetic powered growing rods, and early fusion. Case studies will illustrate the decision making process involved in individualizing treatment based on the co - morbidities in this population, and define the indications for present day treatment modalities. Supported by grants form K2M & Medtronic.

AGENDA

12:30 - 12:35	Introduction *Lawrence Karlin, MD*
12:35 - 12:40	Status of FDA Approval of Growing Spinal Instrumentation *Michael Vitale, MD*
12:40 - 12:50	Overview *Paul D. Sponseller, MD*
12:50 - 1:00	Questions
1:00 - 1:10	Casts and Orthotics *Laurel C. Blakemore, MD*
1:10 - 1:20	Growing Rods (single, dual) *Behrooz A. Akbarnia, MD*
1:20 - 1:30	VEPTR *John Smith, MD*
1:30 - 1:40	Questions
1:40 - 1:50	Hybrid Growing Rods *David Skaggs, MD*
1:50 - 2:00	Shilla *Richard E. McCarthy, MD*
2:00 - 2:10	Magnetic Powered Extensible Rods *Hilali Noordeen, FRCS*
2:10 - 2:20	Early Spinal Fusion *Suken Shah, MD*
2:20 - 2:30	Questions
2:30 - 3:25	Illustrative Case Presentations and Discussions
3:25 - 3:30	Summation/Questions *Lawrence Karlin, MD*

The Treatment of Spinal Deformity Associated with Syndromic Conditions

Location: Archibald Cochrane, Rivue Tower
Co-Chairs: John R. Dimar, II, MD & Lori Ann Karol, MD

Scoliosis and other deformities are often found in association with numerous multi - systemic syndromes. The identification and treatment of these deformities in can be quite challenging, often requiring a special degree of knowledge concerning the syndrome and extra expertise when surgery is indicated. When addressing these conditions, the spine specialist must pay attention to the potential the co - morbidities and complications that are associated with a particular syndrome. The symposium will cover the unique problems associated with the spinal deformities encountered in four major syndrome classes: Down syndrome, Neurofibromatosis, Marfans & Ehlers - Danlos Syndromes, and common miscellaneous syndromes. Supported by a grant from Medtronic.

AGENDA

12:30 - 12:35	Welcome *John R. Dimar II, MD and Lori Ann Karol, MD*
12:35 - 12:55	Deformities Associated with Down Syndrome: Etiology, Radiographic Identification, Non-Operative and Operative Treatment, Common Complications *John R. Dimar II, MD*
12:55 - 1:15	Neurofibromatosis: Etiology, Commonly Encountered Spinal Deformities, Common Complications and Pitfalls of Surgical Treatment *Alvin H. Crawford, MD*
1:15 - 1:35	Connective Tissue Syndromes: The Etiology of Marfan's & Ehlers - Danlos Syndrome and Techniques of Non - operative and Operative Treatment of Patients with Spinal Deformity *Paul D. Sponseller, MD*
1:35 - 1:55	Case Presentations: Down, Marfans, Neurofibromatosis, and Dwarfism *Alvin H. Crawford, MD; John R. Dimar, II, MD; Lori Ann Karol, MD, Paul D. Sponseller, MD*
1:55 - 2:05	Questions
2:05 - 2:15	Achondroplasia: Etiology, Radiographic Identification, Commonly Encountered Deformities, Indications for Surgical Treatment & Potential Complications *Lori Ann Karol, MD*

EDUCATIONAL PROGRAM (continued...)

2:15 - 2:35	Miscellaneous Short Syndrome Deformities: Pseudoachonplasia, Diastrophic Dwarfism, Spondyloepiphyseal Dysplasia, Kniest Dwarfism, Chondrodysplasia Punctata. Radiographic Identification & Indications for Surgical Treatment *James O. Sanders, MD*
2:35 - 2:45	Mucopolysaccharidoses: Etiology, Classification, Deformities Unique to Each Type, Treatment Modalities & Indications for Surgical Intervention *Klane K. White, MD*
2:45 - 2:55	Cervical Deformity in Larson's Syndrome: Etiology, Classification, Types of Cervical Deformities, Techniques of Surgical Treatment *John P. Dormans, MD*
2:55 - 3:05	Osteogenesis Imperfecta: Etiology, Classification, Types of Spinal Deformities, Techniques of Surgical Treatment in Patients with Poor Bone Quality & the Avoidance of Complications *John P. Lubicky, MD*
3:05 - 3:25	Case Presentations: Dwarfs, Mucopolysaccharidoses, Osteogenisis Imperfecta, Larson's and Other Miscellaneous Causes *John P. Dormans, MD; Lori Ann Karol, MD; John P. Lubicky, MD, James O. Sanders, MD; Klane K. White, MD*
3:25 - 3:35	Questions and Summary

A Potpourri of Worldwide Conference Presentations

Location: Carroll Ford

Co - Chairs: Ahmet Alanay, MD & Kamal Ibrahim, MD

This Instructional Course Lecture will present an international approach to various spinal deformity problems. The program will include lectures presented by local experts at recent Worldwide Conferences. Supported by grants from Medtronic and Stryker Spine.

AGENDA

12:30 - 1245	Introduction and Future Direction of Worldwide Conferences *Ahmet Alanay, MD*
12:45 - 1:00	Three Column Osteotomy in the Treatment of Severe Rigid Scoliosis: Approach, Level Selection and Risk Aversion *Dewei Zou, MD* *Originally presented in Nanjing, China, June 2010*
1:00 - 1:15	Coplanar Vertebral Alignment for Thoracic Scoliosis Correction *Yong Qiu, MD* *Originally presented in Nanjing China, June 2010*
1:15 - 1:20	Questions
1:20 - 1:35	Management of Deformity Patients Presenting with Myelopathy *Robert Dunn, FCS (SA)* *Originally presented in Capetown, South Africa, May 2010*
1:35 - 1:50	Fusion in Spondylosis *David Welsh* *Originally presented in Capetown, South Africa, May 2010*
1:50 - 1:55	Questions
1:55 - 2:10	Role of Anterior Surgery in Adult Scoliosis *Yasser El Milgui, MD, FRCS* *Originally presented in Cairo, Egypt, December 2009*
2:10 - 2:25	Revision Scoliosis, Is it Worth Doing? *Youssry El Hawary, MD* *Originally presented in Cairo, Egypt, December 2009*
2:25 - 2:30	Questions
2:30 - 2:45	AIS, Anterior Concavity Approach Release and Fixation *Alejandro Reyes Sanchez, MD* *Originally presented in Acapulco, Mexico, September 2010*
2:45 - 3:00	Fixation in Osteoporotic Bones: Effectiveness, When and How, Complications *Virgilio Ortiz, MD* *Originally presented in Acapulco, Mexico, September 2010*
3:00 - 3:15	Post - traumatic Kyphosis: Indication of Surgery, Degrees of Kyphosis vs. Global Sagittal Alignment, Surgical Execution *Baron Zarate* *Originally presented in Acapulco, Mexico, September 2010*
3:15 - 3:25	Questions
3:25 - 3:30	Closing Remarks *Ahmet Alanay, MD and Kamal N. Ibrahim, MD*

SCOLIOSIS RESEARCH SOCIETY

CASE DISCUSSION PROGRAM


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CASE DISCUSSION PROGRAM

WEDNESDAY, SEPTEMBER 14, 2011

3:45 – 5:00pm

These sessions are open to all Annual Meeting delegates. Pre-registration is not required and no additional fee applies.

The Case Discussion sessions are a new offering at this year's Annual Meeting. They allow an opportunity to present unique and challenging clinical cases to the SRS with a panel of experts present to review and discuss each case and the clinical issues that are highlighted, as well as answer questions from audience participants. The panels will also prepare case studies for presentation and discussion, as time allows. With the exception of the "Proximal Junctional Kyphosis" session, all the following Case Discussion presentations were selected from those submitted through the abstract submission and review process.

Innovative Techniques

Room: Combs Chandler, Ballroom Level
Moderator: Alvin H. Crawford, MD
Panelists: Kamal N. Ibrahim, MD, FRCS(C), MA
Shay Bess, MD

Cases for Discussion:

Maintaining Thoracic Kyphosis in Thoracic AIS Correction When Derotation is Performed
Satoru Demura, Burt Yaszay, Joseph H. Carreau, Tracey Bastrom, Peter O. Newton

The Surgical Management of Severe AIS and Unstable Spondylolisthesis: Can Multiple Lumbar Fusion Levels Be Saved by Addressing the Spondylolisthesis First?
John T. Braun

Radiological Analysis of Pedicle Subtraction Osteotomies in Children: Where Does the Correction Occur?
J. Naresh-Babu, Cheekatla Suresh, Ch V. Swamy

Posterior Tether for Progressive Kyphoscoliosis in a Nine Year Old
Kira Skaggs, Karen S. Myung, Aimee Brasher, David L. Skaggs

Early Onset Scoliosis

Room: Breathitt, Ballroom Level
Moderator: Richard E. McCarthy, MD
Panelists: John P. Dormans, MD
Muharrem Yazici, MD

Cases for Discussion:

Casting for Early Onset Scoliosis: The Pitfall of Increased Peak Inspiratory Pressure
Suken A. Shah, Kenneth J. Rogers, William G. Mackenzie

Scoliosis with Unilateral Contracted Thorax Treated with Instrumented Posterior Spinal Fusion and Expansion Thoracoplasty Using a Hook and Rod Construct
Taichi Tsuji, Noriaki Kawakami, Kazuyoshi MIyasaka, Tetsuya Ohara, Toshiki Saito, Ayato Nohara, Michiyoshi Sato, Kenyu Ito, Kazuki Kawakami

Beware the Risks of Instrumenting to the Pelvis in Ambulatory Early Onset Scoliosis Patients Treated with Growth Sparing Surgery
Burt Yaszay, Nima Kabirian, Jeff Pawelek, John B. Emans, Charles E. Johnston, Suken A. Shah, Gregory M. Mundis, Behrooz A. Akbarnia, Growing Spine Study Group

CASE DISCUSSION PROGRAM (continued...)

Adult Deformity/Complications

Room: Carroll Ford, Ballroom Level
Moderator: Mark B. Dekutoski, MD
Panelists: Jacob M. Buchowski, MD, MS
Youssry El-Hawary, MD

Cases for Discussion:

Delayed Quadraparesis After Posterior Spinal Fusion for Scoliosis: A Case Series
Jahangir Asghar, Paul Sponseller, Dianna C. Morales, Harry L. Shufflebarger

Solution for Late Arising Infection in Stainless Steel Spinal Implants placed for Deformity: Exchange for Titanium Implants
Harry L. Shufflebarger, Jahangir Asghar, Dianna C. Morales

Adult Degenerative Scoliosis: Limited Fusion of the Fractional Curve Technical Note and Preliminary Results
Eijiro Okada, Sigurd H. Berven, Serena S. Hu, Vedat Deviren, Shane Burch, Bobby Tay

Fifty Year Old Female with Severe Kyphotic Deformity at the Lumbosacral Junction with Spondylolisthesis, Scoliosis and Severe Sagittal and Coronal Imbalance Treated with Vertebral Column Resection (VCR) of L5
Mostafa H. El Dafrawy, Khaled Kebaish

Neuromuscular Deformity

Room: Sampson, First Floor
Moderator: Reinhard Zeller, MD
Panelists: Carlos A. Tello, MD
Joseph H. Perra, MD

Cases for Discussion:

Fatal Cerebral Swelling Associated with Scoliosis Surgery in a Patient with Neuromuscular Scoliosis and Congenital Hydrocephalus
Paul Issack, Oheneba Boachie-Adjei

Post Operative Abdominal Compartment Syndrome after Pediatric Deformity Spine Correction
Terry D. Amaral, Vishal Sarwahi, Etan P. Sugarman, Melanie Gambassi, Adam L. Wollowick, Jonathan J. Horn, Preethi M. Kulkarni

T11 Myelomeningocele with Intact Neurological Exam with Significant Scoliotic Deformity
Vishal Sarwahi, Terry D. Amaral, Preethi M. Kulkarni, Jonathan J. Horn, Melanie Gambassi, Adam L. Wollowick

Treatment of Kyphoscoliosis in Proteus Syndrome: Case Report and Review of the Literatrue
Laurel C. Blakemore, Mark A. Anderson, Kimberly A. O'Brien

Proximal Junctional Kyphosis (PJK)

Room: Wilkinson, First Floor
Moderator: Ahmet Alanay, MD
Panelists: Noriaki Kawakami, MD
Sigurd H. Berven, MD

Cases for Discussion: To be presented by the panel.

SCOLIOSIS RESEARCH SOCIETY

SCIENTIFIC PROGRAM


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SCIENTIFIC PROGRAM

THURSDAY, SEPTEMBER 15, 2011

Session I – Adolescent Idiopathic Scoliosis
Moderators: Ahmet Alanay, MD and Daniel J. Sucato, MD, MS

7:55 - 8:00 Welcome & Announcements

8:00 - 8:04 Paper #1
Preoperative Autologous Blood Donation Results in More Transfusions in the Surgical Treatment of Adolescent Idiopathic Scoliosis
Lukas P. Zebala, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Jacob M. Buchowski, MD, MS; Brenda A. Sides, MA

8:04 - 8:08 Paper #2*
A Randomized Prospective Evaluation of Three Techniques of Post-Operative Pain Management Following Posterior Spinal Instrumentation and Fusion
Joshua B. Klatt, MD; Christopher R. Miller, MD; Simon P. Durcan, MD; Jennie B. Mickelson, BS; Man Hung, PhD; John T. Smith, MD

8:08 - 8:12 Paper #3
Intravenous Acetaminophen in Adolescents Undergoing Spine Surgery. A Double-Blind Randomized Clinical Trial
Arja Hiller, MD, PhD; Ilkka Helenius, MD, PhD; Elisa Nurmi, MD; Pertti J. Neuvonen, MD, PhD; Olli Meretoja, MD, PhD

8:12 - 8:21 Discussion

8:22 - 8:26 Paper #4
Characteristics of Patients with Adolescent Idiopathic Scoliosis Who Experience Coronal Decompensation Following Posterior Spinal Instrumentation and Fusion
Jaime A. Gomez, MD; Hiroko Matsumoto, MA; Nicholas D. Colacchio, BA; Daniel J. Miller, BS; David P. Roye, MD; Daniel J. Sucato, MD, MS; B. Stephens Richards, MD; John B. Emans, MD; Mark A. Erickson, MD; James O. Sanders, MD; Lawrence G. Lenke, MD; Michael G. Vitale, MD, MPH

8:26 - 8:30 Paper #5
Which Factors Influence Spontaneous Lumbar Curve Correction After Selective Thoracic Fusion In Lenke Type IB And C Curves?
Azmi Hamzaoglu, MD; Cagatay Ozturk, MD; Ahmet Alanay; Meric Enercan; Emre Karadeniz; Sinan Karaca

8:30 - 8:34 Paper #6
Is Decompensation Preoperatively a Risk in Lenke 1C Curves?
Satoru Demura, MD; Burt Yaszay, MD; Tracey Bastrom, MA; Joseph H. Carreau, MD; Peter O. Newton, MD; Harms Study Group

8:34 - 8:43 Discussion

8:44 - 8:48 Paper #7
Assessment of Proximal Junctional Kyphosis and Shoulder Balance with Proximal Screws vs. Hooks in Posterior Spinal Fusion for Adolescent Idiopathic Scoliosis
Joshua M. Pahys, MD; Amer F. Samdani, MD; Randal R. Betz, MD; Per D. Trobisch, MD; Hitesh Garg, MD; Peter O. Newton, MD; Michelle C. Marks, PT, MA; Tracey Bastrom, MA; Harms Study Group; Patrick J. Cahill, MD

8:48 - 8:52 Paper #8
Clinical, Radiographic and Patient Assessment of Shoulder Imbalance Following Thoracic Adolescent Idiopathic Scoliosis (AIS) Reconstruction
Jeremy J. Stallbaumer, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Christine Baldus, RN, MHS; Linda Koester, BS

8:52 - 8:56 Paper #9
Should Shoulder Balance Determine Proximal Fusion Levels in Patients with Lenke 5 Curves?
Burt Yaszay, MD; Tracey Bastrom, MA; Peter O. Newton, MD; Harms Study Group

8:56 - 9:05 Discussion

* Hibbs Award Nominee for Best Clinical Presentation † Hibbs Award Nominee for Best Basic Science Presentation
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SCIENTIFIC PROGRAM

THURSDAY, SEPTEMBER 15, 2011 (continued...)

Moderators: Hubert Labelle, MD and George H. Thompson, MD

9:06 - 9:10 **Paper #10**

Does the Scoliscore Provide More Information Than Traditional Clinical Estimates Of Curve Progression?

Benjamin D. Roye, MD, MPH; Margaret L. Wright, BS; Brendan A. Williams, AB; Hiroko Matsumoto, MA; Jacqueline Corona, MD; Joshua E. Hyman, MD; David P. Roye, MD; Michael G. Vitale, MD, MPH

9:10 - 9:14 **Paper #11**

To BrAIST or Not to BrAIST: Self-Selection in the Bracing in Adolescent Idiopathic Scoliosis Trial

Lori A. Dolan, PhD; Stuart L. Weinstein, MD

9:14 - 9:18 **Paper #12**

Improvement in Pulmonary Function at Two Years Following Corrective Surgery for AIS - A Prospective Study

Charles E. Johnston, MD; B. Stephens Richards, MD; Daniel J. Sucato, MD, MS; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Mark A. Erickson, MD

9:18 - 9:22 **Paper #13**

Proximal Junctional Kyphosis at Five Years after Fusion for AIS: Does it Matter?

Jahangir Asghar, MD; Amer F. Samdani, MD; Peter O. Newton, MD; Patrick J. Cahill, MD; Dianna C. Morales, BA; Harry L. Shufflebarger, MD

9:22 - 9:34 **Discussion**

9:35 - 9:39 **Paper #14**

Flatback Revisited?: Reciprocal Loss of Lumbar Lordosis Following Selective Thoracic Fusion

Michael G. Vitale, MD, MPH; Nicholas D. Colacchio, BA; Hiroko Matsumoto, MA; Frank J. Schwab, MD; Virginie Lafage, PhD; David P. Roye, MD

9:39 - 9:43 **Paper #15**

Multi-Center Comparison of the Factors Important in Restoring Thoracic Kyphosis During Posterior Instrumentation for Adolescent Idiopathic Scoliosis

Shafagh Monazzam, BS, MD; Peter O. Newton, MD; Tracey Bastrom, MA; Burt Yaszay, MD; Harms Study Group

9:43 - 9:47 **Paper #16**

Cervical Sagittal Contour Decompensation Before and After Posterior Surgery for Adolescent Idiopathic Scoliosis

Suken A. Shah, MD; Brain S. Winters, MD; E. Patrick Curry, MD; Petya Yorgova; Geraldine I. Neiss, PhD; Alan Hilibrand, MD; Harms Study Group

9:47 - 9:56 **Discussion**

9:56 - 10:16 **BREAK**

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SCIENTIFIC PROGRAM

THURSDAY, SEPTEMBER 15, 2011 (continued...)

Session II – Adult Deformity
Moderators: Keith H. Bridwell, MD and Sean Molloy, MBBS, MSc, FRCS, DC

10:16 - 10:20 Paper #17
Early Results and Complications of Posterior-Based Osteotomies in Patients with Previous Spinal Fusions
Stephen Lewis; Hitesh N. Modi, MS, PhD; Sergey Goldstein, MD; Andrew W. Bodrogi, BSc; Sofia Magana, BSc

10:20 - 10:24 Paper #18
Clinical and Radiographic Outcomes of Pedicle Subtraction Osteotomy (PSO) for Fixed Adult Sagittal Imbalance: Does Level of Proximal Fusion Affect Outcome?
Mitsuru Yagi, MD, PhD; Akilah B. King, BA; Matthew E. Cunningham, MD, PhD; Oheneba Boachie-Adjei, MD

10:24 - 10:28 Paper #19
Assessment of Symptomatic Rod Fracture Following Posterior Instrumented Fusion for Adult Spinal Deformity
Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Vedat Deviren, MD; Kai-Ming Fu, MD, PhD; Frank Schwab, MD; Virginie Lafage, PhD; Shay Bess, MD; International Spine Study Group

10:28 - 10:37 Discussion

10:38 - 10:42 Paper #20*
Combined Assessment of Pelvic Tilt, Pelvic Incidence/Lumbar Lordosis Mismatch and Sagittal Vertical Axis Predicts Disability in Adult Spinal Deformity: A Prospective Analysis
Frank J. Schwab, MD; Shay Bess, MD; Benjamin Blondel, MD; Richard Hostin, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Oheneba Boachie-Adjei; Douglas C. Burton, MD; Behrooz A. Akbarnia, MD; Gregory M. Mundis, MD; Christopher P. Ames, MD; Khaled Kebaish; Robert A. Hart, MD; International Spine Study Group; Virginie Lafage, PhD

10:42 - 10:46 Paper #21
T2 or T10: Preoperative Sagittal Parameters Determine Proximal Fusion Levels in Adult Idiopathic Thoracolumbar Scoliosis
Terrence T. Kim, MD; Jennifer Murphy, BA; J. Patrick Johnson, MD; Robert S. Pashman

10:46 - 10:50 Paper #22
Comparative Radiographic Analysis Of The Sagittal Spinopelvic Alignment Between 100 Asymptomatic Adults And 100 Sagittally Imbalanced Patients: The Best Angular Parameters to Sagittal Vertical Axis
Yongjung J. Kim, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Youngbae B. Kim, MD, PhD

10:50 - 10:54 Paper #23
Redefining Global Spinal Balance: Normative Values of Cranial Center of Mass from a Prospective Cohort of Asymptomatic Individuals
Patrick A. Sugrue, MD; Jamal McClendon, MD; Timothy R. Smith, MD; Ryan J. Halpin, MD; Fadi F. Nasr, MD; Brian A. O'Shaughnessy, MD; Tyler Koski, MD

10:54 - 11:06 Discussion

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SCIENTIFIC PROGRAM

THURSDAY, SEPTEMBER 15, 2011 (continued...)

Moderators: Sigurd H. Berven, MD and Praveen Mummaneneni, MD

11:07 - 11:11 **Paper #24**

The Anchor Type at the Proximal Fusion Level has Significant Effect on the Incidence of Proximal Junctional Kyphosis (PJK) and Outcome in Adults Following Long Posterior Spinal Fusion

Hamid Hassanzadeh, MD; Sachin Gupta; Amit Jain; Mostafa H. El Dafrawy, MD; Richard L. Skolasky, ScD; Khaled Kebaish

11:11 - 11:15 **Paper #25**

Incidence, Risk Factors, and Clinical Outcome of Proximal Junctional Kyphosis for Patients with Adult Idiopathic Scoliosis: Minimum Five Year Follow-Up

Mitsuru Yagi, MD, PhD; Akilah B. King, BA; Oheneba Boachie-Adjei, MD

11:15 - 11:19 **Paper #26**

Are TLIFs Necessary for L5-S1 Arthrodesis in Long Constructs to the Sacrum/Pelvis in Primary Adult Deformity Patients?

Ra'Kerry K. Rahman, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Jacob M. Buchowski, MS, MD; Bradley Stephens, MD; Ian G. Dorward, MD; Linda Koester, BS

11:19 - 11:28 **Discussion**

11:29 - 11:33 **Paper #27***

Clinical Results and Functional Outcome in Adult Patients Following Surgical Treatment for Spinal Deformity: Primary vs. Revision

Hamid Hassanzadeh, MD; Amit Jain; Mostafa H. El Dafrawy, MD; Philip Neubauer, MD; Addisu Mesfin, MD; Richard L. Skolasky, ScD; Khaled Kebaish

11:33 - 11:37 **Paper #28**

The Fate of the Adult Revision Spinal Deformity Patient: A Single Institution Experience

Michael P. Kelly, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Jacob M. Buchowski, MD, MS; Lukas P. Zebala, MD; Linda Koester, BS

11:37 - 11:41 **Paper #29**

Is There a Difference in Clinical Outcome between Adult Patients Under and Over Age 60 Who Have Revision Scoliosis Fusion Surgery to the Sacrum?

Samuel K. Cho, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Jin-Seok Yi; Matthew M. Kang, MD; Lukas P. Zebala, MD; Joshua M. Pahys, MD; Christine Baldus, RN, MHS

11:41 - 11:50 **Discussion**

11:51 - 11:56 **Harrington Lecture Introduction**

Lawrence G. Lenke, MD

SRS President

11:56 - 12:16 **Harrington Lecture**

Past, Present and Future Course of the Scoliosis Research Society: What Do the Past Presidents Think?

Keith Bridwell, MD

SRS Past President

Adjourn

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SCIENTIFIC PROGRAM

FRIDAY, SEPTEMBER 16, 2011

Session III – Complications / Safety / Innovative Techniques
Moderators: David W. Polly, MD and David Skaggs, MD

7:55 - 8:00 Welcome & Announcements

8:00 - 8:04 Paper #30
The Degree of Contamination While Performing Spine Surgery
Dongki Ahn; Dae Jung Choi; Hoon-seok Park

8:04 - 8:08 Paper #31
Prospective, Randomized Study of Surgical Site Infections with the Use of Perioperative Antibiotics for 24 Hours vs. the Duration of a Drain After Spinal Surgery
Richelle C. Takemoto, MD; Justin Park, MD; Pedro A. Ricart-Hoffiz, MD; Tate Andres; John A. Bendo, MD; Jeffrey A. Goldstein, MD; Jeffrey M. Spivak, MD; Thomas Errico; Baron S. Lonner

8:08 - 8:12 Paper #32
Surgical Site Infection Following Spinal Instrumentation For Scoliosis: Lessons Learned From an Multi-Center Analysis of 1,352 Spinal Instrumentation Procedures For Scoliosis
Michael G. Vitale, MD, MPH; W.G. Stuart Mackenzie, BS, MS II; Hiroko Matsumoto, MA; Christopher Lee, BS; Stephanie R. Cody, BS; Jacqueline Corona, MD; Brendan A. Williams, AB; Lisa Covington, RN, MPH; Lisa Saiman, MD, MPH; John M. Flynn, MD; David L. Skaggs, MD; David P. Roye, MD

8:12 - 8:21 Discussion

8:22 - 8:26 Paper #33
Assessment of Morbidity and Mortality Collection Data 2009
Dennis R. Knapp, MD; Michael J. Goytan, MD, FRCSC; Joseph H. Perra, MD; Hilali H. Noordeen, FRCS; Justin S. Smith, MD, PhD; Paul A. Broadstone, MD; Sigurd H. Berven, MD; Theodore J. Choma, MD; Christopher P. Ames, MD; Michael S. Roh, MD; Yongjung J. Kim, MD

8:26 - 8:30 Paper #34*
Significant Change or Loss of Intraoperative Monitoring Data: A 25 Year Experience in 12,375 Spinal Surgeries
Barry L. Raynor; Joseph D. Bright; Ra'Kerry K. Rahman, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; K. Daniel Riew, MD; Jacob M. Buchowski, MD, MS; Scott J. Luhmann, MD; Anne M. Padberg, MS

8:30 - 8:34 Paper #35
Prospective Analysis of Intraoperative Neuromonitoring Events During Spinal Corrective Surgery for Adolescent Idiopathic Scoliosis
Jody Buckwalter, PhD; Burt Yaszay, MD; Tracey Bastrom, MA; Ryan M. Ilgenfritz, MD; Peter O. Newton, MD; Harms Study Group

8:34 - 8:43 Discussion

8:44 - 8:48 Paper #36
Intrawound Vancomycin Powder Lowers the Acute Deep Wound Infection Rate in Adult Spinal Deformity Patients
Ra'Kerry K. Rahman, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Jacob Buchowski, MD, MS; Douglas D. Dickson, MD; Alexander Aleem, MD; Brenda A. Sides, MA

8:48 - 8:52 Paper #37
Prophylactic Operative Site Powdered Vancomycin and Postoperative Deep Spinal Wound Infection: 1512 Consecutive Surgical Cases during a Six-Year Period
William J. Molinari, MD; Oner Khera, MD; Robert W. Molinari, MD

8:52 - 8:58 Discussion

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SCIENTIFIC PROGRAM

FRIDAY, SEPTEMBER 16, 2011 (continued...)

Moderators: Steven M. Mardjetko, MD, FAAP and John P. Dormans, MD

8:59 - 9:03 **Paper #38**

How Commonly are Pedicle Screws Adjacent to the Great Vessels or Viscera? A Study of 2,295 Pedicle Screws

Terry D. Amaral, MD; Adam L. Wollowick, MD; Preethi M. Kulkarni, MD; Beverly Thornhill, MD; William Suggs, MD; Etan P. Sugarman, MSIV; Jonathan J. Horn; Vishal Sarwahi, MD

9:03 - 9:07 **Paper #39**

CT-Guided (O-Arm) Navigation of Thoracic Pedicle Screws for AIS Results in More Accurate Placement and Less Screw Removal

Ejovi Ughwanogho, MD; John M. Flynn, MD; Neeraj M. Patel, MBS; Keith Baldwin; Norma Rendon Sampson, MS

9:07 - 9:13 **Discussion**

9:14 - 9:18 **Paper #40**

Neuromonitoring Changes are Common and Reversible with Temporary Distraction Rods for Severe Scoliosis (Mean 113°)

David L. Skaggs, MD; Christopher Lee, BS; Karen S. Myung, MD, PhD

9:18 - 9:22 **Paper #41**

Can Intraoperative Spinal Cord Monitoring Reliably Help Prevent Paraplegia During Posterior VCR Surgery?

Samuel K. Cho, MD; Lawrence G. Lenke, MD; Shelly Bolon, BS, CNIM; Joshua M. Pahys, MD; Woojin Cho, MD PhD; Matthew M. Kang, MD; Lukas P. Zebala, MD; Linda Koester, BS

9:22 - 9:26 **Paper #42**

Neurophysiologic Monitoring of Thoracic Pedicle Screws Intentionally Located within the Spinal Canal. An Experimental Study on Pigs

Luis Miguel Antón-Rodrigálvarez, PHD; Elena Montes; Jesús J Burgos Flores, PH D; Gema De Blas, MD, PhD; Carlos Barrios; Eduardo Hevia, Dr; Carlos Correa; Rafael Lorente, PhD; Daniel Jiménez; Ignacio Regidor, MD, PhD

9:26 - 9:35 **Discussion**

9:36 - 9:40 **Paper #43**

Complications of Posterior Vertebral Column Resection in Children with Severe Spinal Deformity - A Single Center Experience

Firoz Miyanji, MD, FRCSC; Arjun Dhawale; Bronwyn Slobogean; Christopher Reilly

9:40 - 9:44 **Paper #44***

Vertebral Column Resection for Pediatric Spinal Deformity. A Population Based, Multicenter, Retrospective Follow-Up Study

Ilkka Helenius, MD, PhD; Olli T. Pajulo, MD, PhD

9:44 - 9:48 **Paper #45**

Youth and Experience: The Effect of Surgeon Experience on Outcomes in AIS Surgery

Patrick J. Cahill, MD; Amer F. Samdani, MD; Joshua M. Pahys, MD; Megan Gresh, MD; Burt Yaszay, MD; Michelle C. Marks, PT, MA; Tracey Bastrom, MA; Baron S. Lonner; Suken A. Shah, MD; Harry L. Shufflebarger, MD; Peter O. Newton, MD; Randal R. Betz, MD

9:48 - 9:52 **Paper #46**

Effect of Spine Fellow Development on Operative Time and Complication Rate

Qusai Hammouri, MD; Jamie S. Terran, BS; Baron S. Lonner; Thomas Errico

9:52 - 10:04 **Discussion**

10:04 - 10:09 **2011 Research Grant Presentations**

10:04 - 10:24 **BREAK**

* Hibbs Award Nominee for Best Clinical Presentation † Hibbs Award Nominee for Best Basic Science Presentation

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SCIENTIFIC PROGRAM

FRIDAY, SEPTEMBER 16, 2011 (continued...)

Session IV – Early Onset Scoliosis / Neurofibromatosis
Moderators: Muharrem Yaczici, MD and Behrooz Akbarnia, MD

10:24 - 10:28 Paper #47
The Effect of Early Fusion at Ten Years or Earlier for Early Onset Scoliosis - Comparison Between 43 Early Fusion Patients and 39 Growing Rod Patients
Koki Uno, MD, PhD; Teppei Suzuki; Noriaki Kawakami, MD; Taichi Tsuji; Morio Matsumoto, MD; Kota Watanabe; Katsushi Takeshita; Manabu Ito, MD, PhD; Hiroshi Taneichi, MD; Toru Hirano; Haruhisa Yanagida, MD; Ken Yamazaki, MD; Takuya Yamamoto; Shiro Imagama, MD; Shohei Minami

10:28 - 10:32 Paper #48
Proximal Junctional Kyphosis in Distraction-Based Growing Rods
Christopher Lee, BS; Karen S. Myung, MD, PhD; David L. Skaggs, MD

10:32 - 10:36 Paper #49
Psychosocial Effects Of Repetitive Surgeries In Children With Early Onset Scoliosis: Are We Putting Them At Risk?
David P. Roye, MD; Hiroko Matsumoto, MA; Jacqueline Corona, MD; Brendan A. Williams, AB; Benjamin D. Roye, MD, MPH; Michael G. Vitale, MD, MPH

10:36 - 10:45 Discussion

10:46 - 10:50 Paper #50
Serial Casting as a Delay Tactic in the Treatment of Moderate to Severe Early Onset Scoliosis
Nicholas Fletcher, MD; Anna McClung, RN; Karl E. Rathjen, MD; Richard H. Browne, PhD; Charles E. Johnston, MD

10:50 - 10:54 Paper #51
Radiographic Analysis of Progression in Congenital Scoliosis with Rib Anomalies During Growth Period
Noriaki Kawakami, M D; Taichi Tsuji, MD; Haruhisa Yanagida, MD; Koki Uno, MD, PhD; Morio Matsumoto, MD; Kota Watanabe; Takuya Yamamoto; Toru Hirano; Hiroshi Taneichi, MD; Ken Yamazaki, MD; Kenta Fujiwara

10:54 - 10:58 Paper #52
The Effect of Pedicle Screw Insertion on Pedicle and Canal Development in Young Children
Z Deniz Olgun, MD; H Gokhan Demirkiran, MD; Mehmet Ayvaz, MD; Muharrem Yazici, MD

10:58 - 11:07 Discussion

11:08 - 11:12 Paper #53
Growing Rods in Early Onset Scoliosis with Neurofibromatosis Type 1 (NF1)
Viral Jain; Abhishek Ray, MD; Alvin H. Crawford, MD; John B. Emans, MD; Paul Sponseller; Growing Spine Study Group

11:12 - 11:16 Paper #54
NF1 and Idiopathic Scoliosis: Potential Common Genetic Variants
Kandice Swindle; Cristina M. Justice, PhD; Alok Patel, BS; Nancy H. Miller, MD

11:16 - 11:20 Paper #55
All Pedicle Screw Instrumentation for Scoliosis Correction in Neurofibromatosis. Is it Worth It?
Wael Koptan, MD; Yasser ElMiligui, MD, FRCS; Mohammad M. El-Sharkawi, MD; Fady S. Shafik; AbdElMohsen Arafa

11:20 - 11:29 Discussion

11:30 - 11:35 2012 IMAST Preview

11:35 - 11:40 2012 Annual Meeting Preview

11:40 - 11:45 Worldwide Conferences Preview

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FRIDAY, SEPTEMBER 16, 2011 (continued...)

11:45 - 11:55 **Introduction of President**
B. Stephens Richards, III, MD

11:55 - 12:25 **Presidential Address**
Lawrence G. Lenke, MD

12:25 - 1:25 **Lunch**

Session V – Neuromuscular / Kyphosis / Innovative Techniques
Moderators: Reinhard D. Zeller, MD and James O. Sanders, MD

1:25 - 1:29 **Paper #56**
Early Failure of Pelvic Fixation in Neuromuscular Scoliosis
Karen S. Myung, MD, PhD; Christopher Lee, BS; David L. Skaggs, MD

1:29 - 1:33 **Paper #57**
Outcome of Operative Treatment for Spinal Deformity in Patients with Syringomyelia: A Comparison Study to AIS Patients
Daniel J. Sucato, MD, MS; Anna McClung, RN; Zoel G. Allen

1:33 - 1:37 **Paper #58**
Results of Surgical Treatment of Spine Deformities in Patients with Spinal Muscular Atrophy Type II and Type III
Tomasz Potaczek, MD; Daniel Zarzycki, MD, PhD

1:37 - 1:41 **Paper #59**
The Prevalence of Scoliosis and Kyphosis in Achondroplasia: A Ten Year Tertiary Referral Center Experience
Haleh Badkoobehi, MD; Mary T. Yost, BSN; Michael C. Ain, MD

1:41 - 1:53 **Discussion**

1:54 - 1:58 **Paper #60**
Spinal Cord Monitoring During Scoliosis Surgery in Children with Spastic Cerebral Palsy: Is it Feasible and Safe Even with an Active Seizure Disorder?
Suken A. Shah, MD; Cheryl R. Wiggins, AuD; Daniel M. Schwartz, PhD; Anthony K. Sestokas, PhD; Kenneth J. Rogers, PhD; Peter G. Gabos, MD; Kirk W. Dabney, MD; Freeman Miller, MD

1:58 - 2:02 **Paper #61**
Changes in Health Related Quality of Life (HRQL) after Spinal Fusion and Scoliosis Correction in Patients with Cerebral Palsy
Kan Min, MD; Christina Bohtz, MD; Andreas Meyer-Heim, MD

2:02 - 2:06 **Paper #62**
The CPCHILD Questionnaire is Sensitive to Change Following Scoliosis Surgery in Children with Cerebral Palsy
Unni G. Narayanan, MBBS, MSc, FRCS(C); Paul Sponseller; Peter O. Newton, MD; Michelle C. Marks, PT, MA

2:06 - 2:15 **Discussion**

2:16 - 2:20 **Paper #63**
Comparing Meaningful Use: Paper-Based SRS-22 vs. Web-Based Diagnosis-Specific Spine Outcome Tools
Sarah P. Rogers, MPH; Todd A. Milbrandt, MD, MS; Vishwas R. Talwalkar, MD; Janet L. Walker, MD; Henry J. Iwinski, MD

2:20 - 2:24 **Paper #64**
Comparison of Femoral Ring Allograft to Structural Cages in Anterior Instrumentation in Adolescent Idiopathic Scoliosis
Todd A. Milbrandt, MD, MS; Joseph Stone, MD; Brian Blessinger, MD, MS; Hillard Spencer; Richard E. Bowen, MD; Anthony A. Scaduto, MD; Vishwas R. Talwalkar, MD; Henry J. Iwinski, MD

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FRIDAY, SEPTEMBER 16, 2011 (continued...)

2:24 - 2:28 Paper #65
Anterior Short Spinal Fusion in the Treatment of Adolescent Idiopathic Scoliosis - Retrospective Review of 250 Consecutive Patients with Seven Years Follow-Up
Daniel Zarzycki, MD, PhD; Tomasz Potaczek, MD; Robert W. Gaines, MD

2:28 - 2:37 Discussion

Moderators: Michael G. Vitale, MD and Carlos A. Tello, MD

2:38 - 2:42 Paper #66
Maintaining Thoracic Kyphosis in Thoracic AIS Correction When Derotation is Performed
Satoru Demura, MD; Burt Yaszay, MD; Joseph H. Carreau, MD; Tracey Bastrom, MA; Peter O. Newton, MD

2:42 - 2:46 Paper #67
Anterior Release Generates More Thoracic Rotation than Ponte Osteotomy: A Biomechanical Study of Human Cadaver Spines
Adam L. Wollowick, MD; Erin Farrelly, MD; Kathleen N. Meyers, MS; Terry D. Amaral, MD; Seth A. Grossman, MD; Timothy Wright, PhD; Vishal Sarwahi, MD

2:46 - 2:52 Discussion

2:53 - 2:57 Paper #68
Minimally Invasive Surgery for AIS: A Prospective Comparison with Standard Open Posterior Surgery
Firoz Miyanji, MD, FRCSC; Amer F. Samdani, MD; Michelle C. Marks, PT, MA; Peter O. Newton, MD

2:57 - 3:01 Paper #69
Minimally Invasive Surgery in Patients with Adolescent Idiopathic Scoliosis: Is it any Better than the Standard Approach?
Adam L. Wollowick, MD; Terry D. Amaral, MD; Jonathan J. Horn; Etan P. Sugarman, MSIV; Melanie Gambassi, NP; Vishal Sarwahi, MD

3:01 - 3:07 Discussion

3:08 - 3:12 Paper #70
MRI Screening in Operative Scheuermann's Kyphosis: Is it Necessary?
Baron S. Lonner; Jamie S. Terran, BS; Peter O. Newton, MD; Suken A. Shah, MD; Amer F. Samdani, MD; Paul Sponseller; Harry L. Shufflebarger, MD; Randal R. Betz, MD

3:12 - 3:16 Paper #71
Scheuermann's Kyphosis: Impact on Quality of Life in 86 Patients
Baron S. Lonner; Peter O. Newton, MD; Jamie S. Terran, BS; Randal R. Betz, MD; Paul Sponseller; Suken A. Shah, MD; Amer F. Samdani, MD; Harry L. Shufflebarger, MD

3:16 - 3:20 Paper #72
One-Stage Posterior Approach and Combined Interbody and Posterior Fusion for Thoracolumbar Spinal Tuberculosis with Kyphosis in Children
Hongqi Zhang, MD; Yuxiang Wang, MD; Chaofeng Guo

3:20 - 3:24 Paper #73
How to Determine Optimal Fusion Levels of Scheuermann's Kyphosis
Yuan Ning; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Linda Koester, BS

3:24 - 3:36 Discussion

3:36 - 3:56 Break

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SCIENTIFIC PROGRAM

FRIDAY, SEPTEMBER 16, 2011 (continued...)

Session VI - Spondylolisthesis / Tumor / Basic Science
Moderators: Mark Wiedenbaum, MD and Jacob M. Buchowski, MD, MS

3:56 - 4:00 **Paper #74**
The Evolution of the Surgical Treatment of High-Grade Adolescent Isthmic Spondylolisthesis: Successes and Failures. A Single Center 50 Year Experience
Tenner J. Guillaume, MD; Joseph H. Perra, MD; John Lonstein; Robert B. Winter, MD

4:00 - 4:04 **Paper #75**
Sagittal Global Balance and Health-Related Quality of Life in Lumbosacral Spondylolisthesis
Adil Harroud; Jean-Marc Mac-Thiong, MD, PhD; Julie Joncas; Hubert Labelle, MD

4:04 - 4:08 **Paper #76**
Single Stage Reduction and Unilateral Transforaminal Lumbar Interbody Fusion for High Grade Isthmic Spondylolisthesis
Yasser ElMiligui, MD, FRCS; Wael Koptan, MD; Mohammad M. El-Sharkawi, MD; AbdElMohsen Arafa

4:08 - 4:12 **Paper #77**
High-Grade Spondylolisthesis – Twenty-Year Experience at One Institution
Ali Al-Omari; Scott McKay; Lauren A. Tomlinson, BS; David A. Spiegel, MD; John P. Dormans, MD

4:12 - 4:24 **Discussion**

4:25 - 4:29 **Paper #78**
Predictive Value of Tokuhashi Scoring Systems in Spinal Metastases, Focusing on Various Primary Tumor Groups: Evaluation of 448 Patients in the Aarhus Spinal Metastases Database
Miao Wang, MD; Cody E. Bunger; Ebbe S. Hansen, MD, DMSc

4:29 - 4:33 **Paper #79**
Axial Ewing's Sarcoma Family of Tumors Carry a Significantly Less Favorable Prognosis as Compared With Non-Axial locations. A Population Based Study in Finland in 1990-2009
Joni Serlo; Ilkka Helenius, MD, PhD; Mika Sampo; Maija Tarkkanen

4:33 - 4:39 **Discussion**

Moderators: James W. Ogilvie, MD and John R. Dimar, II, MD

4:40 - 4:44 **Paper #80†**
A Genome Wide Association Study Identifies IL17RC as an Adolescent Idiopathic Scoliosis Locus
John P. Dormans, MD; Struan F. Grant, PhD; Norma Rendon Sampson, MS; Rosetta Chiavacci, BSN; Hakon Hakonarson

4:44 - 4:48 **Paper #81†**
Candidate Genes for Susceptibility of Adolescent Idiopathic Scoliosis Identified Through a Large Genome-Wide Association Study
Lesa M. Nelson, BS; Rakesh Chettier, MS; James W. Ogilvie, MD; Kenneth Ward, MD

4:48 - 4:54 **Discussion**

4:55 - 4:59 **Paper #82†**
Functional Assessment of Acute Local vs. Distal Transplantation of Human Neural Stem Cells Following Spinal Cord Injury
Robert E. Mayle, MD; Robert L. Smith, PhD; Ian Corcoran-Schwartz; Karthikeyan Ponnusamy; Glen Kajiyama, BA; Rayshad Oshtory, MD, MBA; Don Y. Park, MD; Ivan Cheng, MD

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SCIENTIFIC PROGRAM

FRIDAY, SEPTEMBER 16, 2011 (continued...)

4:59 - 5:03 **Paper #83†**
Is the Abnormal Melatonin Receptor Expression in Girls with Adolescent Idiopathic Scoliosis a Quantitative Change?
Annie Po Yee Yim, MSc; Guang-quan Sun; Hiu Yan Yeung, PhD; Kwong Man Lee; Bobby KW Ng, MD; Yong Qiu; Jack C. Cheng, MD

5:03 - 5:07 **Paper #84†**
Generalized Gi Protein-Mediated Signal Transduction Impairment Occurs in Patients with Adolescent Idiopathic Scoliosis
Alain Moreau, PhD; Marie-Yvonne Akoume, PhD; Anita Franco, MSc

5:07 - 5:16 **Discussion**

Adjourn

SATURDAY, SEPTEMBER 17, 2011

Session VII – Adolescent / Outcomes / Congenital Scoliosis
Moderators: Oheneba Boachie-Adjei, MD and Laurel C. Blakemore, MD

7:55 - 8:00 **Welcome & Announcements**

8:00 - 8:04 **Paper #85**
Lenke 1C and 5C Spinal Deformities Fused Selectively - A Natural History of Uninstrumented Compensatory Curves
Ryan M. Ilgenfritz, MD; Burt Yaszay, MD; Tracey Bastrom, MA; Peter O. Newton, MD; Harms Study Group

8:04 - 8:08 **Paper #86**
Lumbar Spine is Stable after Selective Thoracic Fusion for Adolescent Idiopathic Scoliosis: A 20-Year Follow-Up
A. Noelle Larson, MD; Nicholas Fletcher, MD; B. Stephens Richards, MD

8:08 - 8:12 **Paper #87**
Is there a Better Alternative to a Randomized Control Design for Assessing the Efficacy and Effectiveness of Bracing in AIS?
Daniel Y. Fong, PhD; Kenneth M. Cheung, MD; Yatwa Wong; Wai Yuen Cheung, MD; Idy C. Fu; Evelyn E. Kuong; Kin C. Mak, MBBS, FRCS; Michael To, FRCSEd (Ortho); FHKCOS; FHKAM (Ortho); Keith D. Luk, MD

8:12 - 8:21 **Discussion**

8:22 - 8:26 **Paper #88**
Optimal Lowest Instrumented Vertebra to Avoid Adding-On or Distal Junctional Kyphosis for Thoracic Adolescent Idiopathic Scoliosis
Yongjung J. Kim, MD; Charla R. Fischer, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Oheneba Boachie-Adjei, MD; Jean-Luc Clement, MD; Munish C. Gupta, MD

8:26 - 8:30 **Paper #89**
Distal Adding-On Phenomenon in Lenke 1A Scoliosis: Risk Factor Identification and Treatment Strategy Comparison
Yu Wang, MD, PHD; Cody E. Bunger

8:30 - 8:34 **Paper #90**
Spinal Deformity in Marfan vs. AIS: Learning from the Differences
Joseph Gjolaj, MD; Paul Sponseller, MD; Suken A. Shah, MD; Peter O. Newton, MD; Michelle C. Marks, PT, MA; Tracey Bastrom, MA; John M. Flynn, MD; Baron S. Lonner; MD; Amer F. Samdani, MD

8:34 - 8:43 **Discussion**

8:44 - 8:48 **Paper #91**
Results for a Randomized Prospective Study Comparing Thoracic Screws vs. Thoracic Hooks for Fixation in Adolescent Scoliosis (AS)
Lawrence L. Haber, MD; Joshua D. Hughes; Erika Womack, MSc

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SCIENTIFIC PROGRAM

SATURDAY, SEPTEMBER 17, 2011 (continued...)

8:48 - 8:52 Paper #92
Five Year Results for Lenke 1 or 2 Curves: Comparison of Anterior, Posterior Hybrid, and Posterior All Pedicle Screws
Amer F. Samdani, MD; Hitesh Garg, MD; Patrick J. Cahill, MD; Michelle C. Marks, PT, MA; Tracey Bastrom, MA; David H. Clements, MD; Suken A. Shah, MD; Harry L. Shufflebarger, MD; Randal R. Betz, MD; Peter O. Newton, MD

8:52 - 8:56 Paper #93
Predictors of Long-Term SRS Total Scores in Patients with Adolescent Idiopathic Scoliosis Treated Surgically
Leah Y. Carreon, MD, MSc; Jonathon M. Spanyer, MD; Steven D. Glassman, MD; Chelsea E. Canan, BA; Lauren O. Burke, BS; Charles H. Crawford, MD

8:56 - 9:05 Discussion

Moderators: Marinus deKleuver, MD and Peter O. Newton, MD

9:06 - 9:10 Paper #94
Fusion Material vs. Outcome after Primary Posterior Spine Fusion with Instrumentation for Adolescent Idiopathic Scoliosis
Mohammad Diab; Tracy Lin; John P. Lubicky, MD

9:10 - 9:14 Paper #95
Ten Year Outcome of Patients Following Initial AIS Surgery: A Comparison of Single Surgery and Revision Surgery Patients
Daniel J. Sucato, MD, MS; Anna McClung, RN; Neil Saran, MD, MHSc, FRCSC; Dinesh Thawrani, MD; Sumeet Garg, MD; Jonathan R. Schiller, MD

9:14 - 9:18 Paper #96
The Effects on the Lumbar Disc Degeneration of Spinal Fusion for Scoliosis Patients - A Minimum Ten-Year Follow-Up
Ayato Nohara; Noriaki Kawakami, MD; Kenji Seki, MD, PhD; Kazuyoshi MIyasaka, MD; Taichi Tsuji, MD; Tetsuya Ohara; Toshiki Saito; Michiyoshi Sato; Kazuki Kawakami

9:18 - 9:27 Discussion

9:28 - 9:32 Paper #97
CT Evaluation of Vertebral Rotation Correction in Posterior Fusion for Thoracic Adolescent Idiopathic Scoliosis: Direct Derotation vs. Concave Rod Rotation
Mario Di Silvestre, MD; Francesco Lolli; Georgios Bakaloudis; Konstantinos Martikos; Francesco Vommaro; Elena Maredi

9:32 Paper #98 — WITHDRAWN

9:32 - 9:36 Paper #99
Corrective Tethering for Scoliotic Deformity: Impact on Growth Plate Histology and Vertebral Dysplasia in an Established Porcine Model
Allen Leung, MD; Frank Schwab, MD; Benjamin Ungar; Ashish Patel, MD; Edward Chay; Bertrand Moal, MS; Jean-Pierre C. Farcy, MD; Virginie Lafage, PhD

9:36 - 9:42 Discussion

9:43 - 9:47 Paper #100
Sagittal Balance in Thoracolumbar or Lumbar Congenital Spinal Deformity with a Minimum Ten-Year Follow-Up After Surgery
Teppei Suzuki; Koki Uno, MD, PhD; Hiroshi Miyamoto, MD; Yoshihiro Inui; Noriaki Kawakami, MD; Taichi Tsuji, MD

9:47 - 9:51 Paper#101
Comparative Analysis of Pedicle Screw Fixation Only vs. Osteotomy with Pedicle Screw Fixation in Congenital Scoliosis - More than Five Years Follow-Up
Se-Il Suk, MD; Jin-Hyok Kim; Dong-Ju Lim; Seung-Hyun Choi; Jae-Min Jeon, fellow; Sung-Soo Kim, MD

9:51 - 9:55 Paper #102
Long-Term Clinical Outcomes of Surgical Treatment for Non-Idiopathic vs. Idiopathic Scoliosis: Minimum 21-Years Follow-Up
Tomu Akazawa, MD; Shohei Minami; Toshiaki Kotani, MD, PhD; Kazuhisa Takahashi

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SCIENTIFIC PROGRAM

SATURDAY, SEPTEMBER 17, 2011 (continued...)

9:55 - 9:59 Paper #103
Congenital Scoliosis: A Single Institution Experience with Long-Term Follow-Up
Daniel J. Sucato, MD, MS; Anna McClung, RN; James Shaha; Andrew S. Matthys, BA in Biology; Neil Saran, MD, MHSc, FRCSC

9:59 - 10:11 Discussion

10:12 - 10:32 Awards Presentation
Russell A. Hibbs Awards
Louis A. Goldstein Awards
John H. Moe Award
Lifetime Achievement Awards

10:32 - 10:50 Transfer of Presidency

10:50 - 11:10 BREAK

SESSION VIII – Basic Science / Adult / Miscellaneous
Moderators: Christopher I. Shaffrey, MD and Mark B. Dekutoski, MD

11:10 - 11:14 Paper #104
Effect of Root Section and Induced Hypotension on Spinal Cord Displacement Limits During Spine Surgery. Experimental Study in Pigs
Gabriel Piza Vallespir, MD, PhD; Carlos Barrios; Jesús J Burgos Flores, PhD; Elena Montes; Gema De Blas, MD, PhD; Carlos Correa; Cesar Perez-Caballero; Fernando Dominguez; Jorge Collazos, MD, PhD; Ignacio Regidor, MD, PhD; Eduardo Hevia, Dr; Alberto Caballero, MD; Ignacio Sanpera, MD PhD

11:14 - 11:18 Paper #105
Post-Operative Hyperalgesia and Nerve Root Inflammation Following Posterolateral Arthrodesis with rhBMP-2. An In Vivo Rat Study
Anton E. Dmitriev, PhD; Lyubov Tsytsikova, BSc; Rachel E. Gaume, BS; Ronald A. Lehman, MD; Aviva Symes

11:18 - 11:22 Paper #106
Treatment of Chronic Spinal Cord Injury with Skin-Derived Precursors Differentiated into Schwann Cells (SKP-SCs) Promotes Axonal Regeneration and Functional Recovery
Peggy Assinck; Shaalee Dworski; Joe Sparling, Master; Di Leo Wu; Gregory J. Duncan, BSC; Jie Liu, MD; Brian K. Kwon, MD, PhD, FRCSC; Wolfram Tetzlaff, MD PhD

11:22 - 11:32 Discussion

11:32 - 11:36 Paper #107
The Study Concomitance of Cervical Myelopathy and Scoliosis: A PearlDiver Study
Chang Hwa Hong; Steven Takemoto, PhD; Benjamin Young, BS; Michael H. Weber, MD, PhD; Serena S. Hu, MD

11:36 - 11:40 Paper #108
Preoperative Vitamin D Deficiency in Adults Undergoing Spinal Deformity Surgery
Geoffrey E. Stoker, BS; Jacob M. Buchowski, MD, MS; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Lukas P. Zebala, MD

11:40 - 11:44 Paper #109
The Effect of Body Mass Index on Adult Idiopathic Scoliosis Patients Older than 30 Years
Ming Li; Zi-Qiang Chen, MD, Xiaodong Zhu

11:44 - 11:53 Discussion

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SCIENTIFIC PROGRAM

SATURDAY, SEPTEMBER 17, 2011 (continued...)

Moderators: Kamal N. Ibrahim, MD, FRCS(C), MA and Kenneth MC Cheung, MD

11:54 - 11:58 Paper #110

Can We Predict Post-Operative Functional Improvement Based On Preoperative Health-Related Quality Of Life Scores In Patients Undergoing Spine Surgery?

Siddharth B. Joglekar; Kimberly Heckmann, BSN; Amir A. Mehbod, MD; Ensor E. Transfeldt, MD; Robert B. Winter, MD

11:58 - 12:02 Paper #111

High Dose Tranexamic Acid Reduces Blood Loss in Complex Pediatric Spine Deformity Surgery

Ra'Kerry K. Rahman, MD; Woo-Kie Min, MD, PhD; Yutaka Nakamura, MD, PhD; Lukas P. Zebala, MD; Brenda A. Sides, MA; Keith H. Bridwell, MD; Lawrence G. Lenke, MD

12:02 - 12:06 Paper #112

The Use of Antifibrinolytics Substantially Reduces Blood Loss During Surgery for Cerebral Palsy Scoliosis

Suken A. Shah, MD; Arun Dhawale; Paul Sponseller; Tracey Bastrom, MA; Geraldine I. Neiss, PhD; Petya Yorgova; Peter O. Newton, MD; Burt Yaszay, MD; Harry L. Shufflebarger, MD; Peter G. Gabos, MD; Kirk W. Dabney, MD; Freeman Miller, MD; Harms Study Group

12:06 - 12:15 Discussion

12:16 - 12:20 Paper #113

Cement Augmented Pedicle Screw Fixation In Osteopenic Patients: Minimum Two-Year Follow-Up Of 1454 Pedicle Screws

Cagatay Ozturk, MD; Ahmet Alanay; Meric Enercan; Selhan Karadereler; Mehmet Tezer; Azmi Hamzaoglu, MD

12:20 - 12:24 Paper #114

Analysis of Direct Cost for Four Diagnostic Categories of Adult Spinal Deformity (ASD)

Michael F. Obrien, MD; Richard Hostin, MD; Chantelle Freeman, BS; Neil Fleming, PhD; Gerald Ogola, MS; Rustam Kudyakov, MD, MPH; Kathleen M. Richter, MS, MFA, ELS; Jay T. deVenny, MBA; Nanette Myers, MBA; Christopher P. Ames, MD; Sigurd H. Berven, MD; International Spine Study Group

12:24 - 12:28 Paper #115

Risk Factors and Natural Course of de Novo Degenerative Lumbar Scoliosis in a Community-Based Cohort: The Miyama Study

Shunji Tsutsui; Atsunori Watanuki; Hiroshi Yamada; Keiji Nagata; Yuyu Ishimoto; Yoshio Enyo; Noriko Yoshimura; Munehito Yoshida

12:28 - 12:32 Paper#116

Can Patients Reliably Work Long-Term after Fusion for Adult Deformity?

Dennis Crandall, MD; Kenneth Schmidt, MD; Jan Revella, RN; Michael S. Chang, MD; Jason Datta, MD; Terrence Crowder, MD; Dustin Revella, BA; Ryan McLemore, PhD

12:32 - 12:44 Discussion

Adjourn

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PODIUM PRESENTATION ABSTRACTS

PAPER #1

Preoperative Autologous Blood Donation Results in More Transfusions in the Surgical Treatment of Adolescent Idiopathic Scoliosis

Lukas P. Zebala, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Jacob M. Buchowski, MD, MS; Brenda A. Sides, MA

USA

Summary: 81% of PABD patients received a perioperative transfusion compared to 41% of NPABD patients. Thinner patients were more likely to receive a transfusion. PABD significantly reduced preoperative hematocrit and a lower preoperative hematocrit and PABD correlated with increased transfusions. At a given hematocrit, PABD patients had a greater chance of receiving a transfusion than NPABD patients. Wasted units of donated blood correlated with increased number of PABD units.

Introduction: Preoperative autologous blood donation (PABD) overuse in adolescent idiopathic scoliosis (AIS) surgery increases morbidity and health-care cost. Our purpose was to evaluate the outcomes of PABD in AIS surgery.

Methods: We prospectively enrolled 86 single-center AIS fusion patients from 2006-2010. Patients were divided into PABD (n=32) or no donation (NPABD, n=54)) as chosen by parents. Variables analyzed included demographic, radiographic, surgical and postop data, # PABD units, preop/postop hematocrit (Hct), and # intraop/postop transfusion units. Wasted PABD was calculated (PABD units - autologous units transfused). Continuous (t-test/Wilcoxon rank test) and categorical (Fischer's exact/chi-square) data were analyzed. Univariate/multivariate logistic regressions were run. 28 PABD/NPABD pairs were matched on preop Hct (within 1 unit) to assess (McNemar's test) if PABD patients are transfused at a higher Hct.

Results: Baseline data was similar between groups (Table 1). More PABD than NPABD patients received intraop (56% vs 33%, p=0.04), postop (56% vs 15%, p<0.0001) and total (81% vs 41%, p=0.0003) transfusions. Transfusion was not related to age, gender, ethnicity or height. Weight influenced transfusion as 40% of patients <56kg and only 20% > 56kg were transfused (p=0.04). Increased # PABD decreased preop Hct (r=-0.27, p=0.01). Univariate logistic regression revealed transfusion was related to preop Hct (OR=0.78, p=0.01), drain output (OR=1.1, p=0.02), # fusion levels (OR=1.4, p=0.01) and PABD (OR=7.4, p=0.0001). Multivariate logistic regression showed PABD (OR=7.7, p=0.001), lower preop Hct (OR=0.75, p=0.03) and # fusion levels (OR=1.6, p=0.003) increased transfusion. Independent predictors of transfusion were EBL (r=0.67, p<0.0001) and PABD (r=0.47, p<0.0001). In the matched analysis, PABD patients were more likely to have transfusion at a given preop (p=0.008) or postop Hct (p=0.005). # PABD units had a strong relationship with wasted PABD (r=0.76, p<0.0001).

Conclusion: PABD lowers baseline Hct and PABD patients are 7.7 times more likely to be transfused. Transfusion triggers differed between groups; PABD patients were more likely to get blood at a given Hct. More PABD was wasted with increased # PABD units.

PAPER #2*

A Randomized Prospective Evaluation of Three Techniques of Post-Operative Pain Management Following Posterior Spinal Instrumentation and Fusion

Joshua B. Klatt, MD; Christopher R. Miller, MD; Simon P. Durcan, MD; Jennie B. Mickelson, BS; Man Hung, PhD; John T. Smith, MD

USA

Summary: This is a Prospective Randomized study of pain management techniques following Posterior Spinal Instrumentation and Fusion of patients with Adolescent Idiopathic Scoliosis. The pain management techniques studied include a single continuous epidural analgesia, double continuous epidural analgesia, and intravenous patient-controlled analgesia.

Introduction: Pain management following posterior spinal Instrumentation and fusion (PSIF) for patients with adolescent idiopathic scoliosis (AIS) is often challenging. While intravenous patient-controlled analgesia (PCA) is used most commonly, continuous epidural analgesia (CEA) has been found to be safe and effective. Recently, the use of two epidural catheters has been thought to be more effective than a single catheter, although the efficacy of using two catheters has not been directly compared to a single catheter.

Methods: We conducted a prospective randomized study of 66 PSIF patients with AIS at our institution from 2009-2011. Patients were randomized into 3 groups prior to PSIF; PCA (n=22), Single CEA (n=22), and Double CEA (n=22). Preoperative data included demographics, Coronal Cobb angle, back pain, and narcotic use. Post-operatively, pain scores were collected using the Wong-Baker FACES Pain Rating Scale. Additionally, side effects, complications, and breakthrough medication were collected. Recovery times were also recorded, including hospitalization, times to first bowel movement, and days to walk and climb stairs. Growth curve modeling and Independent t-tests were used to determine the most effective pain management technique and analyze post-operative data. Four patients were withdrawn due to the inability to maintain the pain management protocol.

Results: Using an advanced statistical technique called growth curve modeling, we found the pain intensity was most effectively controlled with a Double CEA when compared with PCA (p<0.05 and a Single CEA (p<0.05). Pain control was equivalent in both the PCA and Single CEA groups (p> 0.05). The pain control with the fewest side effects trended toward the Single CEA, with an average of 2.55 side effects per patient.

Conclusion: These data document that the Double CEA most effectively controls post-op pain following surgery for AIS. The Single CEA trended towards having

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the fewest side effects when compared to the other techniques. Based on these findings, we now routinely use the double CEA technique for all patients having surgery for AIS.

PAPER #3

Intravenous Acetaminophen in Adolescents Undergoing Spine Surgery: A Double-Blind Randomized Clinical Trial

Arja Hiller, MD, PhD; Ilkka Helenius, MD, PhD; Elisa Nurmi, MD; Pertti J. Neuvonen, MD, PhD; Olli Meretoja, MD, PhD

Finland

Summary: Effect of intravenous acetaminophen on postoperative pain and opioid consumption was analyzed in adolescents undergoing major spine surgery. Intravenous acetaminophen adjuvant to oxycodone did not diminish oxycodone consumption but provided better analgesia during the first 24 hrs after surgery.

Introduction: Nonsteroidal antiinflammatory drugs have been shown to cause better analgesia and diminish the need for opioids, but may interfere spinal fusion. Acetaminophen has not been evaluated for postoperative pain in adolescents undergoing spine surgery.

Methods: We analyzed in a randomized, placebo controlled, double blind study the opioid consumption and analgesic efficacy of acetaminophen (A) in 35 adolescents of 10-18 yrs of age undergoing surgery for scoliosis (n=32; 13 pedicle screw in placebo (P), 10 in A; One hybrid in P and 7 in A; one anterior instrumentation in each group) or high-grade spondylolisthesis (n=3, all in A group). Primary outcome was oxycodone consumption. Acetaminophen 30 mg/kg iv or the same millilitre of 0.9% NaCl was administered at the end of surgery and thereafter eight hourly for 24 hrs. All patients received standard propofol-remifentanil-anaesthesia. Pain was evaluated by objective pain scale (OPS) every 10 min in the recovery room and by visual analogue scale (VAS) every hour for 24 hrs in the ward. The rescue medication was ocycodone 0.25 mg/kg given by patient controlled (PCA) device. If VAS was ≥ 6, intravenous oxycodone 0.05 mg/kg or parecoxib was given. All patients had a minimum two year follow-up.

Results: Main curve averaged 60 (50-78) deg preoperatively and 18 (9-28) deg at 2-year follow-up with no differences in curve correction or blood loss between groups. No major complications occurred in either group. Oxycodone consumption during 24-hrs was 1.34±0.40mg/kg in the A group and 1.38±0.33 mg/kg in the P group(NS). In the ward the number of patients with VAS≥6 was significantly higher in the P group compared with A group (13/18 vs 6/16) ($p<0.05$). There were also significantly more hours with VAS≥6 in the P group compared with A group (45/126 vs 20/131) ($p<0.01$). 16/18 children in the P group and 8/16 children in the A group needed rescue medication ($p<0.01$).

Conclusion: Intravenous acetaminophen adjuvant to oxycodone did not diminish oxycodone consumption after spine surgery but provided better analgesia during 24 hrs after surgery.

Significance: Intravenous acetaminophen (paracetamol) provides a signicant postoperative analgesia in adolescents undergoing spine surgery.

PAPER #4

Characteristics of Patients with Adolescent Idiopathic Scoliosis Who Experience Coronal Decompensation Following Posterior Spinal Instrumentation and Fusion

Jaime A. Gomez, MD; Hiroko Matsumoto, MA; Nicholas D. Colacchio, BA; Daniel J. Miller, BS; David P. Roye, MD; Daniel J. Sucato, MD, MS; B. Stephens Richards, MD; John B. Emans, MD; Mark A. Erickson, MD; James O. Sanders, MD; Lawrence G. Lenke, MD; Michael G. Vitale, MD, MPH

USA

Summary: Male gender, lower preoperative Risser grade, and lower percent major curve correction were significant predictors for higher incidence of coronal decompensation in adolescent idiopathic scoliosis (AIS) patients, 2 years following posterior spinal instrumentation and fusion (PSIF).

Introduction: Coronal decompensation is a potential complication of spinal instrumentation for AIS. This can result in problems requiring revision surgery. The purpose of this study is to investigate risk factors for coronal decompensation 2 years after PSIF for AIS.

Methods: Retrospective review of a large, multicenter dataset identified 890 patients with AIS and at least 2 years of follow up after PSIF. Demographic, clinical and radiographic measures were reviewed. Coronal decompensation was defined as a change farther away from midline (or horizontal) from 6 weeks to 2 years in any one of the following radiographic parameters: change in LIV Tilt Angle > 10°; change in Coronal Position of the LIV > 2 cm; change in Thoracic Trunk Shift > 2 cm; or change in Coronal Balance > 2 cm. Patients with decompensation were compared to those without. The relationship between the lowest instrumented vertebrae (LIV) and lowest end vertebra (LEV) was examined as an independent variable.

Results: 6.4% (57/890) of patients exhibited coronal decompensation at 2 years postop. Univariate analysis demonstrated that decompensated patients were more likely to be males, have lower preop Risser scores, a more cephalad LIV, and lower percent major curve correction (58.7 vs. 64%). Multivariate regression revealed that decompensated patients were twice as likely to be male, to have lower preop Risser score, and lower percent major curve correction. The relationship between the LIV and LEV was not significant.

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PODIUM PRESENTATION ABSTRACTS

Conclusion: AIS patients with male gender, low preoperative Risser score and smaller percent major curve correction following PSIF are more likely to exhibit coronal decompensation at 2 years postoperatively.

Significance: 6.4% of patients with AIS exhibit radiographic decompensation 2 years after PSIF. While this study did not demonstrate a significant association between the relationship of LIV and LEV and decompensation 2 years postoperatively, results of this study indicate that skeletal immaturity, male gender and less correction of the major curve may be related to higher rates of decompensation.

PAPER #5

Which Factors Influence Spontaneous Lumbar Curve Correction After Selective Thoracic Fusion In Lenke Type IB And C Curves?

Azmi Hamzaoglu, MD; Cagatay Ozturk, MD; Ahmet Alanay; Meric Enercan; Emre Karadeniz; Sinan Karaca

Turkey

Summary: Patients younger than age 14, with LIV being both stable and neutral, with lumbar curve flexibility more than 60%, with no sacral tilt, risser sign ≤ 2, preoperative lumbar curve magnitude of less than 45 degrees and apical vertebra translation of lumbar curve less than 2 cm. had more spontaneous lumbar curve correction rates after selective thoracic fusion.

Introduction: The aim of this retrospective study was to analyse Lenke type 1B and C curves treated by selective fusion by using PS and to determine the critical factors which may have influenced spontaneous correction in lumbar spine.

Methods: Between 1999 and 2009, 111 (100 female and 11 male) consecutive patients with Lenke type 1 B and C curves (44 B and 67 C modifier) who underwent selective thoracic fusion by using PS constructs were included. The rule for a safe amount of correction in main thoracic curve was not to correct more than the lumbar curve magnitude in the preoperative side bending x-ray. Preop, postop and follow-up x-ray images were evaluated in terms of curve magnitudes and flexibility, sacral tilt (more than 2°), lower instrumented vertebra (LIV), apical vertebra translation of lumbar curve and maturity.

Results: Average age at the time of surgery was 15 years (range; 11 to 19) and follow-up was 64 (range; 24 to 148) months. The fusion stopped at stable vertebra in 71 patients, at neutral vertebra in 29 patients and stable and neutral vertebra which were the same in 11 patients. Average correction rates at final follow-up for thoracic curve was 81% while it was 68% for lumbar curve. Spontaenous lumbar curve correction ratio was 75% versus 54% for lumbar curves with more or less than 60% flexibility; 76% versus 66% whether LIV being both stable and neutral or not; 72% versus 66% for curves with or without sacral tilt; 71% versus 66% for patients younger or older than 14 years of age; 70% versus 66% for risser grade less or more than 2, 68% versus 53% for lumber curves lesser or greater than 45 degrees and 71% versus 63% for apical vertebra translation of lumbar curve less or more than 2 cm. There was no coronal plane decompensation and imbalance in any of the patients and no reoperation.

Conclusion: Patients younger than age 14, with LIV being both stable and neutral, with lumbar curve flexibility more than 60%, with no sacral tilt, risser sign ≤ 2, preoperative lumbar curve magnitude of less than 45 degrees and apical vertebra translation of lumbar curve less than 2 cm. had more spontaneous lumbar curve correction rates after selective thoracic fusion ($p<0.05$).

Significance: -

PAPER #6

Is Decompensation Preoperatively a Risk in Lenke 1C Curves?

Satoru Demura, MD; Burt Yaszay, MD; Tracey Bastrom, MA; Joseph H. Carreau, MD; Peter O. Newton, MD; Harms Study Group

Japan

Summary: Preoperative coronal balance in Lenke 1C patients was skewed to the left. In the selective fusion group, 57% of the patients who were decompensated preoperatively still remained to the left at 2-year. Lower thoracic correction rate was a risk factor of postoperative decompensation. 31% of patients who were balanced preoperatively were decompensated to the left at 2-year.

Introduction: Selective thoracic fusion (STF) is the traditional treatment of Lenke 1C curves. However, there is concern for post-op coronal decompensation, particularly in patients initially decompensated to the left before surgery when treated selectively.

Methods: Lenke 1C patients prospectively collected from a multi-center study were analyzed. Pre-operatively, patients were further divided as decompensated (C7-CSVL >2cm) or neutral (C7-CSVL within 2cm either direction). Risk factors for postoperative coronal decompensation were sought.

Results: Seventy one patients (53 STF, 18 non-selective fusions) were included. Preoperatively coronal balance was skewed to the left (-18±14mm). Of the 21 STF decompensated to the left pre-operatively, twelve (57%) still remained to the left at 2-year follow-up. Postoperative thoracic correction was significantly better in those balanced post-operatively (57%) compared to those who remained decompensated (46%; $p< 0.05$). There were 32 STF who were balanced preoperatively, with 10 of these (31%) decompensated to the left at 2-year follow-up. This rate (31%) was significantly less than the group that was decompensated pre-operatively (57%, $p=0.04$). In the non-selective group, 16 out of 18 patients (89%) were balanced at 2 year follow-up, which was independent of preoperative balance.

Conclusion: On average, Lenke 1C patients tended to be decompensated to the left preoperatively. In those decompensated preoperatively who underwent a STF, the majority remained greater than 2cm to the left at 2 year follow-up. The

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frequency of decompensation to the left was roughly one-third for those with STF who were balanced preoperatively. Non-selectively treated (both thoracic and lumbar curves fused) patients had better coronal balance at 2 years than selectively treated patients. While not a contra-indication to performing a selective fusion, treating surgeons should be prepared for modest coronal decompensation in 40% of Lenke 1C patients treated selectively.

PAPER #7

Assessment of Proximal Junctional Kyphosis and Shoulder Balance with Proximal Screws vs. Hooks in Posterior Spinal Fusion for Adolescent Idiopathic Scoliosis

Joshua M. Pahys, MD; Amer F. Samdani, MD; Randal R. Betz, MD; Per D. Trobisch, MD; Hitesh Garg, MD; Peter O. Newton, MD; Michelle C. Marks, PT, MA; Tracey Bastrom, MA; Harms Study Group; Patrick J. Cahill, MD

USA

Summary: A large multicenter database review was performed (n=364) to evaluate the effect on proximal junctional kyphosis (PJK) and shoulder balance with the use of proximal hooks vs. screws in an otherwise all pedicle screw posterior spinal fusion (PSF) for adolescent idiopathic scoliosis (AIS). Proximal implant type did significantly affect shoulder asymmetry at 2 years. However, cases with proximal screws demonstrated a significant increase in PJK and decrease in thoracic kyphosis at 2 years compared to hooks.

Introduction: Less rigid forms of fixation at the top of constructs in degenerative lumbar PSF have been postulated to decrease the risk of PJK. This study evaluates a large series of patients to discern the effect of proximal hooks vs. screws on PJK as well as shoulder balance in otherwise all pedicle screw (>80%) PSF constructs in patients with AIS.

Methods: A multicenter AIS surgical database was reviewed to identify all patients who underwent instrumented PSF with all pedicle screw (>80%) constructs and minimum two-year follow-up. The "hook" group of patients had at least one or more hooks used at the top of the construct, compared to the "screw" group in which only pedicle screws were used.

Results: A total of 364 patients were identified, 274 (75%) in the screw group, and 90 (25%) in the hook group. There were no significant preoperative differences with regards to curve type, coronal/sagittal Cobb, and curve flexibility for either group. At two years post-op, the coronal Cobb correction was similar for both groups (60%). There was no difference in correction of shoulder asymmetry when the groups were matched for pre-op shoulder balance. However, in the sagittal plane, T5-T12 Cobb was significantly larger in the hook group ($p<0.001$), while T2-T12 ($p=0.024$) and T2-T5 ($p=0.055$) were larger in the screw group. PJK, defined as the sagittal Cobb between the uppermost instrumented and uninstrumented vertebrae, was significantly higher in the screw group ($p=0.027$). The screw group demonstrated a greater decrease in kyphosis from preop to 2 years postop at T2-T12 ($p<0.001$) and T5-T12 ($p<0.001$). Table 1

Conclusion: This is the largest study to date to evaluate the impact of the type of implant used at the top of an all pedicle screw construct for PSF in AIS. Pedicle screws at the top of a PSF construct lead to a decrease in thoracic kyphosis and an increase in PJK. Hook fixation at the top of a scoliosis construct may protect against PJK. Proximal implant type did not have any bearing on correction of shoulder asymmetry.

PAPER #8

Clinical, Radiographic and Patient Assessment of Shoulder Imbalance Following Thoracic Adolescent Idiopathic Scoliosis (AIS) Reconstruction

Jeremy J. Stallbaumer, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Christine Baldus, RN, MHS; Linda Koester, BS

USA

Summary: Shoulder balance was studied in 90 consecutive AIS patients (pts). Of 8 unbalanced postop (PO), 4 double thoracic curves had left shoulder elevation (75% main thoracic (MT) correction). 4 selective thoracic fusions (lumbar "C" curves) had persistent right elevation. Right elevation is opportunity for aggressive MT correction but selective thoracic fusion must balance overcorrecting MT relative to lumbar C. Consider less MT correction with balanced preop (PRE) and structural proximal thoracic (PT) curve. Patients with balanced shoulders had better SRS outcomes.

Introduction: The purpose of this study was to determine prevalence of shoulder imbalance and variables that influence PO outcomes through analysis of prospectively collected surgical outcomes in thoracic AIS pts.

Methods: Shoulder balance was studied in 90 consecutive pts, one institution, with AIS and MT curve (apex T7-T9) (58 degrees +/- 13). PRE and PO, 2 independent observers measured shoulder height clinically, subtracting vertical distance between horizontal lines placed at highest point of each shoulder. 4 groups were analyzed, categorized as unbalanced if shoulder >2cm higher than the other. Group 1 (n=63) balanced shoulders PRE/ PO. Group 2 (n=19) unbalanced PRE but balanced PO. Group 3 (n=4) unbalanced PRE/PO. Group 4 (n=4) balanced PRE and unbalanced PO. PT, MT and thoracolumbar upright and flexibility measurements assessed PRE and at 2 yr minimum follow-up (2.2 yrs, range 2.0-3.7). We measured T1 tilt, clavicle angle, upper and lower instrumented vertebrae; the SRS-30 pt scores.

Results: 82/90 (91%) pts had level shoulders PO. Of 8 (9%) unbalanced, 4 were level PRE with left elevation PO. All 4 had structural PT curves and underwent 75% +/- 5 MT correction. Proximal instrumentation was T2 or T3. 4 additional pts had right elevation PRE that persisted PO, but improved PRE to PO (not below 2 cm cutoff). This group had lumbar C curves and selective

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PODIUM PRESENTATION ABSTRACTS

MT fusion. MT correction averaged 46% +/- 9. There was difference between groups 3 and 4 MT Cobb change (P=0.029). PO balanced SRS self-image (SI) improved (3.428 PRE vs. 4.438 PO, P=0.000). Compared to PO balanced, unbalanced PO had inferior 2 yr SI scores (3.250 PRE vs. 3.825 PO, P=0.016).

Conclusion: Right shoulder elevation PRE is opportunity for aggressive MT correction. In pts with lumbar C undergoing selective thoracic fusion, this must be weighed against overcorrecting the MT curve relative to the lumbar C. With balanced shoulders PRE and structural PT curve, accepting less correction of the MT (<75%), should be considered. No patient had elevated left shoulder PRE that persisted PO. Patients with balanced shoulders had better SRS outcome scores.

PAPER #9

Should Shoulder Balance Determine Proximal Fusion Levels in Patients with Lenke 5 Curves?

Burt Yaszay, MD; Tracey Bastrom, MA; Peter O. Newton, MD; Harms Study Group

USA

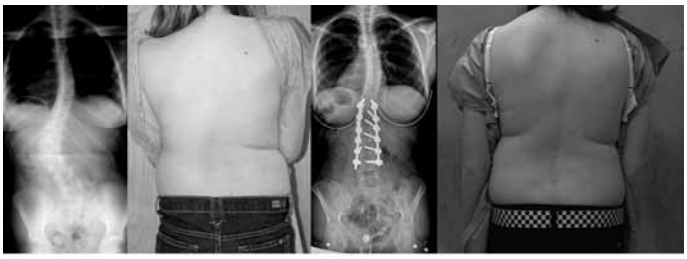
Summary: It is unclear in the literature whether shoulder balance should influence the decision making in Lenke 5 curves. While having a larger thoracic curve increases the risk of having pre-op a high opposite shoulder (right shoulder, left thoracolumbar curve), inclusion of the thoracic curve does not appear to influence post-op shoulder outcome.

Introduction: A high left shoulder is an indication to extend the fusion proximally in a right thoracic curve. Some apply these same rules to high right shoulders in patients with left thoracolumbar/lumbar curves. The purpose of this study was to indentify the frequency of an opposite high shoulder in Lenke 5 patients, and evaluate the factors that influence shoulder balance both pre-op and post-op.

Methods: A prospective multi-center AIS database was queried for patients with Lenke 5 curves and a minimum of 2 yr follow-up. Pre-op and post-op shoulder height differences were recorded and categorized by the opposite shoulder (right shoulder high in a left thoracolumbar curve) as high (>1cm), level (within 1 cm), low (>1cm). Pre-op and post-op radiographic variables were compared based on the patients pre-op and post-op shoulder height.

Results: Of the 104 patients identified, 37% patients had level shoulders and 53% had a high opposite shoulder. The high and low were further classified as slight (1-2 cm), moderate (2-3 cm), significant (>3 cm) as per Kuklo et al. A high shoulder was associated with a greater mean thoracic Cobb (31o) than those with a level or low shoulder (24o and 26o, respectively; p=0.008). Post-op, 64% of patients had level shoulders (<1 cm) and 93% had a shoulder difference less than 2 cm. There were no significant factors predictive for a high post-op shoulder including whether the thoracic curve was included in the fusion (non-selective fusion). A slightly greater proportion of the pre-op high shoulders (36%) had a non-selective fusion than those with a level (27%) or low (9%) shoulder. Among the 29 patients with a pre-op moderate or significant high shoulder (>2 cm), only 3 continued to have a high shoulder greater than 2 cm which was not influenced by fusion of the thoracic spine.

Conclusion: Half of all Lenke 5 curves have a high opposite shoulder which is influenced by the size of the compensatory thoracic curve. Post-op, the majority of patients had level shoulders. Inclusion of the thoracic spine (non-selective fusion) did not appear to influence post-op shoulder balance even among those with a moderate or significant high opposite shoulder.



Lenke 5 curve with high opposite shoulder pre-operatively, treated with selective posterior fusion and resultant leveling of the shoulder.

PAPER #10

Does The Scoliscore Provide More Information Than Traditional Clinical Estimates Of Curve Progression?

Benjamin D. Roye, MD, MPH; Margaret L. Wright, BS; Brendan A. Williams, AB; Hiroko Matsumoto, MA; Jacqueline Corona, MD; Joshua E. Hyman, MD; David P. Roye, MD; Michael G. Vitale, MD, MPH

USA

Summary: Scoliscore is a novel genetic test used for predicting curve progression in AIS patients. This study sought to determine if the information provided by Scoliscore testing is unique from that typically gathered from traditional clinical risk estimates. The Scoliscore and "clinical risk" stratifications of 89 AIS patients were compared. Scoliscores created a markedly different stratification of the patient cohort, clustering more towards low- and intermediate-risk categories. Further work is still necessary to determine the validity of Scoliscore's progression estimates.

Introduction: Scoliscore is a new genetic prognostic test designed to evaluate the risk of curve progression in AIS and is approved for 10°-25° curves in skeletally immature patients. Clinicians are trying to better understand the role this test may play in guiding clinical decision making. Prior to the Scoliscore, risk of progression has been assessed with curve magnitude and age. The purpose of this study is to compare risk stratification between Scoliscore and traditional clinical estimates to determine if Scoliscore provides unique information.

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Methods: Scoliscores were collected for 89 patients fitting the testing criteria. The Cobb angle was submitted with DNA samples, and used in the generation of the Scoliscore. Patients were given a "clinical risk" level using the Risser sign and Cobb angle as described by Lonstein et al. This was compared to the Scoliscore risk level determined by DNA analysis.

Results: Scoliscore risk distribution in our population was 35%-low, 55%-intermediate, and 10%-high. This compares with 2%, 44%, and 46% of patients' comparable "clinical risk" categories (7% unable to determine). Only 20% were in the same risk category for both schemes.

There were no significant correlations between Scoliscore and age, menarchal status, Risser sign or gender. There was a positive correlation between the Cobb angle and the Scoliscore ($r=.512$, $p<.001$). The multivariate regression model ($p<.001$) revealed that the Cobb angle accounted for 29.7% of Scoliscore's variance.

Conclusion: The risk distribution of the two schemas examined differed markedly: Scoliscore predicted 17x more low risk patients and nearly 75% fewer high risk patients. Scoliscore predicted high or low risk of progression in 45% of our cohort, and it is in these groups that Scoliscore may affect decision-making. Further follow up of this cohort will allow us to determine the validity of this information in predicting progression.

Significance: This work advances our understanding of the role of Scoliscore which seems to provide unique information to traditional predictors of curve progression, such as Cobb angle and curve magnitude. Ongoing studies will investigate the validity of this information in predicting curve progression.

PAPER #11

To BrAIST or Not to BrAIST: Self-Selection in the Bracing in Adolescent Idiopathic Scoliosis Trial

Lori A. Dolan, PhD; Stuart L. Weinstein, MD

USA

Summary: Without random selection and random assignment to treatment, the results and conclusions of clinical trials can be subject to selection bias. Selection bias may prevent the generalization of findings to patients outside the trial, and more seriously, may prevent researchers from knowing whether the treatment effect is due to the treatment itself or due to the non-equivalence of the arms at baseline. This study indicates that the BrAIST sample is representative of the target population and the bracing and observation arms are equivalent in terms of known risk factors for curve progression.

Introduction: BrAIST is a partially-randomized trial comparing the outcomes of bracing and observation in children with adolescent idiopathic scoliosis. The purpose of this study is to evaluate two sources of selection bias: self-selection into the study and self-selection of treatment arm. Specifically we asked 1) is the BrAIST sample representative of the target population and 2) are the treatment arms equivalent in terms of risk factors for curve progression?

Methods: We addressed these questions by comparing baseline demographic, radiographic and psychosocial characteristics between the patients who enrolled in BrAIST and those who declined; and between the bracing and observation arms.

Results: Since April 2007, 1131 patients met eligibility criteria; 360 (32%) agreed to participate. There were no statistically significant differences between those who declined and those who agreed to participate in terms of largest Cobb angle, curve type, gender, or age. Blacks/African-Americans were more likely to participate (50%) than other racial groups ($p<0.01$).

Of the 360 participants, 219 (61%) entered into the bracing arm. Prior to treatment, there were no statistically significant differences in demographics, curve characteristics (Cobb angle, curve type, rotation, flexibility, kyphosis, lordosis), skeletal maturity (Risser and digital skeletal age), general health, back pain or psychosocial characteristics including body image and quality of life. However, those who were very dissatisfied with their current back condition were more likely to choose a brace than to be observed (73 vs. 51%, $p<0.01$).

Conclusion: BrAIST is still open to enrollment and these results are preliminary. The lack of difference between those who said "yes" and those who said "no" provides evidence that the sample is representative of the target population of high-risk adolescents. Likewise, lack of difference between the bracing and observation arms at baseline indicates any differences in outcome at the end of the study can be attributed to treatment and not to inbalance related to self-selection.

Significance: This study creates confidence that the final results and conclusions from BrAIST will be free from significant selection bias.

PAPER #12

Improvement in Pulmonary Function at Two Years Following Corrective Surgery for AIS - A Prospective Study

Charles E. Johnston, MD; B. Stephens Richards, MD; Daniel J. Sucato, MD, MS; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Mark A. Erickson, MD

USA

Summary: Patients with preop PFT impairment (<65%pred FEV1/FVC) gain absolute improvement at 2 yr postop but still lag behind postop PFTs for patients with Normal(>or=65%pred)preop values in spite of correction to similar curves magnitudes

Introduction: Previous preop data from SDSG (paper 98,SRS '09) showed 19% of 858 AIS patients have Impaired PFT's (<65%pred). We hypothesize that surgical correction may normalize respiratory function in this group similar to patients with Normal (=or>65% pred) preop values.

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PODIUM PRESENTATION ABSTRACTS

Methods: 351 of the original patients with Lenke 1-4 curves completed 2 yr postop FEV1&FVC tests. Correction of main thoracic(MT), prox thoracic(PT), T5-12 kyphosis (Sag) and axial rotation (Nash-Moe = NM) deformities were correlated with absolute and %pred PFT changes.

Results: In the Impaired group (n=80) FEV1 improved from mean 1.74L, 56.4% pred preop to 2.22L,69.7% at 2 yr (p<.0001). FVC improvement was similar. MT curves were corrected mean 65% (65.5o to 23.2o),PT curves improved 44.6% (30o to 16.6o).

Patients with Normal preop PFT's (n=251) had improved absolute FEV1 (2.5L to 2.8L, p<.0001) but no change in %pred FEV1 (83.7% to 84.5%, p=.1). FVC changes for this group were similar. MT correction for Normals was 62.1% (58.6o to 22.1o),PT correction 41.6% (28.1o to 16.1o).

Deformity parameters: preop MT curves were larger in Impaired patients vs Normal (p=.0002), with no difference in PT curves. There was no difference in postop MT or PT curve magnitudes between the 2 groups. Sagittal plane: Impaired patients were more hypokyphotic preop than Normal (18 vs 23o,p=.002), with no difference in Sag postop, thus the amount of Sag correction was Impaired > Normal (p=.017). No differences in NM axial measures pre or postop for either group were found.

Conclusion: MT, PT and Sag curves in the Impaired group were corrected to same magnitude as the Normal group postop. This produced greater absolute and %pred improvement in FEV1&FVC (p<.002) for Impaired compared to Normal. Nevertheless absolute and %pred PFT values postop for Impaired patients still lagged behind postop PFTs for Normals (70% pred vs 85% pred, p<.0001) at 2 yrs in spite of correction to similar curve magnitudes.

Significance: Further f/u beyond 2 yr is required to determine if complete PFT recovery is possible for patients with Impaired preop FEV1/FVC

PAPER #13

Proximal Junctional Kyphosis at Five Years After Fusion for AIS: Does it Matter?

Jahangir Asghar, MD; Amer F. Samdani, MD; Peter O. Newton, MD; Patrick J. Cahill, MD; Dianna C. Morales, BA; Harry L. Shufflebarger, MD

USA

Summary: This study used a multi-centre dataset, to determine the incidence of abnormal proximal junctional kyphosis (PJK) at 5 yrs. The incidence of abnormal PJK at 5 yr was 8.2%. Ant had the highest incidence of abnormal PJK at 12.5%. There were no re-operations secondary to abnormal PJK. No differences in SRS outcomes were observed. In the Post group, the incidence of abnormal PJK remained stable between 2 and 5 yrs. At 5 yrs follow-up, abnormal PJK has minimal clinical significance.

Introduction: Questions regarding the long-term incidence and the subsequent clinical relevance of proximal junctional kyphosis remain. Our study used a multi-centre dataset, to determine the incidence of abnormal proximal junctional kyphosis (PJK) at 5 yrs.

Methods: All patients with AIS, who underwent a fusion, and had 5 year follow up were included (n=315). Clinical, and radiographic data were collected and categorized based on approach: Anterior (Ant) and Posterior (Post). The Post group was further divided into Hybrid (Hy), All Pedicle Screw (PS), and >80% pedicle screws (80PS). An analysis to identify differences in radiographic and clinical outcome was performed.

Results: The incidence of abnormal proximal junctional kyphosis (>15°) at 5 yr follow up was 8.2%. The incidence at 5 yrs for Ant was 12.5% and Post was 5.8% (p<0.05). In this cohort, no differences were noted in the incidence of PJK between the Post implant groups (Hy- 4.1 %, PS- 8.5%, 80PS- 3.2%, p=0.65). However, the sagittal Cobb angle of PJK measured at 5 yr was significantly different amongst the three groups (PS: 7.55°, Hy: 5.48°, 80PS: 4.29°, p<0.05). The incidence of abnormal PJK, on the first post-operative follow-up was 3.8% and at 1 yr was 4.5%. At 2 and 5 yr follow-up, the incidence of abnormal PJK in the Post group remained unchanged at 5.8%. Conversely, the Ant group had an incidence of 5% on first post-operative follow-up, increasing to 8% at 1 yr, 10.7% at 2yr, and 12.5% at 5 yr follow up.

Pre-operative junctional measurements, T5-T12 and T2-T5 kyphosis, upper instrumented level, coronal curve correction, BMI and the presence of thoracoplasty did not correlate with abnormal PJK in our cohort. There were no significant difference in SRS outcome scores or revisions secondary abnormal PJK at 5 yrs.

Conclusion: The incidence of abnormal PJK at 5 yr was 8.2%. Ant had the highest incidence of abnormal PJK at 12.5%. There were no reoperations secondary to abnormal PJK. No differences in SRS outcomes were observed. In the Post group, the incidence of abnormal PJK remained stable between 2 and 5 yrs.

Significance: At 5 yrs follow-up, abnormal PJK has minimal clinical significance.

PAPER #14

Flatback Revisited?: Reciprocal Loss of Lumbar Lordosis Following Selective Thoracic Fusion

Michael G. Vitale, MD, MPH; Nicholas D. Colacchio, BA; Hiroko Matsumoto, MA; Frank J. Schwab, MD; Virginie Lafage, PhD; David P. Roye, MD

USA

Summary: Investigation of selective thoracic posterior spinal instrumentation and fusion (PSIF) for adolescent idiopathic scoliosis (AIS) found that loss of thoracic kyphosis (TK) was associated with unintended compensatory loss of lumbar lordosis (LL).

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Introduction: A common outcome of segmental instrumentation for AIS is loss of physiological TK. This study aims to investigate the relationship between iatrogenic loss of TK after selective spinal fusion for AIS with straightening of LL and increase in pelvic tilt (PT). This study tests the hypothesis that loss of TK will result in a compensatory and reciprocal loss of LL.

Methods: Query of a prospective multicenter database identified 123 AIS patients (Lenke 1,2,3) at least 2 years following selective thoracic PSIF with lowest instrumented vertebra equal or cephalad to L1. TK (T5-T12), LL (T12-S1), sagittal balance (SB) and PT at preop and 2 years postop were measured. Health related quality of life measures (HRQOL) were also examined.

Results: 31% of patients undergoing a selective fusion had a net loss of TK at 2 years postoperatively (2year TK - Preop TK < 0). Patients who had decreased TK had a significantly higher rate of loss of LL than patients without loss of TK (68% vs. 32%, $p<0.0001$). Change in LL was positively correlated to change in TK ($p<0.0001$) and negatively correlated to both change in SB ($p=0.002$) and change in weight ($p=0.04$). Change in PT was negatively correlated to both change in TK ($p=0.03$) and change in LL ($p<0.0001$), and positively correlated to change in weight ($p=0.01$). Multiple regression analysis revealed that both TK and SB had significant predictive effect on LL ($p<0.001$, $R2=0.31$), and LL had significant predictive effect on PT ($p=0.0045$, $R2=0.12$). There were no significant associations between changes in TK or LL and HRQOL.

Conclusion: Iatrogenic loss of TK occurs commonly in selective fusion for AIS. This loss of kyphosis is strongly associated with a compensatory and reciprocal loss of LL in the unfused segments, as well as an increase in PT. Seen this way, spinal fusion can have unintentional effects on balance and sagittal alignment which may have distant effects that remain to be fully elucidated.

Significance: Although a significant difference in HRQOL at 2 years postoperatively was not appreciated in this study, the experience of adults with "flatback syndrome" suggests that loss of physiologic sagittal alignment in surgical correction of AIS may increase the risk for suboptimal clinical outcomes for these patients in the future.

PAPER #15

Multi-Center Comparison of the Factors Important in Restoring Thoracic Kyphosis During Posterior Instrumentation for Adolescent Idiopathic Scoliosis

Shafagh Monazzam, MD; Peter O. Newton, MD; Tracey Bastrom, MA; Burt Yaszay, MD; Harms Study Group

USA

Summary: Patients with a Lenke type 1-4 curves with pre-operative x-rays showing a hypokyphosis (T5-12: 5-20°) were followed after posterior pedicle screw instrumentation/fusion. Four potential preoperative factors associated with normalization of kyphosis were analyzed: pre-operative kyphosis, surgeon, rod material and degree of posterior release. Of these, the surgeon was most significant predictor of post operative kyphosis.

Introduction: Correcting hypokyphosis in AIS patients is important in preventing junctional kyphosis and increasing pulmonary function. We wished to determine what factors were most predictive of postop correction of hypokyphosis when segmental posterior implants are used in treating thoracic AIS.

Methods: Prospectively collected cases from a multi-center study were analyzed.

Lenke 1-4 AIS patients with preop kyphosis of 5-20 degrees, treated with posterior pedicle screws, with a surgeon who had at least 20 patients in the database were included. Patients were divided into two groups postoperatively based on first erect x-rays: those remaining hypokyphotic (HK, <20° or an increase <5°) and those restored to normal kyphosis (NK, >20° with >5° increase). Patients whose correction was less than 5 degrees were considered unchanged (hypokyphotic). Regression analysis was done on four preop factors thought to influence the postop kyphosis: pre-operative kyphosis, surgeon, rod material utilized (steel vs Ti) and use or not of a posterior release (Ponte).

Results: Of the 280 patients included in the study, 227 remained hypokyphotic and 53 achieved normal kyphosis. There were no differences in preoperative kyphosis (13.4±5 HK group vs 14.5 ±4 NK group) and age (14.7 HK group vs 14.6 NK group). Of the factors evaluated, the surgeon was the most significant predictor of restoration of normal kyphosis (Table I). Comparison of surgeons showed the rate of normalizing kyphosis ranged from 6% to 42% (p=.004) and there was no difference in the degree of preoperative kyphosis between surgeons.

Conclusion: Restoration of thoracic kyphosis remains a challenge in posteriorly treated thoracic AIS cases. "Surgeon" was the only significant predictor of restoring normal kyphosis, emphasizing the importance of intra-operative techniques not presently measured in our study (e.g., extent of release, compression/distraction forces, rod contouring techniques).

PAPER #16

Cervical Sagittal Contour Decompensation Before and After Posterior Surgery for Adolescent Idiopathic Scoliosis

Suken A. Shah, MD; Brain S. Winters, MD; E. Patrick Curry, MD; Petya Yorgova; Geraldine I. Neiss, PhD; Alan Hilibrand, MD; Harms Study Group

USA

Summary: The cervical sagittal contour of patients with AIS was evaluated preoperatively and 2 years postoperatively. Thoracic hypokyphosis is associated with a risk of cervical decompensation into kyphosis. Efforts to restore even some thoracic kyphosis postoperatively during scoliosis surgery may have profound effects in establishment of cervical lordosis.

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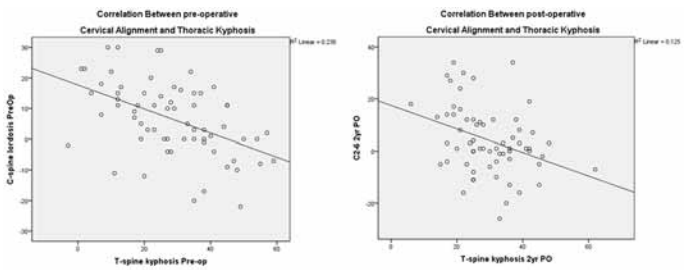
PODIUM PRESENTATION ABSTRACTS

Introduction: The cervical sagittal contour of patients with AIS may be clinically important, as neck pain is a major complaint in long term follow up studies. Cervical spine alignment and sagittal vertical axis are affected by thoracic kyphosis. Thoracic hypokyphosis is a common feature of AIS and can be aggravated by contemporary instrumentation techniques with segmental pedicle screw systems. This study sought to examine the relationship of thoracic hypokyphosis and cervical spine sagittal contour before and after posterior spinal fusion for AIS.

Methods: A single-surgeon's prospective, consecutive series of patients (2005-2008) treated with segmental pedicle screw instrumentation for thoracic AIS (Lenke 1,2) with minimum 2 year follow up yielded 65 patients with adequate cervical spine views for analysis. Cervical sagittal contour was measured by one of two observers from the inferior endplate of C2 to the inferior endplate of C6, as described by Hilibrand, et al (1995) preoperatively, at the first erect film and at two year follow up. Arm position was standardized with hands resting on poles and arms flexed forward 20-30°. A comprehensive collection of global and local sagittal parameters were analyzed.

Results: "Flattening" of the cervical sagittal contour was observed in patients with AIS before and after surgery. Preoperatively, the sagittal contour from C2-C6 was 7.0 ± 2° of kyphosis and 4.6 ± 2° of kyphosis two years after surgery ($p<0.01$). Thoracic sagittal contour preoperatively was 28 ± 6° of kyphosis (T2-T12) and was preserved after surgery (29.6 ± 3°). A strong correlation existed between thoracic hypokyphosis and the development of cervical kyphosis - and this was significant preoperatively ($p=0.003$) and two years postoperatively ($p=0.004$). A relatively small correction of the thoracic kyphosis (4.8%) translated into a substantial and spontaneous correction in the cervical lordosis of -39%.

Conclusion: In AIS, thoracic hypokyphosis is associated with a risk of cervical decompensation into kyphosis. Efforts to restore even some thoracic kyphosis postoperatively during scoliosis surgery may have profound effects in establishment of cervical lordosis.



PAPER #17

Early Results and Complications of Posterior-Based Osteotomies in Patients with Previous Spinal Fusions

Stephen Lewis; Hitesh N. Modi, MS, PhD; Sergey Goldstein, MD; Andrew W. Bodrogi, BSc; Sofia Magana, BSc

Canada

Summary: Retrospective review of 26 consecutive patients undergoing PSO or VCR through previously fused spines for persistent deformity. The mean correction with the osteotomy in Group 1 was 29.0°(10-62°) of sagittal plane and 4.5°(0-19°) of coronal plane compared to 23.6°(0-49°) of sagittal plane and 13.3°(4-23°) of coronal correction in Group 2. There one was major neurologic deficit and one peri-operative death. Significant improvements were noted in SRS30 self-image and satisfaction scores. There was no significant differences noted in ODI.

Introduction: Correction in previously-operated patients with a long fusion mass at the deformed level is often difficult to obtain since correction is limited to the level of the osteotomy.

Methods: Retrospective review was performed of the charts and radiographs of 26 consecutive adult patients treated with posterior-only VCR or PSO through a fusion mass for persistent spinal deformity. by one surgeon between 2005 and 2009. Patients were divided into Group 1 with primary sagittal plane deformity, and Group 2, combined coronal and sagittal deformity.

Results: There were 8 males and 18 females with a mean age of 51.1 (20-77yrs). The mean correction with the osteotomy in Group 1 was 29.0°(10-62°) of sagittal plane and 4.5°(0-19°) of coronal plane compared to 23.6°(0-49°) of sagittal plane and 13.3°(4-23°) of coronal correction in Group 2. There was one major neurological complication with a patient sustaining a Brown-Sequard syndrome following removal of sublaminar wires. There was one peri-operative death, three cases of excessive blood loss, 6 dural tears, and 6 pleural tears requiring chest tubes. There were 15 thoracic level osteotomies and 11 lumbar or sacral. 13(50%) of the patients required extension of the fusions either proximally or distally by a mean of 3.4(1-9) levels. The mean follow-up was 30.2 months (12-61), mean operative time was 7.5 hrs (5-12), mean hospital stay 14.2 days(3-46), and mean number of levels fused 12.7 (3-19). SRS 30 scores showed significant improvements in self-image and satisfaction. There were no significant differences noted in the ODI.

Conclusion: Corrections of previously fused adult spinal deformities with three column osteotomies are possible with a mean angular correction of approimately 35°. Improvements in self-image and satisfaction were noted despite a relatively high complications rate.

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Significance: High satisfaction and good corrections can be achieved with three column osteotomies through previously fused spines despite the risk of significant complications.

PAPER #18

Clinical and Radiographic Outcomes of Pedicle Subtraction Osteotomy (PSO) for Fixed Adult Sagittal Imbalance: Does Level of Proximal Fusion Affect Outcome?

Mitsuru Yagi, MD, PhD; Akilah B. King, BA; Matthew E. Cunningham, MD, PhD; Oheneba Boachie-Adjei, MD

USA

Summary: Pedicle subtraction osteotomy addressed the sagittal imbalance for patients fused short or long with improved SRS and ODI scores. However, increased kyphosis with loss of sagittal balance occured in patients fused short and should be monitored in the post-op period.

Introduction: To assess the clinical and radiographic changes after PSO for the treatment of adult fixed sagittal imbalance. There is a paucity of information regarding the clinical outcome and its correlation with the level of proximal fusion and radiographic change after PSO.

Methods: Charts, x-rays, post-op SRS-22 and ODI scores of 51 adult pts with fixed sagittal imbalance treated with lumbar PSO were reviewed. Long fusion was defined as proximal level greater than or equal to T8 and short fusion as less than T8. Radiographic parameters included thoracic kyphosis (TK), lumbar lordosis (LL), and sagittal balance (SVA). Statistical analysis included student's t test, chi-square test, and Fisher's exact test. P value of <0.05 with confidence interval 95% was considered significant.

Results: There were 38f and 13m with mean age 52.5 yrs (21-74 yrs) and mean f/u 5.8 yrs (2-12 yrs). LL increased from 19.1° pre-op to 52.8° post-op and 52.0° at final f/u. C7PL decreased from 11.3cm pre-op to 3.1cm post-op and 6.3cm at final f/u. There were 26 short fusions and 25 long. SRS scores at latest f/u were: total 3.53, function 3.31, pain 3.40, self image 3.55, and mental health 3.59. 20 pts showed minimal disability, 18 pts showed moderate disability, and 4 pts showed severe disability in ODI score at final f/u (avg 70.2%). SRS and ODI scores were not different between the 2 groups ($p=0.68$, $p=0.79$). Increased SVA at final f/u was significantly larger in short fusion group compared to long fusion group ($p=0.02$). TK (T5-T12) at final f/u also increased in pts having short fusion ($p=0.001$). Major complications occurred in 14 pts, 6 short (24%) and 8 long (31%) ($p=0.754$). 3 pts had additional PSO for the loss of correction in short fusion group.

Conclusion: Despite an increased SVA and high complication rate, PSO provided good sagittal balance and favorable clinical outcomes in both groups. The data suggests that loss of sagittal balance can be attributed to increased kyphosis in short fusion groups and should be monitored for long term outcomes.

PAPER #19

Assessment of Symptomatic Rod Fracture Following Posterior Instrumented Fusion for Adult Spinal Deformity

Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Vedat Deviren, MD; Kai-Ming Fu, MD, PhD; Frank Schwab, MD; Virginie Lafage, PhD; Shay Bess, MD; International Spine Study Group

USA

Summary: Multicenter, retrospective analysis of rod fracture (RF) following multi-level fusion for adult spinal deformity demonstrated a 5.4% incidence over 6 years. Most RFs occurred within one year and occurred with all rod compositions and diameters and all fusion lengths. Early failure was most common following PSO and occurred at the PSO site. Residual postoperative sagittal malalignment may increase the risk for RF.

Introduction: Instrumentation failures continue to be problematic and are poorly understood. Objective: evaluate the etiology and time course of symptomatic rod fracture (RF) following multi-level posterior instrumented fusion for adult spinal deformity (ASD).

Methods: Multicenter, retrospective review of RF in ASD during a 6-yr period (2004-2010) at 10 study sites. Inclusion criteria: ASD, age>18 yrs, and >5 levels posterior instrumented spinal fusion. Exclusion criteria: post-traumatic or neuromuscular deformity, tumor, and infection. RF were divided into early ($\leq$12 mos) and late (>12 mos) failures.

Results: Of 558 patients that met criteria, 5.4% had symptomatic RF. Patient demographics: mean age=61 yrs (range: 29-79); 13 men and 17 women. Diagnosis included: scoliosis (n=21; 70%) and sagittal malalignment (n=26, 87%). The upper instrumented vertebra was cephalad to T6 in 20 patients (67%), 26 patients (87%) had iliac fixation. Seventeen (57%) RF patients received pedicle subtraction osteotomy (PSO). The incidence of RF following PSO was 14.9%. Rod composition in RF cases included: titanium alloy (n=18), stainless steel (n=9), and cobalt chromium (n=3), and rod diameters were 5.5 mm (n=6), 6.0 mm (n=2), and 6.35 mm (n=6). Mean duration to early RF (63%) was 6.4 mos (range: 2-12). Mean duration to late RF (37%) was 31.8 mos (range: 14-73). The majority of RFs following PSO (n=12; 71%) were early (mean 10 mos; range 2.0-29.3). Rod fracture occurred at the PSO site in 15 cases (88%). Among RF cases, SVA improved from preoperative (mean=163mm, range: 0-300mm) to postoperative (mean=76.9mm; range: -25-233mm) measures ($p<0.001$), however, 16 had postoperative malalignment (SVA>50mm; mean=109mm; range: 50-233mm).

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PODIUM PRESENTATION ABSTRACTS

Conclusion: Symptomatic RF occurred in 5.4% of ASD cases and in 14.9% of PSO cases. The majority of RFs occurred within one year and occurred with all rod compositions and diameters. Early failure was most common following PSO and occurred at the PSO site, suggesting that RF may be due to stress at the PSO site or excessive rod contouring. Postoperative sagittal malalignment may increase the risk for RF.

PAPER #20*

Combined Assessment of Pelvic Tilt, Pelvic Incidence/Lumbar Lordosis Mismatch and Sagittal Vertical Axis Predicts Disability in Adult Spinal Deformity: A Prospective Analysis

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

USA

Summary: Sagittal spinal malalignment (SSM) is commonly defined by increased sagittal vertical axis (SVA), however SVA alone may underestimate the severity of SSM. Spino-pelvic parameters provide a more complete assessment of SSM. Multi-center, prospective analysis of consecutively enrolled adult spinal deformity patients demonstrated pelvic tilt (PT) and pelvic incidence/lumbar lordosis mismatch (PI-LL) combined with SVA predict patient disability and provide a guide for patient assessment. Threshold values for severe disability (ODI≥40) included: PT≥22°, SVA ≥46mm, and PI-LL≥11°.

Introduction: Sagittal spinal malalignment (SSM) is commonly defined by increased sagittal vertical axis (SVA), however, SVA alone may underestimate the severity of SSM. Spino-pelvic parameters provide a more complete assessment of SSM. Little data has correlated spino-pelvic parameters with disability. Purpose: evaluate correlations between sagittal spino-pelvic parameters and health related quality of life (HRQOL) scores.

Methods: Demographic, radiographic, and HRQOL data were obtained from patients consecutively enrolled into a multi-center, prospective study evaluating operative (OP) vs. nonoperative (NON) treatment for adult spinal deformity (ASD). Inclusion criteria: age >18 years and radiographic diagnosis of ASD (scoliosis >20°, or SVA > 5cm, or pelvic tilt > 25°, or thoracic kyphosis > 60°). Radiographic evaluation: frontal and lateral spino-pelvic measurements. HRQOL questionnaires: Oswestry Disability Index (ODI), Scoliosis Research Society Questionnaire (SRS-22r). Radiographic parameters were correlated with HRQOL values. Radiographic parameters demonstrating highest correlation with HRQOL values were evaluated to determine a disability threshold of ODI≥40.

Results: Between 10/2008 to 12/2010, 492 consecutive ASD patients (mean age 51.9 years, SD 16.8) were enrolled. Patients treated OP (n=178) were older (55 vs. 50.1 years, p<0.05), had greater SVA (5.5 vs. 1.7cm, p<0.05), greater pelvic tilt (PT; 22° vs. 11°, p<0.05) and greater pelvic incidence/ lumbar lordosis mismatch (PI-LL; 12.2 vs. 4.3; p<0.05) than NON (n=314). OP demonstrated greater disability on all HRQOL measures compared to NON (ODI =41.4 vs. 23.9, p<0.05; SRS total=2.9 vs. 3.5, p<0.05). Pearson analysis demonstrated PT, SVA, and PI-LL correlated most strongly with disability for both OP and NON patients (p<0.001). Linear regression models demonstrated threshold radiographic spino-pelvic parameters for ODI≥40 included: PT≥22° (r=0.38), SVA ≥46 mm (r=0.47), PI-LL≥11 (r=0.45).

Conclusion: SSM is a disabling condition. Prospective analysis of consecutively enrolled ASD patients demonstrated PT and PI-LL combined with SVA predict patient disability and provide a guide for patient assessment. Threshold values for severe disability included: PT≥22°, SVA ≥46mm, and PI-LL≥11°.

PAPER #21

T2 or T10: Preoperative Sagittal Parameters Determine Proximal Fusion Levels in Adult Idiopathic Thoracolumbar Scoliosis

Terrence T. Kim, MD; Jennifer Murphy, BA; J. Patrick Johnson, MD; Robert S. Pashman, MD

USA

Summary: This study identifies critical preoperative sagittal parameters that may lead to failures of short fusions (T10-pelvis), and encourages extending fusions proximally at the index surgery.

Introduction: Global sagittal balance is critical to successful surgical reconstruction in adult idiopathic scoliosis. Selection of the upper instrumented veterbrae is based on several preoperative parameters. Our cohort analysis of long (T2-pelvis) and short (T10-pelvis) fusion constructs have identified several risk factors for loss of sagittal alignment and construct failure.

Methods: 57 pts with adult thoracolumbar and lumbar idiopathic scoliosis treated with PSF. All pts underwent ALIF at L4-S1, and PSF to the pelvis. Pre- and postoperative radiographs were analyzed for: coronal curve magnitude, coronal alignment, cervical lordosis, C2 and C7 sagittal vertical axis (SVA), cervico-thoracic, thoracic and thoracolumbar kyphosis. We also analyzed proximal junctional kyphosis (PJK), loss of sagittal balance, revision surgery, and previous history of ACDF.

Results: 47 females and 10 males with avg age 61 yrs (44-73), avg f/u 38.7 mos. 21 pts had T2-pelvis and 26 pts T10-pelvis with avg 9.6 levels fused. At final f/u, 40 pts maintained sagittal balance (avg. C7 SVA: -2.0cm, PJK: -4.3°). Of these, 21/21 T2-pelvis maintained sagittal balance, while 7/28 T10-pelvis had progressive loss of sagittal alignment (avg. C7 SVA: 4.2cm, PJK: -9°). The

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failed group revealed an increase in preoperative: thoracic kyphosis (T2-T12: 50° v. 32°), cervical kyphosis (C2 SVA: +2.0 v. +1.46cm), cervicothoracic (T1 tilt: 28.7° v. 15.8°) and thoracolumbar kyphosis (-6.75° vs. 2.8°) compared to the balanced group ($p<0.05$). History of ACDF was also found to be significantly higher in failure patients (38% vs. 0%, $p<0.05$).

Conclusion: Our study identifies that C2 SVA >2 cm, T1 tilt >29°, thoracic kyphosis >50° and thoracolumbar kyphosis >7° are key preoperative risk factors that may predict sagittal balance failures. We theorize that patients with these preoperative sagittal parameters have constant cantilevering forces on short fusion constructs leading to failure. In these patients, our study suggests selecting a long fusion (T2-pelvis).

Significance: Previous studies have shown that loss of global sagittal balance postoperatively produces poor clinical outcomes. We compared scoliosis patients with successful and failed fusions in attempts to identify preoperative radiographic risk factors.

PAPER #22

Comparative Radiographic Analysis Of The Sagittal Spinopelvic Alignment Between 100 Asymptomatic Adults And 100 Sagittally Imbalanced Patients: The Best Angular Parameters to Sagittal vertical Axis

Yongjung J. Kim, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Youngbae B. Kim, MD, PhD

USA

Summary: Sagittal standing radiographs of the whole spine and pelvis in 200 adults (100 asymptomatic volunteers, 100 sagittally imbalanced patients who had a subsequent balancing operation) demonstrated useful parameters for the evaluation of sagittal imbalace as well as considerations for correction of sagittal imbalance. The T12 lower endplate - horizontal angle was the simplest and the most correlative.

Introduction: To compare the sagittal plane alignment of the spine between normal asymptomatic adults (NA) and sagittaly imbalanced patients (SI).

Methods: Sagittal standing radiographs of the whole spine and pelvis in 200 adults (100 asymptomatic volunteers, 100 sagitally imbalanced patients who had a subsequent balancing operation) were evaluated. The following parameters were included: thoracic kyphosis (T5-T12), T12 lower rnd plate-horizontal angle, lumbar lordosis (T12-S1), sacral slope, pelvic incidence, pelvic tilt, C7 plumb, T12 plumb, C7 plumb to bicoxofemoral head distance and distance from posterosuperior endplate of S1 to bicoxofemoral head.

Results: The mean differences between two groups were 5° for thoracic kyphosis (32 NA vs. 26 SI), 31° for T12 horizontal angle (-22 NA vs. 10 SI), 45° for lumbar lordosis (-60 NA vs. -15 SI) , 14° for sacral slope (38 NA vs. 24 SI), 19° for pelvic tilt (13 NA vs. 32 SI) and 5° for pelvic incidence (51 NA vs. 57 SI). The mean differences between two groups were 16.3cm for sagittal vertical axis (-0.9cm NA vs. 15.5cm SI), 12.2cm for C7 plumb to bicoxofemoral head distance (-4.9cm NA vs. 7.4cm SI), 4.6cm for T12 plumb to S1 (-1.9cm NA vs. 2.8cm SI) and 4.1 cm for S1 to bicoxofemoral head distance (4cm NA vs. 8.1cm SI). Sagittal vertical axis had strong positive correlation with C7 plumb to bicoxofemoral head distance (r=0.96); T12-horizontal angle (r=0.83); pelvic incidence+thoracic kyphosis+lumbar lordosis (r=0.80); T12-horizontal angle+thoracic kyphosis (r=0.77); lumbar lordosis (r=0.74); and thoracic kyphosis+lumbar lordosis (r=0.69).

Conclusion: These spinal sagittal parameters can be used as a baseline in the evaluation of sagittaly imbalanced patients as well as consideration for correction of sagittaly imbalanced patients. T12-horizontal angle is the simplest and the most correlative to the sagittal vertical axis.

Significance: T12-horizontal angle is the simplest and the most correlative to the sagittal vertical axis.

PAPER #23

Redefining Global Spinal Balance: Normative Values of Cranial Center of Mass from a Prospective Cohort of Asymptomatic Individuals

Patrick A. Sugrue, MD; Jamal McClendon, MD; Timothy R. Smith, MD; Ryan J. Halpin, MD; Fadi F. Nasr, MD; Brian A. O'Shaughnessy, MD; Tyler Koski, MD

USA

Summary: True global sagittal balance must take into consideration the position of the head in relation to the spine and pelvis. We have performed a prospective analysis of asymptomatic adults in two age groups, 20-40 and 60-80 years old, establishing normal values of cranial sagittal balance with comparison to C2 and C7 sagittal alignment.

Introduction: The C7 plumbline defines thoracolumbar sagittal balance and has been shown to have significant impact on patient outcomes. However, the C7 plumbline fails to take into consideration the position of the head in relation to the pelvis. With this study we aim to determine normal values for cranial sagittal balance in asymptomatic individuals.

Methods: 100 asymptomatic 20-40 year-old patients and 100 asymptomatic 60-80 year-old patients were enrolled. 14x36 inch standing scoliosis radiographs were obtained. Cranial center of mass (CCOM), C2, and C7 plumblines were drawn and measured from the superior posterior endplate of S1.

Results: 78 asymptomatic 20-40 year-old patients and 62 asymptomatic 60-80 year-old patients had usable radiographs. The mean plumbline values in the 20-40 year-old patients and 60-80 year-old patients respectively were as follows; CCOM 9.0 mm ± 31.5 and 41.2 mm ± 35.7; C2 -2.7 mm ± 32.7 and 32.1

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PODIUM PRESENTATION ABSTRACTS

mm ± 33.6; C7 27.9 mm ± 21.4 and 110.2 mm ± 27.9. One-way ANOVA and t-tests verified that these mean plumbline values were significantly different between young and old patients ($p<0.001$). The change at each level over time correlated to the other levels ($R > 0.97$, $p<.001$) as did the degree of change between groups ($R > 0.81$, $p<.001$).

Conclusion: Spinal pelvic alignment in conjunction with CCOM has increased our understanding of spinal balance by including the head and may better represent true global spinal balance than the traditional C7 measurement. CCOM is an easily measured parameter by using the nasion-inion technique.

Significance: With this study we have established a normal range for cranial sagittal balance for asymptomatic individuals in both a young and old population.

PAPER #24

The Anchor Type at the Proximal Fusion Level has Significant Effect on the Incidence of Proximal Junctional Kyphosis (PJK) and Outcome in Adults Following Long Posterior Spinal Fusion

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USA

Summary: PJK continues to be a challenging problem in adult spinal deformity surgery. We prospectively collected & retrospectively reviewed clinical and radiographic data on 52 patients undergoing long PSF, comparing the effect of proximal anchor type on the incidence of PJK

Introduction: PJK develops as a result of stresses on the proximal mobile segment by the stiff instrumented vertebrae, ligamentous disruption & fractures are among factors implicated. We hypothesize that using transverse process hooks (TPH) as an anchor at the most cephalad vertebra lowers the incidence of PJK compared to pedicle screws (PS)

Methods: Radiographic results & functional outcome of 52 consecutive patients who underwent long posterior spinal fusion using TPH or PS at the UIV between 2004 -09 were compared. PJK was defined as sagittal Cobb angle ≥10° between the lower endplate of UIV & the upper endplate of the two superior vertebrae & ≥10° increase from prior measurement.

Results: 47 patients completed 2 ys f/u, 20 had TPH at the UIV (group I) average age 45 ys (22-78) (17F, 3M). 27 (22F, 5M) had PS at the UIV (group II) age 57 ys (20-78) . There were 13 levels fused in group I and group II (9-17) & (9-18) respectively. Pre & post-op radiographic characteristics were similar in both groups (Table 1)

Comparing post-op to final follow-up, 0/20 (0%) of patients in TPH group compared to 8/27 (29.6%) of PS group developed PJK (p=0.023). Comparing pre-op & final f/u, 2/22 (9.1%) in TPH group and 13/27 (48.1%) in PS group developed PJK (p=0.008). Of the 8 patients in PS group who developed PJK, 3 required additional surgery. Complication rate was higher in group II than group I; 5 major & 13 minor vs 9 major & 13 minor respectively.

The SRS-24 & ODI at final follow-up were significantly better in the TP hook group compared to those in the pedicle screw group (Table 2)

Conclusion: The use of TP hooks at UIV in long spinal fusion appears to reduce the risk of PJK. Several reasons may contribute to that; the surgical approach for TPH placement is less extensive, preserving the soft tissues & joint capsule, TPHs provide a less rigid proximal segment, exerting less mechanical stress on the level above. TPhDo not weaken the anterior vertebral body potentially preventing compression fracture at UIV

Significance: TP hooks should be strongly considered in the choice of the posterior anchors at the UIV in long spinal fusions in adult deformity surgery

PAPER #25

Incidence, Risk Factors, and Clinical Outcome of Proximal Junctional Kyphosis for Patients with Adult Idiopathic Scoliosis: Minimum Five Year Follow-Up

Mitsuru Yagi, MD, PhD; Akilah B. King, BA; Oheneba Boachie-Adjei, MD

Japan

Summary: This study reports the incidence, risk factors, and natural course of proximal junctional kyphosis (PJK) in a long term follow-up of adult idiopathic scoliosis patients undergoing long instrumented spinal fusion and shows that the majority of PJK developed in the early post-op period and can continue to progress over long term. However, few patients required revision surgery for PJK.

Introduction: PJK is a well recognized post operative phenomenon in adult and adolescent scoliosis after long instrumented fusion. Although recent reports have showed the prevalence, clinical outcomes, and the possible risk factors of PJK, few reports exist about long term follow-up outcome of PJK.

Methods: A retrospective chart and x-ray review of 76 consecutive adult scoliosis pts treated with long instrumented spinal fusion was performed. PJK was defined by a proximal junctional angle greater than 10° and at least 10° greater than the corresponding pre-op measurement. Radiographic measurements included sagittal vertical axis (SVA), thoracic kyphosis (TK), lumbar lordosis (LL) and pelvic incidence (PI) on pre-op, post-op, and latest most recent f/u. Bone mineral density (BMD), body mass index (BMI), age, sex, instrumentation type, surgery type and fusion to sacrum were reviewed. Post-op SRS and ODI scores were also evaluated. Means were compared with student's t test and chi-square test. P value of <0.05 with confidence interval 95% was considered significant.

Results: The mean age was 48.3yrs (23-75yrs) and the avg f/u was 7.3yrs (5-14yrs). PJK occurred in 17pts (22.4%). SRS and ODI scores were not sig-

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nificantly different between PJK group and non PJK group. 76% of PJK occurred within 3 months after surgery, and the remaining 24% identified between 3 months to 5 yrs post-op. 4 pts were symptomatic, and 2 pts had revision surgery. Low BMD, posterior fusion, fusion to the sacrum, inappropriate global spine alignment, and greater SVA change were significant risks for PJK (P=0.035, P=0.03, P=0015, p<0.001 and p<0001).

Conclusion: In a long term review of minimum 5 yrs, 76% of PJK occurred within 3 months after surgery. Despite the occurrence of PJK in 22% of adult scoliosis pts undergoing long fusion, no significant differences were found in SRS and ODI scores in PJK and non PJK pts. Pre-existing low BMD, posterior fusion, fusion to the sacrum, inappropriate global spine alignment, and greater SVA change were significant risks for PJK.

PAPER #26

Are TLIFs Necessary for L5-S1 Arthrodesis in Long Constructs to the Sacrum/Pelvis in Primary Adult Deformity Patients?

Ra'Kerry K. Rahman, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Jacob M. Buchowski, MS, MD; Bradley Stephens, MD; Ian G. Dorward, MD; Linda Koester, BS

USA

Summary: Analysis of adults with long instrumented fusion to the sacrum/pelvis show transforaminal lumbar interbody (TLIF)s are NOT necessary for L5-S1 fusion when compared to 20mg posterolareral BMP-2 at L5-S1 without interbody(NI). There were no pseudoarthroses in the NI group. TLIF cost more per level than 20mg BMP-2.

Introduction: L5-S1 has the highest nonunion rate; thus, obtaining arthrodesis in long fusions to the sacrum/pelvis is challenging. Two strategies to diminish pseudo rates are: TLIF vs. BMP-2 (20mg at 2mg/cc on CRM sponge) at L5-S1. TLIF facilitates circumferential fusion(TLIF) while BMP provides posterolateral fusion only in this study(NI). Study hypothesis: Cost and pseudo rates are the same when lumbo-sacral TLIF is compared to distal 20mg BMP in long instrumented fusions to the sacrum/pelvis.

Methods: A one center study of prospectively entered data examined pseudo, cost and outcomes of 57 consecutive adults with primary scoliosis & fusion from T11 or higher to S1/pelvis with minimum 2-yr f/u. 2 groups were compared: no interbody(NI) but 20mg BMP-2 at L5-S1(N=31; 2M:29F, 35 mo. mean f/u) & transforaminal lumbar interbody(TLIF) at distal level(s) with 12 mg BMP-2 in cage & 6mg BMP-2 posterolateral (N=26; 3M:23F, 37 mo. mean f/u). All pts had bilateral sacral-iliac fixation. Pseudo determined by implant failure/low fusion assessment grade. TLIF group cost included: cage, instrumentation, BMP-2 in cage & posterolateral BMP, additional surgeon fee, & OR time. NI cost: BMP-2, carrier, & instrumentation. Outcomes measured by pre & ultimate postop SRS & ODI.

Results: No pseudos in NI group (0/31) or at cage level in TLIF(0/26). A pseudo (1/26 =4%) was found above the cage level in TLIF. TLIFs cost more at L5-S1 than NI ($25,242 v. $10,301;p<0.0001). NI show significantly less EBL(1091cc< 2084cc; p<0.0001) and less surgery time(411min< 501min;p=0.0013) than TLIF. Both groups were otherwise similar: age(μ=58), fixation points(μ=28), fixation density(>or =1.8 per level), Cobb angles, # of vertebrae fused(μ=12.4) and outcomes score(SRS-30 μ change=30%NI; 28%TLIF;p=0.89).

Conclusion: TLIF strategy is more expensive & NOT necessary with sufficient BMP-2 for long fusions to the sacrum/pelvis.

Significance: When using spinopelvic fixation, surgeons can effectively achieve fusion of L5-S1 by using 20mg BMP-2 at that level and forego the use of TLIF with less expense.

PAPER #27*

Clinical Results and Functional Outcome in Adult Patients Following Surgical Treatment for Spinal Deformity: Primary vs. Revision

Hamid Hassanzadeh, MD; Amit Jain; Mostafa H. El Dafrawy, MD; Philip Neubauer, MD; Addisu Mesfin, MD; Richard L. Skolasky, ScD; Khaled Kebaish

USA

Summary: Revision surgery for spinal deformities in adults is thought to be associated with higher complications & poor outcome. We report on the outcome & complications of revisions vs primary surgeries in spinal deformity

Introduction: Few reports examined the outcomes of surgery in adults with spinal deformities; even fewer studies evaluated the outcome of revision surgery. We hypothesize that although the perioperative complications in revision surgery may be higher than following primary procedures, the long term outcome in the 2 groups is comparable.

Methods: We retrospectively reviewed 167 (128F, 39M) consecutive patients ≥40 ys, undergoing surgeries for spinal deformity using a prospectively collected data. We compared the clinical & radiographic parameters, complications & outcome. All patients had minimum 2 ys f/u.

Results: 58 patients average age 60 ys (40-87) underwent primary surgery (group I) & 109 patients, age 59 (40-80) underwent revision (group II). Group II had on average 2 (1-14) prior surgeries. Number of levels fused in group I was 7 (4-18) & in group II 6 (3-17). Most commonly fused levels in both groups were T11-S2, & most common upper instrumented vertebra (UIV) was T11. Preop, postop & final f/u radiographic data in the 2 groups are listed(Table). Average operative time was 540 min (232-690, EBL 2.35L (0.4-8.5) in group I & 495 min (270-660) EBL 2.75L (0.3-8.5) in group II. There were 10 major & 37 minor complications in group I, & 14 major & 71 minor in group II.

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PODIUM PRESENTATION ABSTRACTS

The SRS-24 & ODI for both groups are listed in the Table. All participants had significant improvements in all SRS domains (Self Image, p<.001; Pain, p<.001; Activity, p<.001; & Mental, p<.001). There was significant reduction in disability as measured by ODI (p<.001). Preoperative, there was no significant difference in the SRS domain scores (Self Image, p=789; Pain, p=.481; Activity, p=.360; Mental, p=.955) or ODI (p=.989) between the 2 groups. Post-operative, there was significant difference in mental health (p= 0.04). At final f/u, there was significant difference in self-image (p= 0.02) with better outcome favoring revision patients.

Conclusion: Revision surgery for spinal deformity in adults although technically challenging & considered higher risk by surgeons, has comparable complications & favorable outcome compared to primary surgery in the properly selected individuals

Significance: Revision surgery for spinal deformity in adults should not be contraindicated in the properly selected patients

PAPER #28

The Fate of the Adult Revision Spinal Deformity Patient: A Single Institution Experience

Michael P. Kelly, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Jacob M. Buchowski, MD, MS; Lukas P. Zebala, MD; Linda Koester, BS

USA

Summary: Nearly 20% of adult patients at our institution having had a revision spinal deformity surgery required another unplanned surgery at some point in follow-up. However, these multiply revised patients still showed a benefit from surgery at a minimum 2-year follow-up following their revised revision.

Introduction: Reported revision rates for primary adult spinal deformity (SD) surgeries have ranged from 9% to 25%, but to our knowledge, the revision rate following revision SD surgery has not been reported. The reported improvements in health-related quality of life (HRQL) measures following revision SD surgery have also been quite modest. The aim of this study was to determine subsequent revision rates for all revision SD surgeries performed at a single center and to investigate the changes in measures of HRQL in these patients.

Methods: 504 consecutive adult revision SD surgeries (1995-2008) were identified and the records were reviewed to determine the reason for and timing to any additional operation(s). SRS Outcomes scores were recorded at the first visit, and at planned follow-up (F/U) visits.

Results: 96/504 patients underwent further surgeries for a subsequent revision rate of 19%. 2-year F/U was available for 73 (77%) of these patients (mean F/U 6.0yrs, range 2.3-12.6, gender: F=60, M=13, mean age 52.7yrs, range 21-78). The most common causes of reoperation following revision surgery were pseudarthrosis (N=28, 38%), adjacent segment disease (N=23, 32%), infection (N=13, 18%), and implant prominence/pain (N=12, 16%). 15 (21%) patients underwent more than one revision procedure. SRS Outcomes scores were available for 50 (68%) patients, at an average F/U of 4.9yrs (range 2-11.4). The mean improvements in the SRS outcomes measures were Pain: 0.74 (p<0.001), Self-Image: 0.8 (p<0.001), Function: 0.5 (p<0.001), Satisfaction: 1.2 (p<0.001) and Mental Health: 0.3 (p=0.012).

Conclusion: The rate of repeat revision following revision spinal deformity surgery was 19%, most commonly due to pseudarthrosis, adjacent segment disease, infection and implant prominence/pain. However, significant improvements in SRS outcome scores were still observed in those patients requiring additional revision procedures.

Significance: Patients planning to undergo revision spinal deformity surgery must understand that the chance of needing additional spinal surgeries nears 20%. Despite sometimes requiring a single or multiple revision procedures, adult spinal deformity patients do benefit from revision surgery.

PAPER #29

Is There a Difference in Clinical Outcome between Adult Patients Under and Over Age 60 Who Have Revision Scoliosis Fusion Surgery to the Sacrum?

Samuel K. Cho, MD; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Jin-Seok Yi; Matthew M. Kang, MD; Lukas P. Zebala, MD; Joshua M. Pahys, MD; Christine Baldus, RN, MHS

USA

Summary: Patients older than 60 years of age who underwent long revision fusion surgery to the sacrum for scoliosis had higher complications compared to younger patients (52.0% vs. 39.1%). Both groups reported similar level of function in all SRS domains, except for mental health, and ODI pre- and postoperatively. Further, the extent of improvement with surgery, i.e., change in SRS and ODI scores, was similar in all categories between the two cohorts.

Introduction: To determine whether there is a difference in clinical outcome between adult patients who are either younger (Y) or older (O) than 60 years of age following revision scoliosis fusion surgery to the sacrum.

Methods: Clinical and radiographic assessment of 94 consecutive adult patients who underwent long revision fusion surgery to the sacrum for idiopathic or de novo scoliosis between 2002 and 2007 by 2 surgeons at a single institution with a minimum 2-year f/u were performed. SRS scores and ODI were used. Complications were divided into major and minor (Glassman, Spine 2007).

Results: There were 69 patients in Y group (mean age 47.8+8.6 years) and 25 in O group (66.9+5.5 years). The two groups had similar f/u (Y=3.8+1.3 vs. O=3.3+1.4 years, p=0.19), number of final levels fused (Y=12.1+3.0

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vs. O=12.2+3.5, p=0.93), smoking status (p=0.08), comorbidities (p=0.33), osteotomy (Y=55.1% vs. O=56.0%, p=0.94), posterior rhBMP-2/level (Y=4.4+4.6 vs. O=6.4+5.6 mg, p=0.11), EBL (Y=1449.4+1037.2 vs. O=1593.8+1259.0 ml, p=0.62), length of surgery (Y=8.2+2.4 vs. O=8.1+3.1 hours, p=0.86), and BMI (Y=27.5+6.7 vs. O=28.8+6.1 kg/m2, p=0.39). Overall complications (Y=39.1% vs. O=52.0%), as well as major complications (Y=20.3% vs. O=44.0%), were higher in older patients. Preoperative mental health was significantly worse in younger patients (Y=3.33 vs. O=3.77, p=0.04), and this relationship persisted even following surgery (Y=3.79 vs. O=4.17, p=0.01). Both O and Y patients reported similar level of function in all other domains and ODI before and after surgery. The extent of improvement with surgery, i.e., change in SRS and ODI scores, was similar in all categories between the two cohorts.

Conclusion: Despite a higher rate of complications, older patients over age 60 seem to benefit as much as younger patients following long revision fusion surgery to the sacrum for adult scoliosis.

PAPER #30

The Degree of Contamination While Performing Spine Surgery

Dongki Ahn, MD; Dae Jung Choi; Hoon-seok Park

Republic of Korea

Summary: We performed a microorganism culture at three different locations: surgical field, under the airflow of air conditioner and pathway to door. During the spine surgery, we also performed this culture at two different hourly schedules-one hour and three hours after commencement. The sorts of bacteria, degree and presumptive source of contamination were investigated. Staphyococcus epidermidis was the most common bacteria. Surgical field was the most severely contaminated area presumably by surgeons themselves. The degree of bacterial contamination increased proportionally to the elapsed time.

Introduction: The participants of surgery and ventilation system have been known as the largest sources of contamination. Effective control of bacterial soiling is the best strategy to prevent surgical site infection.

Methods: Two pairs of culture plates for G(+) and G(-) bacteria were placed at three different locations, surgical field, under the airflow of local air conditioner and pathway to door while performing spine surgery in conventional operation room. One pair of culture plates were retrieved after one hour and the other pair were retrieved after three hours. All experiments were done in the same room and in consecutive surgeries. There were 15 cases, 6 groups of 90 pairs of culture plates which were investigated in total. The bacteria were identified and number of colonies was counted. The difference according to the locations and elapsed time was analyzed.

Results: G(-) bacteria was not identified at all. G(+) bacteria were grown at all 90 air culture blood agar plates. Those were comprised of Staphylococcus aureus 19/90(21%), Staphylococcus epidermidis 90/90(100%), Micrococcus 79/90(88%) and Staphylococcus capitis 17/90(19%). The colony count of the one hour group was 14.5±5.4 at the surgical field, 11.3±6.6 under the local air conditioner and 13.1±8.7 at the pathway to door. There was no difference among three locations. The colony count of the three hour group was 46.4±19.5, 30.3±12.9 and 39.7±15.2 respectively. There was more at the surgical field than under the air conditioner(p=0.03). The number of colonies of the one hour group was 13.0±7.0 and the three hour group was 38.8±17.1. There was positive correlation between the elapsed time and the number of colonies(r=0.76, p=0.000).

Conclusion: The degree of contamination was highest at the surgical field presumably due to the continuous exposure to surgeons. Direct airflow of local air conditioner didn't increase the bacterial contamination even without ultraclean air technology. The number of bacteria increased proportionally to the elapsed time.

Significance: The status of bacterial contamination was investigaed at the actual operation room to institute preventive measures against surgical site infection

PAPER #31

Prospective, Randomized Study of Surgical Site Infections with the Use of Perioperative Antibiotics for 24 hours vs. the Duration of a Drain After Spinal Surgery

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USA

Summary: In a prospective randomized study, continuing antibiotics for the duration that a drain is in place after spinal surgery did not decrease the rate of acute surgical site infection.

Introduction: The use of a postoperative spinal drain for spine surgery patients is widely thought to increase the risk of postoperative infection. While antibiotics are commonly given postoperatively to decrease bacterial seeding of the hematoma, the duration of postoperative antibiotics is more debatable, and protocols may vary.

Methods: 315 patients who underwent multilevel thoracolumbar spine surgery requiring a postoperative drain were enrolled and randomized into two groups: one group receiving 24 hours of perioperative antibiotics and one group receiving antibiotics for the duration that the drain was in place. Surgical site infections (SSI) were defined as purulent drainage; organisms obtained from an aseptically obtained culture; pain, swelling and redness; and/or diagnosis of infection by a

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PODIUM PRESENTATION ABSTRACTS

surgeon. Data collected included demographics, medical co-morbidities, type of spine surgery and surgical site infection.

Results: 13/170 (7.6%) in the 24 hours of antibiotic group developed a surgical site infection while 21/145 (14.5%) in the antibiotic for the duration of the drain were found to have a surgical site infection. The differences between each group were significant (p=0.05). There were no significant differences between the groups with respect to demographics, surgical time, type of surgery, drain output or length of stay.

Conclusion: Continuing postoperative antibiotics for the entire duration a drain is in place after spine surgery does not decrease the rate of surgical site infections.

PAPER #32

Surgical Site Infection Following Spinal Instrumentation For Scoliosis: Lessons Learned From an Multi-Center Analysis of 1352 Spinal Instrumentation Procedures For Scoliosis

Michael G. Vitale, MD, MPH; W.G. Stuart Mackenzie, BS, MS II; Hiroko Matsumoto, MA; Christopher Lee, BS; Stephanie R. Cody, BS; Jacqueline Corona, MD; Brendan A. Williams, AB; Lisa Covington, RN, MPH; Lisa Saiman, MD, MPH; John M. Flynn, MD; David L. Skaggs, MD; David P. Roye, MD

USA

Summary: This large, multicenter review provides etiology- and procedure-specific infection rates representative of current techniques and practices. Surgical Site Infection (SSI) rates were determined for definitive fusion in AIS (1.6%) and neuromuscular scoliosis (12.4%). SSI rates associated with growing strategy procedures were: idiopathic-10.2% and neuromuscular-4.4%. S. aureus, S. epidermidis, and P. aeruginosa were the 3 most common organisms identified. An elevated prevalence of gram-negative bacteria (GNB) in non-idiopathic scoliosis SSIs was also observed, indicating a potential need for targeted gram-negative prophylaxis.

Introduction: The purpose of this study is to document the risk factors for, and prevalence and microbiology of infection in a large, diverse, multicenter cohort of children undergoing scoliosis surgery.

Methods: This retrospective chart review included all pediatric scoliosis patients who underwent posterior or combined approach spinal instrumentation at 3 tertiary care children's hospitals between 1/2006 and 12/2008. Demographic and surgical data were collected for each patient, and SSIs were defined according to the CDC's National Healthcare Safety Network case definition. Clinical symptoms and microbiology results were obtained for each infection. Analysis was performed to determine relation between infection rate, scoliosis etiology, surgical procedure and pathogens causing SSI.

Results: 905 patients underwent 1352 procedures (39% idiopathic, 61% non-idiopathic). Infection rate was associated with scoliosis etiology (Idiopathic: 13/510 [2.5%] vs. Non-idiopathic: 65/842 [7.7%], p<0.001). SSI rates for idiopathic fusions and growing procedures differed (7/451 [1.6%] vs. 6/59 [10.2%], p=0.002). Rates varied among etiologies of non-idiopathic scoliosis; neuromuscular (NM) scoliosis rates were higher (36/393 [9.2%]) than those for syndromic (14/160 [8.8%]), other (7/84 [8.3%]) and congenital (8/205 [3.9%]). Fusion and growing procedure SSI rates differed markedly among NM patients (29/233 [12.4%] vs. 7/153 [4.4%]).

The 3 most common organisms in order were: S. aureus, S. epidermidis, and P. aeruginosa. Overall, 46% of SSIs contained ≥1 GNB, with no significant difference in prevalence between centers. Patients with non-idiopathic scoliosis were more likely to have with SSIs caused by GNB than idiopathic patients (31/61 [50.8%] vs. 1/13 [7.7%], p=0.009).

Conclusion: SSI rates were higher for growing strategies than fusion in idiopathic patients (10.2% vs. 1.6%) while an opposite pattern was observed for NM patients (4.4% vs. 12.4%). Gram-negative organisms were much more prevalent among non-idiopathic patients.

Significance: This multicenter review establishes baseline SSI data for modern techniques and practices and strongly suggests a role for routine, targeted prophylaxis for GNB in non-idiopathic spinal instrumentation procedures.

PAPER #33

Assessment of Morbidity and Mortality Collection Data 2009

Dennis R. Knapp, MD; Michael J. Goytan, MD, FRCSC; Joseph H. Perra, MD; Hilali H. Noordeen, FRCS; Justin S. Smith, MD, PhD; Paul A. Broadstone, MD; Sigurd H. Berven, MD; Theodore J. Choma, MD; Christopher P. Ames, MD; Michael S. Roh, MD; Yongjung J. Kim, MD

USA

Summary: This study was undertaken to assess the new SRS Morbidity and Mortality reporting format and the data collected. Comparison could be performed with previous years' information. Membership response rates and number of deformity cases reported increased dramatically. Decreased neurologic injury rates were noted in all categories (scoliosis, kyphosis, and spondylolisthesis). Three of four cases of blindness occurred in adolescent idiopathic scoliosis. Three cases of blindness resolved.

Introduction: The 2009 Morbidity and Mortality (M&M) reporting format was dramatically changed from previous years. This was done in an attempt to simplify the reporting process and to narrow the reporting to only three sentinel events: death, blindness and neurologic injury. Only deformity cases including scoliosis, kyphosis, and grade III or greater spondylolisthesis were included. More detailed information could then be obtained about each of these complications. The purpose of this study was to assess the new format and evaluate the data collected.

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Methods: Results were obtained from the SRS M&M reporting summary for 2009. These were compared to similar statistics obtained from the years dating back to 2001. These included detailed analysis for only complications including death, blindness, and neurologic injury. Blindness has not previously been reported.

Results: 80.1% of SRS members submitted 35,267 deformity cases. Both the percentage of members submitting data and the number of deformity cases far exceeded any previous year total. 57.6% of cases involved scoliosis, 10.5% kyphosis, and 31.9% spondylolisthesis. The largest subcategories were adolescent idiopathic scoliosis 35%, degenerative spondylolisthesis 71.4%, and kyphosis-other 73% (including fixed sagital plane deformity, post traumatic, post laminectomy, osteoporosis, etc). Neurologic complications were lower in each major category (scoliosis, kyphosis, and spondylolisthesis) compared to previous years. The death rate was similar to prior reporting 0.12%. Four cases of blindness were reported, three of which occurred in AIS. Three of four resolved.

Conclusion: The altered format and requirement for all members to participate has dramatically increased the total number of deformity cases reported and percent of membership responding. Neurologic injury rates in each category (scoliosis, kyphosis, spondylolisthesis) are decreased from previous years. Four cases of blindness occurred, three of which resolved. The characteristics of these blindness cases seem to vary from previous reports in the literature. Further collection of data is needed to elucidate mechanism and prevention.

PAPER #34*

Significant Change or Loss of Intraoperative Monitoring Data: A 25 Year Experience in 12,375 Spinal Surgeries

Barry L. Raynor; JosePhD. Bright; Ra'Kerry K. Rahman, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; K. Daniel Riew, MD; Jacob M. Buchowski, MD, MS; Scott J. Luhmann, MD; Anne M. Padberg, MS

USA

Summary: Intraoperative monitoring (IOM) identified 386 patients (3.1%) with significant change or loss of IOM data in a population of 12,375 undergoing spinal surgery. These IOM data changes & subsequent interventions helped reduce this number to 16 patients with permanent post-op neurologic deficits, translating the true positive outcome to 0.13%. Revision spinal surgery has a significantly increased risk of IOM data changes/loss. No improvement/return of data significantly increased the risk of permanent neuro deficit.

Introduction: The purpose of this study was to report the spectrum of intraoperative events responsible for a significant change in or loss of monitoring data to support the efficacy of spinal cord/nerve root monitoring. The study population consisted of a large, single institution series of patients involving all levels of the spinal column (occiput to sacrum).

Methods: Multimodality IOM included somatosensory evoked potentials (SSEP), descending neurogenic evoked potentials (DNEP), motor evoked potentials (MEP) & spontaneous and triggered EMG. 406 instances of change/loss of IOM data occurred in 386 of 12,375 patients operated on between 1/85 & 12/10. 59.3% (7178) of patients were female; 40.7% (5197) were male. Procedures by spinal level: cervical 29.7% (3671), thoracic/thoracolumbar 45.4% (5624) & lumbosacral 24.9% (3080). Age breakdown: >18 yrs 72.7% (8993), <18 yrs 27.3% (3382). 9633 (77.8%) of patients were primary & 2742 (22.2%) were revision surgeries.

Results: Causes for the 406 instances of data change/loss included: instrumentation (n=131), positioning (n=85), correction (n=56), systemic (n=49), unknown (n=24) & focal spinal cord compression (n=15) (see table). Overall, 88.7% (n=360) had improvement following intervention vs. 11.3% (n=46) with no improvement in IOM data. 16 patients had permanent neurologic deficit post-op: 15 of these pts had no improvement in IOM data despite intervention vs. 1 patient with improved data following intervention ($p<0.0001$). Data change/loss was seen in revision (8.4%/231 pts) surgeries significantly more that primary (1.6%/155 pts; $p<0.0001$).

Conclusion: IOM data identified 386 (3.1%) patients with loss/degradation of data in 12,375 spinal surgery procedures. Fortunately, in 93.3% of patients, intervention led to data recovery and no neurologic deficit. Reduction from a potential 3.1% (n=386) of patients with significant change/loss of IOM data to a permanent deficit rate of 0.13% (n=16) patients was achieved ($p<0.0001$), thus confirming the efficacy of intraoperative monitoring.

Significance: Intraoperative interventions leading to IOM data recovery after a data change/loss significantly decreases permanent neurologic deficit.

PAPER #35

Prospective Analysis of Intraoperative Neuromonitoring Events During Spinal Corrective Surgery for Adolescent Idiopathic Scoliosis

Jody Buckwalter, PhD; Burt Yaszay, MD; Tracey Bastrom, MA; Ryan M. Ilgenfritz, MD; Peter O. Newton, MD; Harms Study Group

USA

Summary: The rate of intraoperative neuromonitoring events was 3.6% when utilizing both TcMEPs and SSEPs during AIS surgery. The majority (86%) of these returned to baseline following corrective action: elevate blood pressure, adjust screw position, and remove traction. Of the 3 that remained abnormal, 2 awoke with neurologic deficits

Introduction: The purpose of this study was to determine the frequency and outcome of intraoperative neuromonitoring alerts during surgical correction of AIS.

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Methods: Prospectively gathered clinical data and intraoperative neuromonitoring reports recorded during spinal surgery for AIS were analyzed. Patients were divided into two groups, those with clear intra-operative neuromonitoring changes and those with no intra-operative neuromonitoring events. A neuromonitoring event was defined as a change from baseline Transcranial Motor Evoked Potentials (TcMEPs) or SomatoSensory Evoked Potentials (SSEPs) in the lower extremities. The risk, rate, cause and outcome of each neuromonitoring alert were assessed.

Results: A total of 582 AIS cases were analyzed. 21 cases (3.61%) had an intraoperative neuromonitoring event. In 18 of the 21 cases (86 %) the potentials returned to baseline following corrective action. Of the 3 with remaining abnormalities, 2 (0.3%) awoke with deficits (1 with unilateral weakness, 1 with unilateral sensory changes). In 12 cases the changes were thought to be due to low BP, all responded to elevation of the mean arterial pressure. 5 changes were associated with misplaced screws (in 4 the monitoring returned after removal/redirection, all 5 normal postop). Traction was the cause in 2 cases, both responding to reduction in traction. In 4 cases the cause was unclear. 2 remained abnormal and both awoke with a neuro deficit. There were no postoperative neurologic deficits in any cases with normal neuromonitoring. Surgical time (416 min vs. 290 min, $p<0.001$) and estimated blood loss (1971 ml vs. 1034 ml, $p<0.001$) were both significantly increased in the cases in which intraoperative events were observed.

Conclusion: The rate of neuromonitoring changes was 3.6% when utilizing both TcMEP and SSEP monitoring, most responsive to elevation of the MAP. When a cause was identified and corrective action taken, there were no postoperative neuro deficits. 2 of the 582 cases (0.3%) had postop deficits, both in cases where the cause of the change was unclear.

PAPER #36

Intrawound Vancomycin Powder Lowers the Acute Deep Wound Infection Rate in Adult Spinal Deformity Patients

Ra'Kerry K. Rahman, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Jacob Buchowski, MD, MS; Douglas D. Dickson, MD; Alexander Aleem, MD; Brenda A. Sides, MA

USA

Summary: 920 adult spinal deformity procedures were analyzed after receiving preop and postop IV antibiotics alone (IV-ABX) or preop and postop IV antibiotics and intrawound Vancomycin powder (IW-vanco + ABX). The IW-vanco+ABX group had a lower acute infection rate versus IV-ABX alone (0.7% vs. 5%; $p<0.0001$) Intrawound vanco powder is effective in lowering acute deep wound postop infection rates.

Introduction: Postop spinal infection can be a devastating complication, especially for pts with instrumentation. The novel use of intrawound vanco powder has been reported in spinal surgery patients, but not in the spinal deformity population. We hypothesize that intraop administration of intrawound vanco powder plus IV Antibiotics will effectively lower the rate of acute postoperative infections when compared to IV antibiotics alone.

Methods: A single center study of 920 procedures was undertaken. The control group, IV-ABX, (N=334) had preop/postop IV antibiotics only & underwent spinal deformity surgery between 2002-2005. The study group, IW-vanco+ABX, (N=586) received preop/postop IV antibiotics plus intraop intrawound vanco powder (1-2gm) and underwent surgery between 2007-2010. 2005-2007 was a transition period with some pts receiving the vanco powder and some not; therefore, we excluded this time period to reduce inaccuracy. 2 surgeons operated on both groups; prepping, draping, and staff were unchanged between the control and the study group. The vanco powder (500-1000gm) was applied immediately before closure onto the spine and paraspinal musculature. Additional vanco powder (500-1000gm) was placed directly onto the closed fascia. All pts had Hemovac drains deep and superficial with IV antibiotics continued until all drains removed. Infection was defined as deep wound process requiring operative I&D within 90 days of index procedure. Stats: Chi2.

Results: The deep wound infection rate for IW-vanco+ABX (4/586) = 0.7% was significantly less than the IV-ABX rate of (16/334) = 5% [$p<0.0001$]. Evaluation of infected procedures showed: revision surgeries: 75% (IW-vanco+ABX) vs 50% (IV-Abx); smoking: 25% (IW-vanco+ABX) vs 38% (IV-Abx); BMI >0 kg/m2 25% (IW-vanco+ABX) vs 50% (IV-Abx). Further study group characterization included in Figure 1. The small number of infections prevents statistical analysis of differences among infected patients. There were no complications associated with the use of intrawound vanco.

Conclusion: Intrawound Vancomycin powder along with IV-ABX effectively lowers the deep postop wound infection rate in adult spinal deformity pts vs IV-ABX alone. This method is both a safe and inexpensive in lowering deep wound infection rates.

PAPER #37

Prophylactic Operative Site Powdered Vancomycin and Postoperative Deep Spinal Wound Infection: 1,512 Consecutive Surgical Cases during a Six-Year Period

William J. Molinari, MD; Oner Khera, MD; Robert W. Molinari, MD

USA

Summary: During a 6-year period 1512 consecutive adult spinal surgical cases were performed by a single surgeon in which 1 gram of powdered vancomycin was placed in the wound prior to closure. The overall rate of deep wound infection was .86% (13/1512). The rate of deep wound infection was 0.90%

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(6/663) for instrumented spinal surgeries, and 0.82% (7/849) for uninstrumented surgeries. Deep infection occurred in only 0.93% (3/324) of multilevel instrumented posterior spinal fusion procedures The use of intraoperative powered vancomycin appears to be associated with a low rate deep spinal wound infection in this case series. Rates of deep infection for instrumented fusion surgeries in this series appear to be among the lowest reported in the existing literature. Further investigation of this prophylactic measure is warranted.

Introduction: The use of intraoperative powdered vancomycin as a prophylactic measure in an attempt to reduce the incidence of postoperative deep spinal wound infection has not been sufficiently evaluated in the existing literature.

Methods: During the period from 2005-2010, 1512 consecutive adult spinal surgery cases were performed by the same fellowship-trained spinal surgeon (RWM) at a level one trauma center. One gram of powdered vancomycin was placed in all surgical sites prior to wound closure. 849 cases were uninstrumented, 443 cases were instrumented posterior thoracic or lumbar, 27 instrumented anterior thoracic or lumbar, 146 instrumented anterior cervical,47 instrumented posterior cervical. A retrospective operative data base and medical record review was performed to evaluate for evidence of postoperative wound infection.

Results: 13 of the 1512 patients (0.86%) were identified as having evidence of postoperative deep wound infection. All 13 patients had reoperation for wound irrigation, debridement, and reclosure. Staph aureus and MRSA were the most commonly identified organisms (10/13 cases). The rate of deep wound infection was 0.90% (6/663) for instrumented spinal surgeries, and 0.82% (7/849) for uninstrumented surgeries. Deep infection occurred in only 0.93% (3/324) of multilevel instrumented posterior spinal fusions, 0.73% (1/73) of open PLIF procedures, and 0.81% (1/81) of single-level instrumented posterior fusions. Deep infection was not observed in any patient who had uninstrumented spinal fusion (0/162). Increased rates of complications related to powered vancomycin use were not identified in this series.

Conclusion: Powdered intraoperative vancomycin placed in the wound prior to closure appears to associated with a low rate deep spinal wound infection in both instrumented and uninstrumented cases. Rates of deep infection for instrumented fusion surgeries appear to be among the lowest reported in the existing literature. Further investigation of this prophylactic measure using the case-controlled methodology with larger surgical subpopulations is warranted.

Significance: Rates of deep infection for instrumented spinal fusion surgeries in this series appear to be among the lowest reported in the existing literature.

PAPER #38

How Commonly are Pedicle Screws Adjacent to the Great Vessels or Viscera? A Study of 2,295 Pedicle Screws

Terry D. Amaral, MD; Adam L. Wollowick, MD; Preethi M. Kulkarni, MD; Beverly Thornhill, MD; William Suggs, MD; Etan P. Sugarman, MSIV; Jonathan J. Horn; Vishal Sarwahi, MD

USA

Summary: Misplaced pedicle screws impinging upon blood vessels or viscera is a rare but formidable event and seems to be unrelated to patient or curve characteristics.

Introduction: The rate of pedicle screw misplacement is estimated to be 10%. Vascular or visceral injury can be catastrophic for the patient. As most misplacements are asymptomatic, they are frequently undetected. This study identified the rate of screw placement in proximity to vital structures using post-operative CT scans.

Methods: Post-operative low-dose CT scans of 106 patients who underwent posterior spinal fusion for scoliosis were reviewed. Screws adjacent to, in contact with, impinging upon, or penetrating blood vessels, pleura, esophagus, diaphragm, or trachea were evaluated. 2229 screws were reviewed. Limited low-dose CT scan in the prone position was performed when screw location was ill defined. Patient and curve characteristics were recorded for correlation.

Results: 45 screws (2.2%) in 27 patients (25%) were found to be of great concern. 36 were in proximity to aorta, 1 to left subclavian artery, 5 to esophagus, 3 to trachea, 2 to pleura, and 1 to diaphragm. Of the 36 screws in proximity to the aorta, 13 screws in 6 patients were impinging or distorting the aortic wall. 95% of misplaced screws were in the thoracic spine. 53.3% were lateral, 28.9% were anterolateral, and 17.8% were anterior. 55.5% were 35mm long, 37.7% were 30mm, and 6.6% were 25mm. 56% were in pedicles with normal morphology, and 75% were in curves between 40-70 degrees.

Conclusion: Pedicle screws placed in close proximity to blood vessels or viscera are rare when compared to the total number of screws placed. However, a large number of patients (25%) had screws of concern. Most are in the thoracic spine, in curves between 40-70 degrees, and are equally likely in normal and abnormal pedicles. However, the majority of misplacements are asymptomatic and thus are undetected.

Significance: Although only a small number of screws are of concern, they occurred in a large percentage of patients (25%). A single screw of concern in any patient can lead to significant consequences for the patient. Surgeons placing pedicle screws in deformed spines must be vigilant about proper placement. Post-operative imaging beyond routine x-rays may be needed to detect screws of concern even in asymptomatic patients.

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PODIUM PRESENTATION ABSTRACTS

PAPER #39

CT-guided (O-Arm) Navigation of Thoracic Pedicle Screws for AIS Results in More Accurate Placement and Less Screw Removal

Ejovi Ughwanogho, MD; John M. Flynn, MD; Neeraj M. Patel, MBS; Keith Baldwin; Norma Rendon Sampson, MS

USA

Summary: In a study of 485 thoracic pedicle screws for AIS, a CT (O-arm) guided technique yielded significantly more accurate placement and fewer screw removals than a freehand technique with C-arm.

Introduction: Several recent studies show that, even in experienced hands, thoracic pedicle screws are misplaced more than 10% of the time. CT (O-arm) guided navigation may improve accuracy and safety, but there is little data weighing its benefits against cost and radiation concerns. We performed an independent evaluation of CT (O-arm) guided navigation vs. standard freehand with C-arm technique to compare accuracy of screw placement and frequency of removal.

Methods: We reviewed intraoperative CT images in a consecutive series of PSF AIS cases over a 1-year period. All surgeons were experienced SRS members; no authors have a financial relationship to the O-arm manufacturers. Three types of screws were identified: (1) an optimal screw - the central axis is in the plane & axis of the pedicle with the tip completely within the vertebral body; (2) an acceptable screw - the majority of the screw shank is outside the central axis of the pedicle, but not potentially unsafe; (3) a potentially unsafe screw - either (a) the central axis of the screw traversed the spinal canal, (b) there was left anterior/lateral vertebral body perforation, risking the aorta, or (c) the surgeon removed or repositioned the screw after reviewing the intra-operative, post-implant CT.

Results: 547 thoracic screws were assessed in 42 patients; 485 screws were evaluable with a visible pedicle and screw (300 O-arm, 185 non-navigated). Fewer potentially unsafe screws were placed with navigation ($p < 0.001$). A potentially unsafe screw was 3.8 times less likely to be inserted with navigation ($p = 0.003$) (Table 1). The odds of a significant medial breach (> 50% of the screw diameter) were 7.6 times higher without navigation ($p < 0.001$). A screw was 8.3 times more likely to be removed intra-operatively in the non-navigated cohort ($p = 0.003$). Two patients in the freehand cohort had bilateral pleural effusions.

Conclusion: Using a CT guided (O-arm) navigation technique, experienced surgeons were able to place thoracic pedicle screws with significantly better accuracy. Compared to a freehand (with C-arm confirmation) technique, CT-guided navigation resulted in more optimally placed thoracic pedicle screws, fewer potentially unsafe screws, and fewer screw removals.

PAPER #40

Neuromonitoring Changes are Common and Reversible with Temporary Distraction Rods for Severe Scoliosis (Mean 113°)

David L. Skaggs, MD; Christopher Lee, BS; Karen S. Myung, MD, PhD

USA

Summary: Use of temporary rods to provide internal distraction in the correction of severe scoliosis is an alternative to halo traction or VCR. In this retrospective study, we find that posterior-only spinal fusion with temporary distraction rods provides very significant correction of severe deformity, comparable to VCR, as well as a large increase in height (mean 8 cm), in a neurologically safe manner, provided there is high quality neuromonitoring.

Introduction: Use of temporary rods to provide internal distraction in the correction of severe scoliosis is an alternative to halo traction or VCR. We examine the neurologic implications of applying significant distraction to large curves.

Methods: A retrospective review of a single surgeon's consecutive experience with posterior-only spinal fusion with temporary distraction rods was performed. Inclusion criteria were long posterior spinal fusions performed for scoliosis > 80°. 24 patients with average age 14 years and an average of 14 levels fused (7-19) were included.

Results: The average preoperative Cobb angle was 113° (84-144°), and an average correction of 58° (51%) was achieved. There was an average T1-S1 increase of 8.4 cm (2.4-14 cm). 7 patients had staged correction, and 17 patients had a single surgery. 9/24 patients (37%) had intraoperative neuromonitoring events, which were reversed within moments of releasing distraction on the temporary rod. No patient had a clinical neurologic deficit. There were no deaths. Patients with neuromonitoring events had a higher rate of staged procedures (56%, $p=0.082$), yet achieved the same amount of final correction as patients who did not have neurologic events ($p=0.71$).

Conclusion: Use of temporary rods for severe scoliosis produces curve correction similar to VCR, while providing a mean increase in T1-S1 height. We find this technique to be technically easier than a VCR. Most steps are reversible, never creating a completely unstable spine. Neuromonitoring changes are common (37%), but immediately reversible with release of distraction. When neuromonitoring changes occur, we recommend consideration of finishing surgery another day to allow the spinal cord to accommodate. Neuromonitoring changes did not affect final magnitude of correction. We recommend this procedure be performed only with good neuromonitoring.

Significance: Posterior-only spinal fusion with temporary distraction rods provides very significant correction of severe spinal deformity (mean 113°), with a large increase in height, in a neurologically safe manner, provided there is good quality neuromonitoring.

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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).

PAPER #41

Can Intraoperative Spinal Cord Monitoring Reliably Help Prevent Paraplegia during Posterior VCR Surgery?

Samuel K. Cho, MD; Lawrence G. Lenke, MD; Shelly Bolon, BS, CNIM; Joshua M. Pahys, MD; Woojin Cho, MD, PhD; Matthew M. Kang, MD; Lukas P. Zebala, MD; Linda Koester, BS

USA

Summary: Retrospective review of 90 consecutive all-posterior vertebral column resection surgeries at the spinal cord level for severe spinal deformity demonstrated 16.7% intraoperative spinal cord monitoring data change, most of which occurred during osteotomy and rod compression. All patients had return of data with immediate intervention and had intact lower extremity neurologic function postoperatively. These SCM "saves" strongly emphasize the importance of using multimodal neurophysiologic monitoring during such high risk cases to minimize postoperative paraplegia.

Introduction: Posterior vertebral column resection (VCR) is an increasingly common technique to treat severe adult and pediatric spinal deformity but carries a potentially high risk of major spinal cord deficits.

Methods: Clinical and radiographic assessment of 90 consecutive adult and pediatric pts (mean age 24.8yrs, range 7.5-76.8) who underwent VCR at or above L1 (spinal cord level) with detectable intraop spinal cord monitoring (SCM) data for severe spinal deformity was performed. All surgical procedures were performed between 2002-2010 by 1 surgeon at 1 institution. The electrophysiologic monitoring records, surgeon's operative reports, and radiographs were used.

Results: 15 pts (10M/5F; mean age 14.8yrs) out of 90 (16.7%) had either loss of SCM data (n=13) or degradation to meet warning criteria (n=2). Diagnoses were kyphoscoliosis (n=8), angular kyphosis (n=3), global kyphosis (n=2) and severe scoliosis (n=2). 7 were revisions. Mean operative time was 531min and EBL was 963mL. The ave pre and postop scoliosis for these 15 pts was 92.4° (range 11-150°) and 40.2° (range 0-76°), respectively. The ave pre and postop kyphosis was +100.4° (range 60-170°) and +54.0° (range 32-100°), respectively. SCM fluctuated during osteotomy on 9 occasions that stabilized with elevation of blood pressure in all cases, in addition to anterior spinal cord decompression in 4, correction of subluxation in 1 and lessening of traction in 1. 7 pts had SCM change during rod compression, requiring partial release of correction in 3, larger cage insertion in 2, correction of subluxation in 1 and removal of pedicle screw in 1. 1 pt experienced SCM changes during rod placement/removal and another due to hypothermia. All 15 pts had return of SCM data following prompt intervention (mean 10.1 min, range 1-60) and awoke with intact lower extremity neurologic function.

Conclusion: The prevalence of intraop SCM data change during VCR surgery was 16.7%, most of which occurred during osteotomy and rod compression. All pts had return of data with immediate intervention and had intact lower extremity neurologic function postop. These SCM "saves" strongly emphasize the importance of using multimodal neurophysiologic monitoring during such high risk cases to minimize postop paraplegia.

PAPER #42

Neurophysiologic Monitoring of Thoracic Pedicle Screws Intentionally Located within the Spinal Canal. An Experimental Study on Pigs

Luis Miguel Antón-Rodrigálvarez, PhD; Elena Montes; Jesús J Burgos Flores, PHD; Gema De Blas, MD, PhD; Carlos Barrios; Eduardo Hevia, Dr; Carlos Correa; Rafael Lorente, PhD; Daniel Jiménez; Ignacio Regidor, MD, PhD

Spain

Summary: In a pig model, screws were intentionally placed inside the spinal canal with different grades of cord displacement. Evoked potentials were recorded by cord-to-cord technique. Thoracic pedicle screws causing slight spinal cord displacement do not cause immediate or delayed neurophysiologic changes of spinal cord potentials. Those screws causing marked lateral displacement of the spinal cord cause late neurophysiologic changes that, in most cases, recover 15 minutes after removal of the screw.

Introduction: A high proportion of thoracic screws invading the spinal canal may not be detected by intraoperative neurophysiologic current techniques. The aim of this study was to experimentally assess the neurophysiologic changes occurring in the spinal cord during thoracic pedicle screws placement within the canal.

Methods: The spinal canal of 3 domestic pigs was exposed by a right hemilaminectomy at three different thoracic levels (T6, T9 and T11). Pedicle screws (diameter 4.5 mm) were intentionally placed within the canal. A screw was firstly placed on the outer edge of the dural sac causing slight cord displacement. A second screw was later placed in the center of the canal causing a marked encroachment of the dural sac. Evoked potentials were recorded distally in the spinal cord during and after the screws placement with one-minute intervals. If the potentials disappeared, the screw was removed and potentials recording continued for 15 minutes more to assess recovery.

Results: In all nine experiments, there were no alterations in evoked potentials during the 20 minutes recording when the screws were placed at the outer edge of the dural sac. Changes in the evoked potentials occurred when the screws were placed in the center of the canal. Minimal changes occurred a mean period of 10.1 ± 2.1 minutes from the screw placement. Complete loss of potentials

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occurred at a mean period of 11.6 ± 1.9 minutes. After screws removal, evoked potential began to recover after a mean latency of 9.7 ± 3.0 minutes in 6 screws, and there was no recovery in the other 3 after 15 minutes of monitoring.

Conclusion: Thoracic pedicle screws causing slight spinal cord displacement do not cause immediate or delayed neurophysiologic changes of spinal cord potentials. Those screws causing marked lateral displacement of the spinal cord cause late neurophysiologic changes that, in most cases, recover after removal of the screw.

Significance: This work shows the difficulties to detect some misplaced screws by the current neurophysiologic techniques. Only those screws severely encroaching the spinal cord show changes in the elicited evoke potentials

PAPER #43

Complications of Posterior Vertebral Column Resection in Children with Severe Spinal Deformity - A Single Center Experience

Firoz Miyanji, MD, FRCSC; Arjun Dhawale; Bronwyn Slobogean; Christopher Reilly

Canada

Summary: Posterior vertebral column resection (VCR) has been described for the treatment of severe rigid spinal deformity. Although satisfactory curve correction can be obtained, a significant complication rate may be encountered. In our series of 19 patients, 6 had intra-operative neuromonitoring changes, 7 had deep wound infections, 2 had revision of their instrumentation, and 1 pseudarthrosis occurred. Our results caution surgeons around the significant complication rate associated with these technically demanding procedures.

Introduction: Vertebral column resection (VCR) through a single posterior approach has been described for the treatment of severe rigid spinal deformity with Lenke et al. reporting on the only pediatric series. We evaluated the early results and complications of posterior VCR in 19 children.

Methods: This is a retrospective review of 19 children with spinal deformities of various etiologies that underwent VCR over a 3 year period (2007-2010). The primary outcome was mean %curve correction. Secondary outcome measures were operative time (ORT), estimated blood loss (EBL), intra-operative neuromonitoring changes, length of hospital stay (LOS), and peri-operative complications.

Results: Of the 19 cases, 6 were revision surgeries. A one-level VCR was performed in 15 cases and >1 level VCR was done in 4 cases. Five patients had staged procedures. In these 19 patients, 6 had intra-operative neuro-monitoring changes; 4 had MEP changes and 2 patients had both MEP and SSEP changes. One patient had complete neurological deficit and 2 patients had a transient neurological deficit immediately post-operatively with full recovery at final follow-up. Seven patients had deep wound infections requiring repeat debridements. Revision of implant prominence was required in 2 patients, and there was 1 pseudarthrosis. [Table1]

Conclusion: Although satisfactory curve correction is achieved with posterior VCR, there is a high rate of peri-operative complications with a risk of neurological deficit. Deep wound infection is not uncommon in these complex surgeries possibly due to the prolonged operative time.

Significance: Posterior VCR should be performed very selectively weighing the potential advantages of curve correction through a single approach against a potential significant complication rate.

PAPER #44*

Vertebral Column Resection for Pediatric Spinal Deformity. A Population Based, Multicenter, Retrospective Follow-Up Study

Ilkka Helenius, MD, PhD; Olli T. Pajulo, MD, PhD

Finland

Summary: Need and outcomes of VCR for pediatric spinal deformity were evaluated in a population based follow-up study. The incidence of VCR was 3.5 per one million per year. VCR provided 64% correction of the initial deformity without any permanent neurologic complications.

Introduction: Severe spinal deformity may necessitate vertebral column resection (VCR) to allow adequate correction. VCR can be performed anteroposteriorly (AP) or posterolateral only (PL).

Methods: All VCRs (n=45) for pediatric spinal deformity were retrospectively identified from four university hospitals performing these procedures in our country between 2005 and 2009 with a minimum two-year follow-up. After excluding single hemivertebra resections (n=25) and vertebral column resections performed for patients with MMC (n=6), 14 patients with full VCR (mean age at surgery 12.3 yrs [range 6.5-17.9] AIS 1, NMS 3, Congenital scoliosis 1, Congenital scoliosis revision 4, Congenital kyphosis 2, global kyphosis 2, and secondary scoliosis associated with NF 1 pt) were identified. Seven procedures were performed AP and seven PL. Mean follow-up time 2.6 years (range 2.0 - 5.5).

Results: Major Curve (MC) averaged preop 86 (67 - 120), 31 (15-53) at 6 mths, and 37 (17-80) deg at 2 yr fu. MC correction averaged 61% (46-86%) in the AP and 67% (57-83%) in the PL group at 6 months and 54% (18-86%) and 60% (41-70%) at 2-yr FU (NS). Blood loss averaged 4200 (range 500-8200) mL with no differences between the study groups. The mean SRS-24 total scores were 100 (92-108) for the AP and 102 (95-105) for the PL group. There was one paraparesis in the AP group necessitating urgent re-decompression of the spinal cord due to compression of bone graft applied anteriorly with full

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recovery. One peripheral L5 motor deficit resolved fully within few days (PL group). Two junctional kyphosis were observed (one in both group), the other required revision surgery. One one-sided partial lower instrumentation pull-out was observed, but spinal fusion occurred during follow-up without additional procedures. One pseudoarthrosis occurred after thoracolumbar VCR in AP group.

Conclusion: Full VCR is rarely needed for pediatric spinal deformity with an estimated incidence of 3.5 per one million per year. All posterior VCR allows better control of spinal cord during deformity correction as compared with AP approach.

Significance: VCR performed AP or PL only provides good correction of severe pediatric spinal deformities with acceptable complication rate and high patient satisfaction.

PAPER #45

Youth and Experience: The Effect of Surgeon Experience on Outcomes in AIS Surgery

Patrick J. Cahill, MD; Amer F. Samdani, MD; Joshua M. Pahys, MD; Megan Gresh, MD; Burt Yaszay, MD; Michelle C. Marks, PT, MA; Tracey Bastrom, MA; Baron S. Lonner; Suken A. Shah, MD; Harry L. Shufflebarger, MD; Peter O. Newton, MD; Randal R. Betz, MD

USA

Summary: Surgeons who have less than five years of experience in practice have significantly higher operative times and blood loss and lower SRS-22 scores than their more experienced counterparts.

Introduction: Single surgeon series on the learning curve in spinal deformity surgery have been published but may be confounded by changes in technology and techniques. We present the first cross-sectional multicenter analysis of the impact of surgeon experience on surgery for adolescent idiopathic scoliosis (AIS).

Methods: A multicenter prospective study of AIS provided the dataset for assessment. All surgeries performed in 2007 and 2008 with 2 years of follow-up were included. Two groups were created based on the surgeon experience. The young surgeons' group (YS) included subjects who were operated on by surgeons with < 5 years experience, and the experienced surgeons' group (ES) were those operated on by surgeons with 5 or more years of experience. Various outcomes were compared.

Results: 165 subjects who were operated on by 9 surgeons (YS: 4, ES: 5) were included in the analysis. The surgeon's experience in AIS surgery ranged from < 1 to 36 years. The groups had similar pre-op curve magnitudes, SRS-22 scores, and distribution of Lenke curve types. There were significant peri- and post-op differences. YS fused an average of 1.2 levels longer than ES ($p=0.045$). The average blood loss in YS was more than twice that of the ES (2042 cc v. 1013, $p<0.001$). The duration of surgery was 458 v. 265 minutes, respectively ($p<0.001$). The overall SRS-22 scores were significantly worse in the YS group (4.1 vs. 4.5, $p=0.001$). The difference was significant in the domains of pain ($p=0.018$), self-image ($p=0.008$), and function ($p=0.00$). Complication rates were not different.

Conclusion: Perioperative results and health related quality of life are significantly positively correlated with surgeon experience in AIS surgery.

Significance: This is to our knowledge the only cross-sectional study of the effect of surgeon experience on the outcomes of AIS surgery.

PAPER #46

Effect of Spine Fellow Development on Operative Time and Complication Rate

Qusai Hammouri, MD; Jamie S. Terran, BS; Baron S. Lonner; Thomas Errico

USA

Summary: The effect of spine fellow assistantship during adult spinal deformity surgery has never been assessed. We sought to determine the impact of a fellow's education over the course of the academic year on intra-operative surgical outcome.

Introduction: There is a high cost, both financially and physically to patients who undergo surgery for idiopathic scoliosis. There has been a movement to ensure that all surgical procedure is causing no additional negative impact on the patient. The education of residents and fellows intraoperatively seems the next factor which must be analyzed regarding surgical outcomes. The authors sought to determine the effect of fellow development over the course of the academic year on surgical outcomes in complex spine surgery.

Methods: 67 Patients were identified as a subset of the patients isolated from a previous project. Idiopathic scoliosis (IS) patients operated by a single attending at a single institution with a fellow as the only surgical assistant were included. The deidentified data sheet was queried for demographic and perioperative data and segmented by surgical data into quarters according to the academic year; August - October, November - January, February - April and May -July. Several intra operative factors were examined and compared with ANOVA to determine differences between the quarters of the year.

Results: There were no significant differences between the groups regarding age, sex, or Lenke curve type. After surgery we found no statistically significant differences between the quarters regarding EBL, Length of Stay, Operative time, use of cell saver, and complication rate. (Table 1)

Conclusion: Never before has the effect of fellow development over the course of the academic year been assessed in IS population (has it been for other populations) . It is clear that while there is significant academic benefit to the fellows as they complete their spine fellowship there is not negative impact for patients.

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Significance: It is equally important that spine fellows education be substantial and that their participation not negatively impact patient safety. Recent studies showed there is no significant difference between attendings and fellows as assistants, we have expanded on this knowledge demonstrating there is no difference in outcomes from the start and the end of the fellowship year.

	Operative Time	EBL	Length of Stay
Quarter 1	226.3	1176.5	5
Quarter 2	193.6	1775	6
Quarter 3	222.6	1128.6	6
Quarter 4	205.7	1296.7	5

PAPER #47

The Effect of Early Fusion at Ten Years or Earlier for Early Onset Scoliosis - Comparison between 43 Early Fusion Patients and 39 Growing Rod Patients

Koki Uno, MD, PhD; Teppei Suzuki; Noriaki Kawakami, MD; Taichi Tsuji; Morio Matsumoto, MD; Kota Watanabe; Katsushi Takeshita; Manabu Ito, MD, PhD; Hiroshi Taneichi, MD; Toru Hirano; Haruhisa Yanagida, MD; Ken Yamazaki, MD; Takuya Yamamoto; Shiro Imagama, MD; Shohei Minami

Japan

Summary: To evaluate the effect of early fusion for early onset scoliosis (EOS), 43patiens who had fusion at 10years old or earlier(Fusion Group;FG) and 39 EOC patients treated with dual growing rod(Growing Rod Group;GRG) was examined and compared. Spine elongation(T1-S1 gain after surgery)and lung space gain between pre and post opeative period was significantly less in FG. However there was no statistical difference of lung space between post and final follow, curve correction, and spinal balance.

Introduction: To evaluate the effect of early fusion for early onset scoliosis (EOS), 43patiens who had fusion at 10years old or earlier(Fusion Group;FG) and 39 EOC patients treated with dual growing rod(Growing Rod Group;GRG) was examined and compared.

Methods: There were 43 patients(16 male, 27 female) inFG, and 39 patients (17 male, 22 female)in GRG , average age at surgery was 8.1 and 8.5 years and average follow up was 7.5 and 4.2 years respectively. Diagnosis included idiopathic in10(FG), 8(GRG), Congenital in 0(FG), 6(GRG), Neurifibromatosis in 11(FG),4(GRG), Marfan in 6(FG),0(GRG) , Syndromic in 3(FG), 3(GRG), Neuromuscular in 4(FG),6(GRG) , and others in 9 (FG),8(GRG) respectively.

Data of FG was collected from 7 different hospital as a multicenter study, and the data of GRG was collected from one institution. Hight, sitting hight, radiological findings(magnitude of scoliosis,kyphosis, T1-S1 length, lung capacity, trunk balance), at pre, post surgery, final follow up was measured and examined. Clinical symptoms of the FG was also examined.

Results: Curve Magnitude was 73(FG) and 80 degees(GRG) pre op, 29 (FG) and 30degrees (GRG)post op, 35 (FG)and 35 (GRG)degrees at final follow.

Kyphosis(T5-12) was 45(FG) and 40(GRG) degees pre op, 30(FG) and 30(GRG)degrees post op, and 30 (FG) and 35(GRG) degrees at final follow up.

Good Coronal balance and sagittal balance was obtained in both groups. T1-S1 gain between pre and post operative period was 29(FG),38mm(GRG)(p=0.02), T1-S1 gain between post op and final follow was 25(FG),49(GRG)mm respectively.(p=0.017). Lung space gain was 14(FG),22(GRG) mm between pre and post op period(p=0.006). However lung space between post op and final follow was 23(FG), 29(GRG)mm), and there was no significant difference.

Conclusion: Spine elongation(T1-S1 gain after surgery) throughout the treatment and lung space gain between pre and post opeative period was significantly less in FG. However there was no statistical difference of lung space between post and final follow, curve correction, and spinal balance. The clinical significancy of these results need to be examined.

Significance: This is the first paper compared early fusion and growing rod for EOS with respect to spine elongation and lung space gain.

PAPER #48

Proximal Junctional Kyphosis in Distraction-Based Growing Rods

Christopher Lee, BS; Karen S. Myung, MD, PhD; David L. Skaggs, MD

USA

Summary: This study examines the rate of proximal junctional kyphosis (PJK) in distraction-based growing rods. PJK occurs in more than half of children (56%) treated with distraction-based growing rods. When PJK occurs, the final fusion is likely to involve additional cephalad vertebrae than the original growing rod construct. In addition, we find that placement of upper anchors on ribs reduces the risk of PJK.

Introduction: This study examines the rate of proximal junctional kyphosis (PJK) in distraction-based growing rods.

Methods: A retrospective review of 32 consecutive cases with growing rods for early onset scoliosis was performed. Average age at initial surgery was 4 years (1-10), with diagnoses of congenital scoliosis (15), neuromuscular (11), idiopathic (4), and other (2) were included. Minimum follow up was 24 months (mean 52, 24-88). PJK was defined as fulfilling 2 criteria: 1. An angle >10° between the endplates of the vertebrae two levels cephalad to the upper

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instrumented vertebrae and two vertebrae caudal to the upper instrumented vertebrae; 2. This angle must be at least 10° greater than preoperative values. Z-test was performed to compare rates.

Results: Of the 32 patients, 18 (56%) developed PJK. 8/ 18 patients (44%) with PJK had upper anchor failure, with 7 requiring unplanned operations to revise the failed implants. In comparison, 5/14 patients (36%) without PJK had upper anchor failure, which was not statistically significant (p=0.89). In the 4 patients with PJK that underwent final fusion, 3 (75%) underwent fusion and instrumentation to levels cephalad to the growing rod construct. PJK was more common in patients with dual rods (10/16; 62%) than single rods (5/13; 38%) (p=0.36), and in spine-to-spine constructs (10/17; 59%) compared to hybrid constructs (upper hooks on ribs) (5/12; 42%) (p=0.59).

Conclusion: With a mean follow-up of 4 years, 56% of patients with distraction-based growing rods developed PJK. PJK is almost twice as common with dual rods compared to single rods, and more common if the upper anchors are spine anchors compared to rib anchors.

Significance: PJK occurs in more than half of children treated with distraction-based growing rods, and the final fusion is likely to involve additional cephalad vertebrae than the original growing rod construct. Placement of upper anchors on ribs reduces the risk of PJK.

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).

PAPER #49

Psychosocial Effects Of Repetitive Surgeries In Children With Early Onset Scoliosis: Are We Putting Them At Risk?

David P. Roye, MD; Hiroko Matsumoto, MA; Jacqueline Corona, MD; Brendan A. Williams, AB; Benjamin D. Roye, MD, MPH; Michael G. Vitale, MD, MPH

USA

Summary: Use of growing instrumentation in children with EOS has created interest in determining if these repetitive procedures are prompting the development of lasting psychosocial effects. In order to address this concern, a cross-sectional assessment of EOS patients was performed utilizing two well-established, caregiver based psychiatric instruments. Results demonstrated that EOS patients with abnormal assessment scores had more surgery and were younger at the time of initial scoliosis surgery, indicating a need for further exploration of this issue.

Introduction: Given the increasing use of surgically expandable instrumentation in the treatment of early onset scoliosis (EOS), this study aimed to examine if the repetitive procedures inherent to this treatment modality have harmful psychosocial effects.

Methods: Achenbach's Child Behavior Checklist (CBCL) and the Strength and Difficulties Questionnaire (SDQ) were completed for 34 EOS patients with growing instrumentation (18% Growing Rods, 82% VEPTR). Mean age was 7.79yo ± 2.23 (2-15). Domain scores were calculated for 6 SDQ domains and 16 CBCL domains. Patient's domain scores were grouped as "Affected" or "Not Affected." Domain scores were correlated with age at first scoliosis surgery, total number of operative procedures and total number of growing instrumentation surgeries.

Results: Children whose CBCL "Total Problems" domain score were clinically abnormal were younger at the time of first scoliosis surgery (2.50 vs. 5.52yo). "Affected" and "Not Affected" groups showed significant differences in number of total surgeries, scoliosis surgeries and growing instrumentation surgeries in the "Prosocial" (SDQ), "Total Competence," "Aggressive Behavior," "Rule-Breaking" and "Conduct" domains (CBCL). Abnormal "Prosocial" scores were associated with fewer growing instrumentation surgeries (1.57 vs. 4.11), scoliosis surgeries (2.29 vs. 5.11) and total surgeries (4.29 vs. 7.67). Those with abnormal "Total Competence" scores (combined measure of academic performance and social/extracurricular involvement) had undergone significantly more growing instrumentation surgeries (7.33 vs. 4.64) and scoliosis surgeries (6.44 vs. 3.50). Aggression, Rule-breaking, and Conduct were positively correlated with total number of surgeries.

Conclusion: Our findings indicate that EOS patients with abnormal psychosocial scores had more surgery and were younger at the time of initial scoliosis surgery. Aggressive behavior, rule-breaking and conduct problems also correlated with repetitive surgeries.

Significance: These findings are concerning given the increasingly common role of this treatment modality and indicate a need for further exploration of this issue.

PAPER #50

Serial Casting as a Delay Tactic in the Treatment of Moderate to Severe Early Onset Scoliosis

Nicholas Fletcher, MD; Anna McClung, RN; Karl E. Rathjen, MD; Richard H. Browne, PhD; Charles E. Johnston, MD

USA

Summary: Serial casting may be used to delay surgical intervention in children older than 2.5 years with moderate to severe early onset scoliosis.

Introduction: Serial casting may cure mild early onset scoliosis (EOS) in children less than 19 months of age. The use of growth sparing surgery prior to definitive spinal fusion has increased perhaps due to a perceived lack of efficacy of casting in children older than 2.5 years and in those with larger curves.

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PODIUM PRESENTATION ABSTRACTS

Methods: A clinical and radiographic review of patients casted for idiopathic, syndromic or congenital scoliosis > 2.5 years of age and with curves > 50° with minimum 2 years of follow up was performed.

Results: 58 patients underwent serial casting for progressive scoliosis between 1998 and 2010 with 28 meeting all inclusion criteria. 10 were idiopathic and 18 were syndromic curves. Average age at first casting was 4.4±2.1 years. Patients were followed for 5.3 years (range 2.0-9.9). Patients underwent 4.1±1.7 cast changes over 1.1±0.9 years. Main thoracic Cobb angle prior casting was 67.7°±13.0° which corrected to 39.7±15.9° (43.8±15.8%) in a cast. Cobb angle after cast removal was 60.9°±19.1° and increased to 75.0°±25.3° at final follow up. All patients were braced after cast removal. While 8 patients (28.6%) ultimately required growth sparing surgery, 7 patients (25%) were successfully delayed until definitive anterior/posterior fusion and 13 (46.4%) remain in a brace following casting at final follow up. Surgery was delayed 3.1±2.0 years from the first cast. Preoperative Cobb angle was 89.9°±9.3° (50.9°±16.8° on bending films) which corrected to 44.6°±15.7° post operatively (50.3±17.4% correction). The surgical group had a greater loss of correction out of the cast (23.46° vs 9.73°, p=0.017) than the nonsurgical group with a trend towards larger precast thoracic Cobb angle (71.8° vs 63.5°, p=0.08) and more time in a cast (1.43 vs 0.8 years, p=0.06).

Conclusion: Serial casting is a viable alternative to surgical techniques in the management of moderate to severe EOS. While a cure cannot be expected in many patients, 74% of patients in this cohort have successfully avoided growth sparing surgery with surgery being delayed an average of 3.1 years.

Significance: Surgeons should consider serial casting in the initial nonoperative management of moderate to severe EOS.

PAPER #51

Radiographic Analysis of Progression in Congenital Scoliosis with Rib Anomalies during Growth Period

Noriaki Kawakami, M D; Taichi Tsuji, MD; Haruhisa Yanagida, MD; Koki Uno, MD, PhD; Morio Matsumoto, MD; Kota Watanabe; Takuya Yamamoto; Toru Hirano; Hiroshi Taneichi, MD; Ken Yamazaki, MD; Kenta Fujiwara

Japan

Summary: This study was designed to evaluate the progression of scoliosis in patients with congenital scoliosis (CS) and rib anomalies (RA). Scoliosis progressed most severely during infancy. 4 grades in severity of progression (most severe, severe, moderate and mild) were set up based on the correlation between space available of the lung (SAL) and scoliosis to enable strategic planning of expansion thoracoplasty (ET) for patients with CS with RA. This grade system may be useful to determine the appropriate time for ET.

Introduction: Expansion thoracoplasty (ET) using rib-based devices is recognized as one of the effective treatments for young children with CS and RA. The goals of this study were to evaluate the progression of various types of CS with RA during each of the growth periods, and to assess the severity of progression for strategic planning of ET.

Methods: This was a retrospective study. 70 patients (M-32 and F-38 with an average age of 2.6 years at the first visit.) from 9 institutions matched the inclusion criteria: CS with RA, no procedures that could influence the natural history, repeated plain X-ray check-ups at at least a 2-year interval during growth periods. The average F/U time was 5.4 years (2-14). X-ray images of 70 pts. were divided into 3 age groups, infantile (0-6), juvenile (5-11), and adolescent (11-18) and evaluated in terms of laterality, range and type of RA, severity of scoliosis, type of CS, and SAL.

Results: RA included rib fusion in 52, mixed type (fusion and defect) in 8, rib proximity in 6, and rib defect in 4. 54 of 70 patients had unilateral RA. The magnitude of scoliosis was 46.9° at the first visit and 65.7° at the final F/U. Scoliosis progressed at the rate of 4.6°/y in 70, 3.6°/y in bilateral RA involvement and 4.9°/y in unilateral. Scoliosis progressed most severely during infancy with the rate of 5.0°/y, followed by 3.8°/y during adolescence. Patients with rib defects or unilateral unsegmented bar showed higher progression rates (10.7°/y and 7.0°/y) during infancy. 4 grades in severity of progression (most severe, severe, moderate, mild) were set up based on the relationship between SAL and scoliosis with cut-off values of 70%, 85% of SAL and 45°, 85° of scoliosis for strategic planning of ET. Those grades were significantly related with types and location of RA and types of vertebral anomalies.

Conclusion: Scoliosis in patients with CS and RA progressed most severely during infancy and was significantly related to the types and location of RA as well as the type of VA. The results of this study suggest the timing of ET for the patients with CS and RA.

Significance: Progression of CS with RA was assessed and ranked into 4 grades based on those data. This grade system may be useful to determine the appropriate time for ET.

PAPER #52

The Effect of Pedicle Screw Insertion on Pedicle and Canal Development in Young Children

Z Deniz Olgun, MD; H Gokhan Demirkiran, MD; Mehmet Ayvaz, MD; Muharrem Yazici, MD

Turkey

Summary: This study was performed in order to examine the effect of the widely popular pedicle screw used at relatively young ages (<7yrs) for early-

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onset spinal deformity on the growth and development of pedicles and the spinal canal.

Introduction: During their usage in the treatment of early-onset scoliosis, pedicle screws must pass through the growth plate called the neurocentral cartilage (NCC) that is thought to be active in this age group. It has been found in animal studies that when placed at a young age, pedicle screws may cause retardation in pedicle and canal growth and result in a rotational scoliosis. This study was designed to determine if such a retardation of growth takes place in children who undergo pedicle screw instrumentation at an early age.

Methods: Patients with early-onset deformity of various causes who received pedicle screw instrumentation before the age of 7 and had preoperative and final follow-up cross-sectional imaging were included. AP and transverse diameters of the canal, its area and pedicle lengths were measured on transverse images going through the middle of the pedicle.

Results: 16 patients (7M, 9F) met inclusion criteria. Average age at surgery was 48.0 (29-79) months, average follow-up 49.4 (24-82) months. A total of 97 levels (47 with screws, 50 without) were analyzed. 28 screws were upper & mid-thoracic (T1-9), 18 lower thoracic (T10-12), 48 lumbar. Numeric results for parameters can be found in the following table. At no level or age at placement did screws cause retardation of any parameter. This is also true for thoracic pedicles placed in children before age 4, where the NCC is known to be active.

Conclusion: Animal studies have shown the potential retardation of pedicle and canal growth with pedicle screws but there is no previous study to detail the behavior of human immature vertebrae when instrumented early with pedicle screws except for a few cross-sectional studies with few patients. Our study shows that early application of pedicle screws does not cause adverse effects on pedicle and canal growth. Although the neurocentral cartilage is still visible it may not be physiologically active in this age group, a single screw across may not exert sufficient compression, or the canal may have means of expansion that remains unknown.

Significance: Pedicle screw instrumentation does not appear to cause detectable growth retardation in pedicles, vertebral bodies or, most importantly, the spinal canal, even when applied at a young age (younger than 48 months).

PAPER #53

Growing Rods in Early Onset Scoliosis with Neurofibromatosis Type 1 (NF1)

Viral Jain; Abhishek Ray, MD; Alvin H. Crawford, MD; John B. Emans, MD; Paul Sponseller; Growing Spine Study Group

USA

Summary: This multicenter retrospective study shows that use of growing rods in early onset scoliosis associated with NF1 effectively controls the spinal deformity and facilitates the growth of the spine. It is associated with similar high rates of implant related complications as compared to other patients with early onset scoliosis reported in the literature. Dystrophic involvement of the bone might be the cause of this complication.

Introduction: Early Onset Scoliosis (EOS) deformity in NF1 poses a challenge due to its rapid progression and inability of cast/brace to control it. Spinal fusion may not be appropriate in young children due to crankshaft and interference with chest and trunk growth. Growing Rods (GR) have been used in EOS effectively. Purpose of this study was to evaluate GR use in NF1.

Methods: A retrospective data review was performed from Growing Spine Study Group (GSSG) database as well as from our own institute on EOS patients with genetic diagnosis of NF1 and minimum 2 years follow-up. Results were compared with reported results of GR in literature.

Results: 14 patients from 5 institutes underwent a total of 71 procedures with an average follow-up of 54 months. Mean age at surgery was 6.8 years. Means of initial and final curves were 74 and 36 degrees respectively (53% correction). Spine grew an average of 6.6 cm (2cm/yr). Implant related complications were the most common (8/14, 57%), including failure of proximal construct (6/14) and rod breakage (2/14). There was no significant difference between screws and hooks as proximal anchors (Fischer's test, p=0.36). 2 patients had deep infection requiring debridement. MRI was available for review in 10 patients and showed presence of dystrophic features including dural ectasia in proximity of proximal anchors in 7.

Conclusion: The use of growing rods in patients with EOS with NF1 provides curve correction and allows growth of the spine. It has similarly high complication rates (50-70%), the most common complication being failure of proximal anchors.

Significance: This retrospective pooled data study represents the first report on the treatment of a very select, challenging spinal problem (EOS in NF1) by growing rods. Historically these patients have been noted to progress relentlessly when not fused prematurely. Our study reveals that the complications of growing rods in these patients were no greater than those seen in other conditions causing EOS.

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).

PAPER #54

NF1 and Idiopathic Scoliosis: Potential Common Genetic Variants

Kandice Swindle; Cristina M. Justice, PhD; Alok Patel, BS; Nancy H. Miller, MD

USA

Summary: 25 families (207 individuals) in which a male diagnosed with ≥30° IS curvature underwent finemapping utilizing custom SNP panels to refine the genetic locus on chromosome 17p11.2 continquous to that of NF1. The

PODIUM PRESENTATION ABSTRACTS

critical locus was narrowed with the most significant results within the serotonin transporter gene (SLC6A4), a gene with potential effects on bone mineral content, density and mechanical strength. The potential of shared genetic variants between these two disorders with marked spinal deformity merits continued investigation.

Introduction: Idiopathic Scoliosis (IS) has been linked previously to chromosome 17p11 flanking the Neurofibromatosis Type 1(NF1) indicating a potential genetic correlation within this region that relates causally to scoliosis. The objective of this research is to identify these causative genetic variants.

Methods: 25 families (207 individuals; 123 affected of which 48 male, 75 female) in which a male diagnosed with ≥30° IS curvature underwent genomic screening followed by finemapping utilizing a custom SNP panel and ABI Taqman methodology on an ABI 377 platform. Data were analyzed by model-independent linkage analysis using SIBPAL (SAGE, v5). The most prominent marker, D17s975, (P=0.0003) at 25.12 Mb is adjacent to the NF1 deletional region. A custom panel of SNPs extending from 18.30-31.47 Mb was then analyzed for linkage through Taqman SNP assay protocol. With allele specific fluorescent tags, allelic discrimination was performed using Real-Time PCR.

Results: Results narrowed an identified region with ≥2 contiguous SNPs of significance (P<0.05;Table). The most significant results lie within the serotonin transporter gene SLC6A4, whose product is a modulator of serotonin activity.

Conclusion: An enlarging subset of families with FIS continues to support and narrow a locus contiguous with the NF1 locus.

Significance: The elucidation of shared genetic variations within this region by two disorders marked by scoliosis bears significance on the molecular understanding of the pathogenesis of scoliosis and axial development. Future work will focus on targeted genetic sequencing.

PAPER #55

All Pedicle Screw Instrumentation for Scoliosis Correction in Neurofibromatosis. Is it Worth It?

Wael Koptan, MD; Yasser ElMiligui, MD, FRCS; Mohammad M. El-Sharkawi, MD; Fady S. Shafik; AbdElMohsen Arafa

Egypt

Summary: A prospective study of 15 patients with Neurofibromatosis whose non dystrophic spinal deformities were corrected with a single stage all pedicle screws technique and compared to an earlier series of 13 patients who had a two staged procedure with hybrid posterior instrumentation. Patients were followed up for a minimum of 2 years. A better correction was achieved by all pedicle screws constructs; with significantly less blood loss, operative time, hospital stay and complications without the need for anterior surgery.

Introduction: Spinal deformities are considered the most common skeletal manifestation in Neurofibromatosis (NF) and have long been corrected by anterior fusion and posterior hybrid constructs. All pedicle screw constructs are currently widely used in the treatment of spinal deformities and accurate evaluation of this recent application in Neurofibromatosis patients is necessary. The aim of this work is to compare the results of segmental all pedicle screw constructs versus hybrid instrumentation analyzing the amount of correction achieved, clinical outcome and the incidence of complications.

Methods: The study included 28 patients with non dystrophic NF spinal deformities surgically treated between 1997 and 2008 and followed-up for an average of 6y (range 2 - 9y). It included 15 consecutive patients corrected by a single stage segmental all pedicle screw constructs (Group 1) compared to an earlier series of 13 patients who had an anterior release followed by posterior hybrid instrumentation (Group 2). The average age was 13y+8m and 14y+1m respectively. The average preoperative scoliosis was 63.6 degrees (Group 1) and 61.2 degrees (Group 2).

Results: A significantly better correction was achieved in Group 1 with an average of 81.2% postoperatively and 1.2% correction loss at final follow-up compared to Group 2 where correction was 73.8% postoperatively and 2.5% correction loss at final follow-up. The average operative time and blood loss were considerably less in Group 1 with an average of 4.5 h and 740 cc than Group 2 with an average of 6.45 h and 1050 cc respectively. Group 2 patients had a longer hospital stay and had 4 complications in 4/13 patients.

Conclusion: A better correction of non dystrophic spinal deformities was achieved in NF patients by multiple levels all pedicle screws technique; with significantly less operative time, blood loss, hospital stay and complications.

PAPER #56

Early Failure of Pelvic Fixation in Neuromuscular Scoliosis

Karen S. Myung, MD, PhD; Christopher Lee, BS; David L. Skaggs, MD

USA

Summary: This study evaluates the failure of pelvic fixation in long instrumented posterior spinal fusions for neuromuscular scoliosis. We report that failure of traditional pelvic fixation is common and the amount of distal fixation affects the failure rate. Fixation in the pelvis failed in 30% of cases. However, no construct failed when sacroiliac screws (S2 screws) and bilateral pedicle screws at L5 and S1 was achieved.

Introduction: This study evaluates the failure of pelvic fixation in long instrumented posterior spinal fusions for scoliosis. This data reports that failure of traditional pelvic fixation is common and the amount of distal fixation affects the failure rate.

* Hibbs Award Nominee for Best Clinical Presentation † Hibbs Award Nominee for Best Basic Science Presentation

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Methods: A retrospective review of consecutive cases of posterior-only spinal instrumentation and fusion to the pelvis with iliac screws was performed. 43 patients (18 female, 25 male) with average age 14 years and an average of 16 levels fused (9-19) met inclusion criteria. Diagnoses include cerebral palsy (22), Duchenne's muscular dystrophy (7), other neuromuscular (12), and spina bifida (2). Z-test was used to compare rates of failure.

Results: The average preoperative primary Cobb angle was 81 (21-144) degrees. The pelvic obliquity correction was 88%. All, but one, of the patients were non-ambulatory. The fixation in the pelvis failed in 13/43 patients (30%). Failures include: screw head of iliac screw disengaged from screw shaft (5), iliac screw disengaged from rod (1), iliac connector disengaged from rod (3), iliac connector disengaged from iliac screw (2), and iliac screw loosened from bone (2). No failures occurred if there were at least 6 screws in L5, S1 and pelvis (0/17 patients). The failure rate with less than 6 screws in L5, S1 and pelvis was significantly higher at 50% (13/26 patients) (p=0.002). When using traditional iliac screws with connectors to rods, all constructs had < 6 screws in L5, S1 and pelvis. No failures occurred when sacral alar-iliac screws were used. The mean time from surgery to failure was 18 months (1-49 months).

Conclusion: Not placing bilateral pedicle screws at L5 and S1, in addition to 2 iliac screws, was associated with a 50% failure rate of pelvic fixation.

Significance: Even in a non-ambulatory population, we recommend placement of 2 pedicle screws at L5, 2 pedicle screws at S1 and 2 iliac screws. This construct is technically most easily achieved when using sacral alar-iliac screws instead of traditional iliac screws with offset connectors.

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).

PAPER #57

Outcome of Operative Treatment for Spinal Deformity in Patients with Syringomyelia: A Comparison Study to AIS Patients

Daniel J. Sucato, MD, MS; Anna McClung, RN; Zoel G. Allen

USA

Summary: A study of patients with operative scoliosis associated with a syrinx were compared to AIS patients and demonstrated similar preoperative curve magnitudes, but greater curve stiffness, more left thoracic curves, and greater kyphosis preoperatively in the syrinx patients. Despite this, curve correction was similar using a similar number of fusion levels as the AIS group and demonstrated similar coronal and sagittal balance at 2 years.

Introduction: Spinal deformity associated with a syringomyelia may be more challenging to treat than AIS due to kyphosis, curve stiffness and in deciding fusion levels. The purpose of this study is to quantify the differences between patients with syringomyelia-associated scoliosis and AIS and to determine correct fusion levels to achieve a balanced spine in the coronal and sagittal planes.

Methods: An IRB-Approved retrospective review of a consecutive series of patients who had scoliosis associated with syringomyelia (SS group) were compared to AIS patients (AIS group) matched by curve type and magnitude (1:2 ratio). Medical record and radiographs were reviewed preop, postop and at 2 years. Radiographic outcome was characterized as satisfactory at 2 years if the coronal and sagittal balance ≤2 cm.

Results: There was no difference between the SS (N= 38) and AIS group (N= 82) for age (13.3 vs 14.1 yrs), ethnicity and curve type, however, there were more males (39.5% vs 17.1%, p=0.01) in the SS group. The coronal major curve preoperatively was similar (62.6° vs 64.5°), but curves were stiffer (flexibility index: 39.7% vs 54.2%, p=0.001), and thoracic curves were more often to the left (51.5% vs 2.8%, p<.0001) in the SS group. Thoracic kyphosis was greater in the SS group preop (38.8° vs.21.2°, p<.0001), and at 2 years (31.7° vs.23.9°, p=0.01). Major coronal curve correction was similar postoperatively (56.1% vs 60.2%) and final followup (47.4% vs 53.5%), without a difference in number of fusion levels (10.7 vs 10.2). Preoperative coronal (1.6cm vs. 1.7cm) and sagittal balance (2.3cm vs. 2.6cm) and final follow-up (1.3cm vs. 1.1cm) (3.4cm vs. 3.4cm) were similar. Selection of the LIV was no different between the SS and the AIS groups relative to the neutral (p=0.05), stable (p=0.08), distal end vertebra (p=0.2) or the last vertebra touched by the center sacral line (p=0.4).

Conclusion: Surgical treatment of scoliosis associated with a syrinx has a high likelihood of achieving a satisfactory result using similar fusion levels and selection of an LIV that is similar to AIS patients. The need to include more fusion levels for the SS group similar to a neuromuscular construct was not seen in this series.

PAPER #58

Results of Surgical Treatment of Spine Deformities in Patients with Spinal Muscular Atrophy Type II and Type III

Tomasz Potaczek, MD; Daniel Zarzycki, MD, PhD

Poland

Summary: Review of surgically treated spinal deformities in patients with spinal muscular atrophy(SMA).

Introduction: SMA is a group of hereditary diseases that manifests in weakness and flaccid paresis,marked mostly in lower limbs and proximal rather than distal muscle groups.Three clinical types are distinguished depending on the level of muscle involvement.Spine deformity,present in all non-ambulatory patients poses the greatest orthopaedic challenge.Scoliosis called "collapsing scoliosis" hampers or impairs independent sitting in this way decreasing patients function.Treatment

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PODIUM PRESENTATION ABSTRACTS

of choice is surgical that leads to deformity correction,prevents further curve progression and facilitates independent sitting.Aim of paper is radiological evaluation of results of surgical treatment of spine deformity in patients with SMA type 2 and SMA type 3a all treated with the same Galvestone-Luque posterior fusion surgical technique.The study is to establish the optimal criteria for surgical treatment.

Methods: Among 173 patients with SMA diagnosis 45 fulfilled the inclusion criteria.The minimal follow-up period was 5 years,mean-6.9 years(5-15).Clinical data,preoperatively and perioperatively was evaluated:age of SMA diagnosis,age of scoliosis onset,perioperative complications.Moreover radiological data pre- and postoperatively was assessed.

Results: Age at surgery in the study group was mean 11.4years.Achieved mean correction after surgery was 49% and 41.9% at final follow-up.Evaluation of radiological data revealed better correction in younger patients with smaller initial curves.Above that loss of correction was significantly lower in the more mild form of SMA.Number of postoperative complications did not correlate with the preoperative pulmonary function.

Conclusion: Treatment of spinal deformities in SMA patients is justified;achieved correction is approximately 40% with minimal loss during follow-up.Surgical treatment should be introduced early as possible,in patients with curves less than 80° and younger than 11 years.Those two factors significantly influence the final outcome.

PAPER #59

The Prevalence of Scoliosis and Kyphosis in Achondroplasia: A Ten Year Tertiary Referral Center Experience

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USA

Summary: A retrospective review of 108 medical records was conducted to determine the prevalence of scoliosis and kyphosis in patients with achondroplasia.

Introduction: To date, there is limited data on the prevalence of scoliosis and kyphosis in achondroplasia. We present our ten year experience at a busy tertiary referral center.

Methods: A retrospective chart review of 414 patients with achondroplasia seen by the Department of Orthopaedics at the John Hopkins Hospital was conducted. Inclusion criteria for acceptance into this study were diagnosis of achondroplasia and full medical record availability, including PA and lateral radiographs. A cohort of 108 patients seen from 1999-2009 met these criteria. Degrees of scoliosis and kyphosis were determined by Cobb angle measurements on PA and lateral radiographs by a single reviewer. Scoliosis was defined as lateral curvature greater than 10 degrees, and kyphosis as posterior convex curvature greater than 40 degrees. Prior to analysis, data was stratified by gender and age groups (i.e. group A: 0-2 years, group B:>2-12 years, group C:13-19 years, group D: 20-40 years, group E:>40 years).

Results: Of the 108 patients, 62 were male and 46 were female. The average patient age was 14.6 years, with a median age of 2.9 years. Male predominance of achondroplasia was noted with a male to female ratio of 1.3. Scoliosis was observed in 29.7% of the cohort, kyphosis in 15.7% and kyphoscoliosis in 12%. No significant differences in prevalence of either scoliosis or kyphosis were noted in males versus females. The degree of scoliosis was greatest in group B males (12±8.4 degrees) and in group D females (12.5±9.8 degrees). There were no significant differences in angles of kyphosis in any age group or gender.

Conclusion: The prevalence of scoliosis and kyphosis in achondroplasia is considerably higher than that of the general population, however the degree of scoliosis and kyphosis is mild and non-progressive in our experience. These patients are generally managed conservatively with good results.

PAPER #60

Spinal Cord Monitoring During Scoliosis Surgery in Children with Spastic Cerebral Palsy: Is it Feasible and Safe Even with an Active Seizure Disorder?

Suken A. Shah, MD; Cheryl R. Wiggins, AuD; Daniel M. Schwartz, PhD; Anthony K. Sestokas, PhD; Kenneth J. Rogers, PhD; Peter G. Gabos, MD; Kirk W. Dabney, MD; Freeman Miller, MD

USA

Summary: tceMEP monitoring was attempted in 138 consecutive patients; 63 (46%) had an active seizure disorder.There was no physical or EEG manifestation of seizure elicitation in any of the 138 children who received RTES for motor evoked potential monitoring, nor was there evidence of increased frequency of post-operative seizures. Surgeon concerns that transcranial electric stimulation for tceMEP monitoring can elicit intraop seizures during correction of NMS in children with CP, with or without active seizure disorder, appears unsubstantiated and hence, should not preclude its routine use.

Introduction: Spinal cord monitoring in children with severe spastic quadriplegia (SSQ) and neuromuscular scoliosis (NMS) is both challenging and controversial. Is repetitive high voltage transcranial electric stimulation (RTES) for motor evoked potential monitoring contraindicated in the presence of active seizure disorder? This study sought to assess the safety and feasibility of RTES for MEP monitoring in patients with NMS due to CP.

Methods: The medical charts of 261 children with CP and SSQ who underwent correction of NMS from 2001-2009 were analyzed. 158 (61%) showed sufficient purposeful lower extremity motor function to warrant neuromonitoring for preservation of residual spinal cord function. 74 (47%) of these had active seizure disorder, while the remaining 84 (53%) were seizure-free.

* Hibbs Award Nominee for Best Clinical Presentation † Hibbs Award Nominee for Best Basic Science Presentation

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Results: tceMEP monitoring was attempted in 138 (87%) patients; 63 (46%) had active seizure disorder. There was no physical or EEG manifestation of seizure elicitation in any of the 138 children who received RTES for MEP monitoring, nor was there evidence of increased frequency of post-opseizures.

For the 63 children in the active seizure group, lower extremity tceMEPs were monitorable in 30/63 (48%). Parenthetically, SSEP monitoring was attempted in 60/63 of these same children and was successful in 31/60 (52%). For the seizure-free group, lower extremity tceMEPs and SSEPs were each recorded successfully in 47/75 (63%) children.

Conclusion: Contrary to conventional opinion, RTES for eliciting MEP is not contraindicated in CP children with SSQ and NMS who present with active seizure disorder. This special population of NMS patients presents a unique challenge for reliable and valid spinal cord monitoring, even in the absence of seizure disorder. These results demonstrate that spinal cord monitoring with tceMEPs is both safe and feasible, and do not support the oft-held opinion that it is contraindicated in children with active seizure disorder.

Significance: Surgeon concerns that repetitive transcranial electric stimulation for tceMEP monitoring can elicit intraoperative seizures during correction of NMS in children with SSQ, with or without active seizure disorder, appears unsubstantiated and hence, should not preclude its routine use.

PAPER #61

Changes in Health Related Quality of Life (HRQL) after Spinal Fusion and Scoliosis Correction in Patients with Cerebral Palsy

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Switzerland

Summary: A retrospective review of 50 consecutive patients with CP, who had spinal fusion for scoliosis with minimal 2 year f-up. The assessment of the HRQL was done through a modified version of the Caregiver Priorities and Child Health Index of Life with Disabilities(CPCHILD) questionnaire. The study shows that the scoliosis correction by spinal fusion improves the subjective HRQL.The improvement of HRQL is subjective and does not show significant correlation with the objective radiographic changes brought about by the operation.

Introduction: The purpose of this study was to evaluate the outcome of surgical scoliosis correction measured by the subjective change in the HRQL and the objective radiological changes. Factors that could influence the subjective outcome were examined to investigate their correlation to the re-sults of HRQL.

Methods: A retrospective review of 50 consecutive patients with CP, who had spinal fusion for scoliosis with minimal 2 year follow-up. Radiographic data were obtained from preoperative, postoperative and last follow-up examinations. The assessment of the HRQL was done through a modified version of the Caregiver Priorities and Child Health Index of Life with Disabilities(CPCHILD) questionnaire, assessed by the caregivers of the patients.

Results: There was a significant improvement (p= 0.001) of HRQL postoperatively. The satisfaction rate of the patients with outcome of the operation was 91.7%. There was an average of 64.3% scoliosis correction, 57.7% pelvic tilt correction, 53% improvement of apical vertebral rotation, 67.2% improvement of apical vertebral translation. At the last follow-up the average scoliosis angle was 32.0°, pelvic tilt was 8.8°. Weak but not significant correlation between the amount of scoliosis correction and the subjective change in the HRQL could be established (R2 = 0.321, p= 0.078). No correlation between the occurrence of complications and changes in the HRQL (p=0.122) or the satisfaction rate with the outcome of the operation (p=0.764). Extension of spinal fusion to sacropelvis had no influence on the occurrence of complications (p=0.42) or changes in HRQL (p=0.71).

Conclusion: The study shows that the scoliosis correction by spinal fusion improves the subjective HRQL in the patients with CP. There was patient's satisfaction rate of more than 90%, assessed by their caregivers. The improvement of HRQL in our study population is subjective and does not show significant correlation with objective radiographic changes brought about by the operation, which indicates that the present operation indications and achieved correction are adequate to achieve improvement of the subjective HRQL in this patient group.

Significance: Therapeutic-level IV, retrospective study.

PAPER #62

The CPCHILD Questionnaire is Sensitive to Change Following Scoliosis Surgery in Children with Cerebral Palsy

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Canada

Summary: The CPCHILD Questionnaire is a valid measure of HRQL for children with severe CP. The CPCHILD was tested for responsiveness following scoliosis surgery for this population in a prospective longitudinal cohort study. The CP-CHILD was shown to be sensitive to change at 6 and 12 months, with significant improvements in total scores and domains of Positioning & Transfers; & Quality of Life. The CPCHILD can be used to measure the effectiveness of spine interventions for this population.

Introduction: The Caregiver Priorities & Child Health Index of Life with Disabilities (CPCHILD) questionnaire is a valid measure of comfort, health & well being, ease of caregiving and quality of life of children with severe disabilities. The purpose of this study was to establish whether the CPHILD is sensitive to change (responsive) in a cohort of children with CP undergoing scoliosis surgery.

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PODIUM PRESENTATION ABSTRACTS

Methods: Parents (n=156) of 62 girls & 94 boys (Mean age: 14y8m) with severe CP completed the CPCHILD questionnaire at baseline in an international multi-centred cohort study; 120 of 156 underwent surgery. Responsiveness of the CPCHILD was evaluated in 62 patients at 6 months & 47 patients at 12 months after surgery, using i) Paired t-test of the pre-post scores; ii.) Standardized Response Mean (SRM); & iii.) Correlation of change in CPCHILD domain & total scores with external verification criteria measured as parents' perceived change on a 5 point ordinal scale in each of four domains (QOL; comfort; health; ease of caregiving).

Results: 92% were non-ambulant; mean Cobb angle was 85° (SD 29°); The mean pre-op total CPCHILD score was 49.9 (SD:14.7; Range:17.9 - 83.6). The post-op total CPCHILD score was 53.2 (Range:24.6 - 83.1) at 6 months and 54.7 (Range: 24.4 - 82.3) at 12 months; with a mean difference from pre-op of 3.3% points ($p = 0.04$) & 5.4% points ($p= 0.004$) at 6 & 12 months respectively. At 6 months there were significant improvements in Positioning/Transfers (5.4%; $p=0.01$) & Overall QOL (6.4%; $p = 0.07$) which were larger at 12 months Positioning/Transfers (9.7%; $p <0.001$); Health (6.5%; $p=0.08$) & Overall QOL (9.1%; $p=0.04$). The SRM for these domains were 0.26, 0.60, 0.26 and 0.31 respectively; and 0.44 for the total score. There were poor to moderately positive correlations (0.02 - 0.37) between the changes in the domain scores and external criteria ratings.

Conclusion: The CPCHILD is sensitive to change following scoliosis surgery for children with severe CP and is able to measure significant improvements in Total and some domain scores at 6 & 12 months following surgery.

Significance: The CPCHILD can be used as a meaningful outcome measure of the effectiveness of interventions for scoliosis in children with severe cerebral palsy.

PAPER #63

Comparing Meaningful Use: Paper-Based SRS-22 vs. Web-Based Diagnosis-Specific Spine Outcome Tools

Sarah P. Rogers, MPH; Todd A. Milbrandt, MD, MS; Vishwas R. Talwalkar, MD; Janet L. Walker, MD; Henry J. Iwinski, MD

USA

Summary: The purpose of this study was to create a web-based clinical medical record to complete diagnosis-specific tools at check-in and evaluate its efficacy. This system improved data capture by 3 times. More web-based tools than paper-based tools were completed during observation visits. Missing answers and time to electronic availability improved significantly. This structured web-based system utilized at the point of care in outpatient pediatric orthopaedics collates patient data into easily interpreted graphs, facilitates translational research, and improves clinical outcomes documentation.

Introduction: Tracking patient-reported outcomes over time is important for clinical decision-making, but doing so in the midst of a busy clinic is a challenge. Previously, patient clinical outcomes were managed in various ways, and no data integrity plan existed. This made reviewing patient clinical outcomes cumbersome and confusing. The purpose of this study was to create a web-based clinical medical record to complete diagnosis-specific tools at check-in and evaluate its efficacy.

Methods: The system was created and results were instantly saved and available for clinicians to review. Data integrity checks occurred daily at the point of care and weekly. Published diagnostic population comparison scores were built into same-day and longitudinal reports for patient-reported outcome tools (Fig 1). Reports highlighted areas of importance for discussion via graphics and color-coding. Spine tools were completed every 6-months. Paired t-tests and chi-square tests compared the previous paper-based SRS-22 to current web-based, diagnosis-specific spine outcome tools.

Results: In the 2008 paper-based SRS-22 data, 339 patients had 354 visits. It took an average of 13.8 days (SD 15.4) for tools to be entered. Almost 20% of tools had one or more answers missing. In 2010, the web-based system improved the data capture by 3 times as evidenced by documenting 980 patients with a spine diagnosis over 1404 visits. More web-based tools than paper-based tools were completed during observation visits (70% paper vs 88% web, chi-square $p<0.001$). No web-based tools had any missing answers. Missing answers (20% paper vs 0% web) and time to electronic availability (13.8 days paper vs 0 days web) improved significantly (paired t-tests $p<0.001$). Compliance for web-based medical record documentation averaged 73%, which were then corrected.

Conclusion: This structured web-based system utilized at the point of care in an outpatient pediatric orthopaedics collates patient data into easily interpreted graphs, facilitates translational research, improves clinical outcomes documentation, and enhances patient education. It provides faster access and higher quality data for tracking patient progress, outcomes, and interventions, which in turn may lead to improved clinical care.

Fig 1. Sample dashboard at point of care for SQLI

Outcome Tools

SQLI (1/31/2011)

Domain	Today's Score	Compared to Last Visit	Compared to Diagnostic Peers
Self-Esteem	90	No Change	Above Average
Back Pain	60	Declined	Below Average
Physical Activity	55	Declined	Below Average
Moods & Feelings	90	Declined	Average
Satisfaction		No Change	n/a
Global Score	73.75	Declined	Below Average

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PODIUM PRESENTATION ABSTRACTS

PAPER #64

Comparison of Femoral Ring Allograft to Structural Cages in Anterior Instrumentation in Adolescent Idiopathic Scoliosis

Todd A. Milbrandt, MD, MS; Joseph Stone, MD; Brian Blessinger, MD, MS; Hillard Spencer; Richard E. Bowen, MD; Anthony A. Scaduto, MD; Vishwas R. Talwalkar, MD; Henry J. Iwinski, MD

USA

Summary: Femoral ring allograft is statistically comparable to structural cages when comparing curve correction and complication profile. However, there is a five fold decrease in cost per case in the femoral ring group.

Introduction: Using anterior column support during anterior instrumentation of thoracolumbar and lumbar adolescent idiopathic scoliosis is recommended to prevent loss of lordosis and pseudarthrosis over the instrumented segments. The purpose of this study is to compare the results, complication profile and cost of femoral ring allograft versus cages.

Methods: A retrospective case series comparing complications was undertaken at two different tertiary pediatric orthopaedic hospitals. We identified 30 patients undergoing anterior single-rod fusion, 13 with structural cages(Group SC) and 17 with multiple femoral ring allografts(Group FR). Coronal and sagittal Cobb angles were assessed preoperatively, initial postoperative and at final followup. Complication profile was analyzed with evaluation for pseudarthrosis, loss of correction (specifically, kyphosis of the instrumented lumbar segment), implant failure, and need for reoperation.

Results: Average follow up for Group SC and FR was 31 and 29.5 (p value=0.79). No significant differences between SC and FR were found in terms of age (14.7 vs 14.9 years), Initial coronal Cobb (53 ° vs 58°), initial post-op coronal Cobb (9 ° vs 16°), or final coronal Cobb (15° vs 20°). No significant differences were noted in the intial sagittal Cobb (56° vs 57 °) or final sagittal Cobb (60° vs 58°), Progressive post operative kyphosis was not seen in either group. Loss of coronal correction was rare in both SC and FR (0/13 vs. 1/17 p=0.44) as was pseudarthrosis (1/13 and 2/17 p=.062) all of which were asymptomatic incidental radiographic findings. Implant failure was noted in both groups (1/13 vs. 1/17 p=0.67). None required re-operation. An average of 2.23 structural titanium cages were used per case at a cost of $4527/case compared to $893/case for femoral ring allograft.

Conclusion: Both FR and SC implants resulted in excellent maintenance of correction with a low complication profile. The FR group however was able to obtain and maintain this correction with a 5 fold decrease in cost per case.

Significance: Studies such as this are critical as greater scrutiny will be placed on implant costs in this era of cost containment. Femoral ring allograft provides significant cost savings with similar results.

PAPER #65

Anterior Short Spinal Fusion in the Treatment of Adolescent Idiopathic Scoliosis. Retrospective Review of 250 Consecutive Patients with Seven Years Follow-Up

Daniel Zarzycki, MD, PhD; Tomasz Potaczek, MD; Robert W. Gaines, MD

Poland

Summary: The goal of operative treatment of AIS is to obtain a solid fusion with correction of the deformity and restoration of coronal and sagittal plane balance over as few segments as possible.Currently recommended anterior or posterior approaches include 'long segment' instrumentation and fusion which includes all vertebrae contained within the Cobb angle of the major.Our described procedure can be several levels shorter.During this study supine stretch films were used for pre-operative planning.

Introduction: From 2002 to 2010 we operated 885 patients with AIS using anterior short spinal fusion ("Bone-on-Bone" technique).We retrospectively reviewed 250 consecutive patients operated between 2002 and 2005 for single curve at a mean of 7-year follow-up

Methods: The mean age at surgery was 15.8 years (9-48), 86% of the cohort was female and the mean follow-up was7 years (5.7-8.3).We operated on curves less than 900 by the short segment anterior approach

Results: Surgical correction of the major curve averaged 54.6% over the entire curve,from upper end vertebra to lower end vertebra,correction of the operated segment was 61.1%.The average number of vertebrae fused was 5.4 (4 discs),mean operative time-205 min,blood loss-559ml and hospitalization time-11.1 days.The compensatory curves spontaneously improved by an average of 34.8%. 89% of the patients' curves were reduced to below 450 ,all spines were well balanced in the coronal and sagittal planes.Complications:haemothorax 2 cases,paraplegia 2 cases (epidural haematoma - resolved),screw migration 7 cases,chylothorax 4 cases,flat back 8 cases,dural tear 1 case,too short fusion in the upper part-9 cases,too short fusion in the lower part-10 cases.No patient had any pulmonary limitations post-operatively.All the patients were back to an un-restricted lifestyle within 6 months

Conclusion: We report good results following surgical correction of single primary curves with the instrumentation of fewer levels than would have been operated by posterior segmental instrumentation by using our short segment bone-on-bone technique

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PODIUM PRESENTATION ABSTRACTS

PAPER #66

Maintaining Thoracic Kyphosis in Thoracic AIS Correction When Derotation is Performed

Satoru Demura, MD; Burt Yaszay, MD; Joseph H. Carreau, MD; Tracey Bastrom, MA; Peter O. Newton, MD

Japan

Summary: Three dimensional correction following posterior spinal fusion and instrumentation utilizing an aggressive combination of correction strategies was performed in 26 cases. A high degree of coronal correction can be achieved in association with vertebral derotation without sacrificing sagittal plane alignment.

Introduction: With increasing use of posterior segmental screw fixation and attempts at vertebral derotation, there has been concern about loss of thoracic kyphosis. The purpose of this study was to analyze outcomes with regard to completeness of 3 dimensional correction following posterior spinal fusion (PSF) and instrumentation utilizing an aggressive combination of correction strategies.

Methods: A consecutive single center series of AIS patients with thoracic curves (Lenke 1 and 2) who underwent PSF and instrumentation with the following: segmental uniplanar screws, ultra high strength 5.5 mm steel rods, aggressive differential rod contouring, periapical Ponte osteotomies, and segmental direct vertebral derotation, with 2-year follow-up were evaluated. Radiographic measures were made in the coronal plane, sagittal plane, and axial plane (degree of vertebral rotation: Perdriolle preop, Upasani postop). Angle of trunk rotation and SRS 22 data were also compared.

Results: 26 patients were included (13.6 ± 1.5 years). The preop thoracic Cobb angle of 52.4° ± 8.8° improved to 16.5° ± 4.0° at 2-year, resulting in correction of 67.5% ± 9.4%. The average thoracic kyphosis (T5 to T12) did not change significantly from 20.7 ± 10.4° to 22.0 ± 4.6° at 2-year ($p>0.05$). However, in patients with kyphosis <20° preop (avg. 12.9° ± 5.3°), kyphosis increased (2-year: 20.2° ± 3.9°). Preoperatively, axial rotation was more than 13 degrees in 21 out of 26 cases. At 2-year, axial rotation was corrected to less than 13 degrees in 22 of 26 cases ($p<0.01$). The average rib hump prominence was 17.1° ± 4.7° preoperatively, and improved significantly to 9.7° ± 4.0° at 2-year. Post-op SRS domain scores significantly improved in pain (4.3 to 4.7), self image (3.7 to 4.3), and satisfaction (3.3 to 4.6).

Conclusion: A high degree of coronal correction can be achieved in association with vertebral derotation without sacrificing sagittal plane alignment. High strength rods aggressively bent to create kyphosis allow restoration of kyphosis and axial plane derotation in thoracic idiopathic scoliosis.

PAPER #67

Anterior Release Generates More Thoracic Rotation than Ponte Osteotomy: A Biomechanical Study of Human Cadaver Spines

Adam L. Wollowick, MD; Erin Farrelly, MD; Kathleen N. Meyers, MS; Terry D. Amaral, MD; Seth A. Grossman, MD; Timothy Wright, PhD; Vishal Sarwahi, MD

USA

Summary: A biomechanical study of human cadaver spines found that anterior release generates more thoracic rotation than Ponte Osteotomy. Sequential sectioning failed to identify an anterior or posterior structure that contributes most to rotational stability.

Introduction: Historically, large and/or stiff spinal deformities were treated with anterior release to facilitate correction. However, anterior release increases risks and requires a two-part procedure. Recently, large or rigid deformities have been treated with a single posterior procedure using pedicle screws and osteotomies. No study in the literature has evaluated the effect of anterior release or posterior osteotomy on thoracic rotation.

Methods: 14 fresh frozen human thoracic spines were randomly assigned to anterior or posterior groups. Specimens were disarticulated at T4-T5 and T8-T9 to test upper, middle, and lower thoracic segments. Sections were potted, and reflective markers were placed on the vertebrae of interest (T2-T3, T6-T7, T10-T11). Specimens were mounted on a servo-hydraulic load frame. Specimens were cyclically loaded to ±5Nm axial rotation for 10 cycles with data from the 10th cycle analyzed. Specimens were tested intact then retested after sequential sectioning or removal of various structures. Anterior structures removed were: ALL, annulus fibrosis, nucleus pulposis, and PLL. Posterior structures removed were: intraspinous ligament, inferior facets, superior facets, spinous process, lamina, & ligamentum flavum. Motion was recorded using a 3D motion capture camera, and the relative motion of one vertebra to the other in axial rotation was calculated.

Results: Posterior sectioning produced a 27-82% increase in rotation from the intact specimens, while anterior release generated a 201-534% increase. Removal of the annulus, nucleus, and PLL led to a significant increase in rotation compared to intact specimens. Ponte osteotomy increased rotation 1.8-4.2°, while anterior release increased rotation 6.6-13.4°. (See attached table).

Conclusion: Anterior release generated significantly more thoracic rotation than Ponte osteotomy in biomechanical testing of human cadaver spines. An anterior or posterior structure that contributed most to rotational stability was not identified.

Significance: Although many surgeons favor a single posterior approach to correct severe spinal deformity, anterior release may be needed to maximize correction. With increased emphasis being placed on spinal derotation, the use of anterior release should be reconsidered.

* Hibbs Award Nominee for Best Clinical Presentation † Hibbs Award Nominee for Best Basic Science Presentation

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PODIUM PRESENTATION ABSTRACTS

PAPER #68

Minimally Invasive Surgery for AIS: A Prospective Comparison with Standard Open Posterior Surgery

Firoz Miyanji, MD, FRCSC; Amer F. Samdani, MD; Michelle C. Marks, PT, MA; Peter O. Newton, MD

Canada

Summary: Minimally invasive surgery (MIS) has evolved in an effort to decrease approach-related morbidity associated with conventional open procedures. Its widespread use in spinal trauma and degenerative disorders has yielded similar clinical results to open techniques with added benefits of optimizing peri-operative morbidity. This study prospectively compared MIS to open techniques for the treatment of AIS and found no statistically significant difference in curve correction however length of hospital stay (LOS) and blood loss were more favorable in the MIS group.

Introduction: The use of MIS in deformity is ill-defined with a lack of comparative studies between MIS and open procedures in this setting. The aim of this study was to compare curve correction between MIS and open techniques used to treat AIS and secondarily to analyze peri-operative variables between the two groups.

Methods: Patient's enrolled in a multi-center, longitudinal, prospective AIS study were included in this analysis. Pre-op, peri-op and first erect post-op data was evaluated. 16 MIS patients were matched for age, sex, Lenke classification, and curve size with 16 conventional open posterior procedures. All cases were also matched to a single surgeon to reduce potential surgeon-induced variability. Statistical analysis was done using SPSS v.18.

Results: The male to female ratio in both the MIS and open groups were comparable with similar distribution of curves according to the Lenke classification. Age, BMI, Risser, and the pre-operative major cobb were all comparable between the two groups. Mean % curve correction in the MIS group was 63% and 68% in the open group, which did not reach statistical difference within 95% CI. The differences in operative time, LOS, and blood loss between the two groups were all statistically significant. [Table 1]

Conclusion: MIS for AIS has similar results to standard open posterior techniques, specifically for curve correction. Although increase in operative time was noted in the MIS group, advantages of MIS over standard open procedures seem to be decrease LOS and blood loss.

Significance: No previous study has compared prospectively a matched cohort of patients treated by MIS with standard open posterior surgery for deformity. We found the results of MIS to be similar to open techniques with near equivalent correction of the major cobb in both groups. The added benefits of MIS in AIS appear to be decrease in LOS and blood loss.

PAPER #69

Minimally Invasive Surgery in Patients with Adolescent Idiopathic Scoliosis: Is it any Better than the Standard Approach?

Adam L. Wollowick, MD; Terry D. Amaral, MD; Jonathan J. Horn; Etan P. Sugarman, MSIV; Melanie Gambassi, NP; Vishal Sarwahi, MD

USA

Summary: MIS scoliosis surgery is technically challenging but feasible in AIS. Coronal and sagittal correction is comparable to the standard PSF approach. At two year follow-up, results are comparable; however, no distinct short term advantage was demonstrated. Our experience is limited to curves less than 70° with 50% flexibility.

Introduction: The use of minimally invasive surgical (MIS) techniques for the treatment of spinal deformity is becoming more popular in adult patients. Purported advantages include decreased blood loss and length of hospital stay, better pain control, and faster recovery. Since 2008, we have utilized an MIS technique in a select group of patients with adolescent idiopathic scoliosis (AIS).

Methods: Charts, x-rays, and low dose CT-scans of fifteen standard cases and seven MIS cases were reviewed. Groups were matched for patient demographics and curve characteristics. Posterior spinal fusion with pedicle screws was carried out for both approaches. For the MIS technique, three midline incisions were made. Stab incisions in the fascia were made to allow for freehand screw insertion. MIS screws with extended tabs were used to allow rod passage and corrective maneuvers. BMP and autograft were used at each level. Rod derotation, translation, and DVR were performed.

Results: The groups were well matched for pre-operative patient and curve characteristics. There was no significant difference in blood loss or need for blood transfusion with either technique, but the MIS patients had significantly longer surgical times (8.7 vs. 6.8 hours). There was also no difference in the post-operative pain scores, time to mobilization, or length of stay. Both groups achieved comparable curve correction and had similar sagittal and coronal balance. There were more complications in the MIS group including two revision surgeries. The accuracy of screw placement was similiar as confirmed by post-operative CT scan. (See attached table)

Conclusion: The MIS technique acheived curve correction equal to that of the open technique. However, the short term advantages seen in MIS for adult scoliosis were not as obvious. Concerns regarding quality of fusion, learning curve, and instrumentation persist. Rod dislodgement, over-correction, and wound dehiscence were seen with MIS. Long term studies are needed to determine the role of MIS in the AIS population. MIS surgery is an innovative treatment for AIS that is technically feasible, however, better studies are needed to define the role of MIS in the treatment of AIS.

* Hibbs Award Nominee for Best Clinical Presentation † Hibbs Award Nominee for Best Basic Science Presentation

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PODIUM PRESENTATION ABSTRACTS

PAPER #70

MRI Screening in Operative Scheuermann's Kyphosis: Is it Necessary?

Baron S. Lonner; Jamie S. Terran, BS; Peter O. Newton, MD; Suken A. Shah, MD; Amer F. Samdani, MD; Paul Sponseller; Harry L. Shufflebarger, MD; Randal R. Betz, MD

USA

Summary: Neural axis abnormalities in operative Scheuermann's Kyphosis (SK) patients has not been prospectively studied previously. We found a 58% prevalence of abnormalities including posterior disc protrusion in 51% of patients. The operative plan was impacted by MRI findings in 4/79 cases. Routine preoperative MRI may be indicated in SK.

Introduction: Neurological risk associated with surgery for Scheuermann's kyphosis (SK) has been reported to be higher than that for AIS surgery. The reason for this has not yet been identified. No study to date has prospectively investigated the spinal cord, spinal canal, and intervertebral discs pre-operatively in SK patients with preoperative MRI, which was the purpose of this study.

Methods: 79 operative SK patients < 25 years of age were enrolled in a prospective fashion with one aim being to assess the spinal cord/canal and posterior intervertebral discs for herniations into the canal. Screening MRI of the cervical, thoracic and lumbar spine were performed on all patients. Posterior intervertebral disc herniations were analyzed by their proximity to the curve apex.

Results: 79 patients of 112 prospectively enrolled operative SK patients, 41% F, mean age 16.2 had pre-operative MRI, which were reviewed by a radiologist and the lead author. 46 patients (58.2%) had abnormalities. Of these, 40 patients had a total of 41 disc hernations, 39 contained and 2 extruded. 6 patients (7.5%) had syrinx, 1 (1.3%) had low lying conus, 1 (1.3%) had congenital lumbar stenosis and 1 (1.3%) had lack of segmentation C2/3. Only 5 (6.3%) had neural element impingement, 1 from congenital stenosis, one from the spinal cord draping over the apex, 3 from disc herniations. The average distance of the disc herniation from the apex of kyphosis was 3.71 ± 5.56 discs, median 5 discs. In 4 cases, the surgical plan was changed as a result of the MRI; in 3 cases anterior discectomy was performed and in 1 case fusion level selection was impacted. 1 patient had intraoperative spinal cord monitoring changes without post operative deficit in whom a small apical disc herniation was noted preoperatively and was not removed and 1 patient who did not have MRI abnormalities had post operative paraplegia requiring implant removal.

Conclusion: The prevalence of posterior disc herniation and spinal cord abnormalities in the SK population was defined. Routine MRI screening for the preoperative SK patient may be indicated to avoid neurological complications associated with corrective surgery.

Significance: No study before has prospectively evaluated the impact of preoperative MRI SK on surgical planning.

Table 1. Number of disc protrusions at each disk.

Cervical							Thoracic											Lumbar				
1-2	2-3	3-4	4-5	5-6	6-7	7-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	5-S1
0	0	1	1	2	1	0	0	1	0	0	2	3	8	8	2	4	5	2	2	2	5	14	16

PAPER #71

Scheuermann's Kyphosis: Impact on Quality of Life in 86 Patients

Baron S. Lonner; Peter O. Newton, MD; Jamie S. Terran, BS; Randal R. Betz, MD; Paul Sponseller; Suken A. Shah, MD; Amer F. Samdani, MD; Harry L. Shufflebarger, MD

USA

Summary: The impact on health related quality of life (HRQOL) as assessed by the SRS 22 outcome instrument is great for operative Scheuermann's kyphosis than for operative adolescent idiopathic scoliosis.

Introduction: The clinical presentation and impact on health-related quality of life (HRQOL) of Scheuermann's Kyphosis (SK) has not been previously evaluated in a prospective manner. Previous studies have assessed the impact of adolescent idiopathic scoliosis (AIS) and kyphosis in AIS patients on HRQOL. The purpose of this study was to identify the clinical impact of Scheuermann's kyphosis on HRQOL compared to that for AIS and normal controls (NC).

Methods: 86 pts enrolled in a prospective study of patients with operative Scheuermann's kyphosis were evaluated. Impact of kyphosis magnitude, apex location (thoracic, TL) were evaluated with SRS-22 and VAS outcome instruments. These patients were compared to a cohort of operative AIS patients from a prospective database as well as to normal controls. ANOVA and the Bonferroni post hoc comparison were utilized to compare the groups. Pearson correlation was utilized for correlation comparisons.

Results: Mean age for SK, AIS, and NC, were 14.96, 14.16 and 16.10 respectively ($p<0.001$). SK, AIS and NC were 39.5%, 75% and 74.19 % female respectively ($p< 0.001$). Preoperatively, SK pts have significantly lower scores in all domains of the SRS-22 compared to AIS pts. SK and AIS pts scored significantly lower than NC on the pain and image domains, as well as mean scores ($p<0.05$). There was no significant difference between SK and NC for the mental health domain. SK patients with TL apex scored significantly lower than those with T apex in the pain domain. There were no significant differences in SRS scores between patients with kyphosis < 80° and > 80°. When AIS and SK T5-12 K was pooled, there was a significant negative correlation to all domains of the SRS. SK patients mean VAS score was 3.36 ± 2.74. VAS score negatively correlates to pain, image mental health and total SRS score. There is no correlation of VAS to curve magnitude or apex location for AIS or SK.

* Hibbs Award Nominee for Best Clinical Presentation † Hibbs Award Nominee for Best Basic Science Presentation

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Conclusion: The clinical impact on HRQOL of SK as compared to AIS and NC has been demonstrated for the first time. Kyphosis appears to impart a significantly negative impact on quality of life in the adolescent population.

Mean SRS - 22 scores for SK, AIS and Normal Controls.

	SK	AIS	Normal	p-value
Activity	4.27	4.50	4.23	<0.001
Pain	3.84	4.12	4.52	<0.001
Image	2.83	3.46	4.45	<0.001
Mental	3.65	4.09	3.97	<0.001
Total	3.61	4.02	4.29	<0.001

PAPER #72

One-Stage Posterior Approach and Combined Interbody and Posterior Fusion for Thoracolumbar Spinal Tuberculosis with Kyphosis in Children

Hongqi Zhang, MD; Yuxiang Wang, MD; Chaofeng Guo

China

Summary: Various surgeries have been applied to treat children spinal tuberculosis.Anterior and combined anterior and posterior surgery have been recommended by most surgeons.However,as the treatment strategy has become more conservative in recent years, some surgeons have performed one-stage posterior surgery for the treatment of adult spinal tuberculosis during these years and have proved that it is an effective method in the treatment of spinal tuberculosis. Surgical management of advanced children thoracolumbar spine tuberculosis with kyphosis and in poor general condition by using this method in one center is not reported in the peer-reviewed literature nowadays.

Introduction: The goal of this study was to determine the efficacy and feasibility of surgical management of advanced thoracolumbar spine tuberculosis with kyphosis in children in poor general condition with 1-stage posterior decompression, interbody grafts, and posterior instrumentation and fusion.

Methods: Between 2006 to 2008,seven children with advanced thoracolumbar spinal tuberculosis accompanied by kyphosis and in poor general condition were treated with one-stage posterior decompression, interbody grafts and posterior instrumentation and fusion followed by chemotherapy.The chemotherapy persisted for at least 12 months in all patients.The mean follow-up was 34 months (range27-42 months).Patients were evaluated before and after surgery in terms of ESR,neurological status,pain,spinal canal compromise,kyphotic angle.

Results: Spinal tuberculosis was completely cured and the grafted bones were fused in all 7 patients.There was no recurrence and persistence of the disease in any of the patients at the final follow-up.ESR got normal within 3 months in all patients.The Frankel neurological classification improved in all cases.Pain relief was obtained in all patients.The average canal compromise was 52.57% (range, 35-75%) before surgery and 9.86% (range, 0-19%) after surgery.The average preoperative kyphosis was 37.9°and decreased to 5.4°postoperatively.There was no significant loss of the correction at the latest follow-up.

Conclusion: Although we do not underestimate the usefulness of anterior surgery in spinal tuberculosis,our results show that one-stage posterior decompression, interbody grafts, and posterior instrumentation and fusion followed by chemotherapy was an alternative treatment for children with advanced thoracolumbar spinal tuberculosis and in poor general condition.It is characterized as minimum surgical intervention,encouraging neurological recovery,good correction of kyphosis and prevention of progressive kyphosis.

PAPER #73

How to Determine Optimal Fusion Levels of Scheuermann's Kyphosis

Yuan Ning; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Linda Koester, BS

China

Summary: 86 patients with Scheuermann's kyphosis with a minimum 2-year follow-up were reviewed for evidence of proximal (33%) or distal (11%) junctional problems. The upper instrumented vertebra should be the proximal end vertebra, or T2 if the spine is in forward sagittal imbalance, and the LIV should be the vertebra below with first lordotic disc, or the SSV if the spine is in global sagittal imbalance.

Introduction: The optimal proximal and distal fusion levels in patients undergoing instrumented spinal fusion for Scheuermann's kyphosis (SK) is still controversial. Previous studies recommend the proximal fusion level to be the proximal end vertebra (PEV) but still 30% of the pts developed proximal junctional kyphosis (PJK). As to the optimal distal fusion level, most of the surgeons select the vertebra below the first lordotic disc. A recent study recommended selection of the sagittal stable vertebra (SSV) as the lowest instrumented vertebra (LIV). However, distal junctional problems (DJP) still may occur even using these criteria.

Methods: 86 pts (53 males/33 females) who underwent instrumentation and correction surgery for SK were reviewed (ave age, 18.3±6.6). Cobb angles were measured on preop lateral standing, initial postop lateral standing, 2yrs postop lateral standing, last F/U lateral standing radiographs.

Results: The mean preop max Cobb angle was 85.8°±11.7, corrected to 54.8°±14.2 postoperatively, maintained at 59.7°±16.8 at last F/U (PJK group: 66.9°±18.3; nonPJK group:56.3°±15.1). The mean correction ratio was 43.6%. PJK occurred in 28 cases (33%). DJP occurred in 11 cases (13%). There was a significant difference in PJK morbidity between the groups regarding fusion levels at or above the PEV and the fusion level below the PEV ($p<0.05$). Pts with a proximal fusion level at or above T2 had less PJK morbidity vs below T2 ($p<0.05$). 5 out of the 6 pts with a preop C7 plumbline (C7PL) ≥50mm developed PJK, which was significantly different from pts with C7PL <50mm

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PODIUM PRESENTATION ABSTRACTS

($p<0.05$). There was a significant difference in DJP morbidity between the groups regarding fusion level above the first lordotic disc vs below first lordotic disc ($p<0.05$). 4 pts had a fusion level below the first lordotic disc but DJP still occurred. All had global sagittal imbalance preop.

Conclusion: In SK, the optimal proximal fusion level is the PEV. It is better to select T2 or above when it is difficult to determine the PEV especially when the C7PL ≥50mm. The optimal distal fusion level is the vertebra below the first lordotic disc. If preop sagittal imbalance exists, the distal fusion level should extend distally to the SSV or one level lower than the first lordotic vertebra.

PAPER #74

The Evolution of the Surgical Treatment of High-Grade Adolescent Isthmic Spondylolisthesis: Successes and Failures. A Single Center 50 Year Experience

Tenner J. Guillaume, MD; Joseph H. Perra, MD; John Lonstein; Robert B. Winter, MD

USA

Summary: Retrospective chart and Xray review to evaluate procedure associated fusion rates, complications, reoperations, and the risks and benefits of aggressive surgical reduction at a single center over a 50-year period.

Introduction: The benefits of aggressive surgical reduction of high-grade adolescent isthmic spondylolisthesis do not outweigh the risks.

Methods: 63 patients met the inclusion criteria of high-grade (>50%) isthmic spondylolisthesis, patient less than 18 years old at surgery, surgical intervention performed between 1960 and 2008, and absence of a syndromic diagnosis.

Results: Of the 63 patients, 34 had slips of 51% - 75%, 13 had slips of 76% - 100%, and 10 had slips of > 101%. 39 patients had 2-year radiographic follow-up. 43 patients underwent either no or table assisted reduction. A posterior fusion was performed in 32 patients (25 uninstrumented and 7 instrumented), 10 with 360-degree fusion (6 uninstrumented and 4 instrumented), and 1 with uninstrumented anterior fusion.

18 patients underwent aggressive active reduction. A posterior fusion was performed in 12 patients (1 uninstrumented and 10 instrumented), a 360-degree fusion was performed in 6 patients (5 uninstrumented and 1 instrumented) and 1 had an uninstrumented anterior fusion.

There were 5 (11.6%) pseudoarthroses in the minimally reduced group, all of which were uninstrumented posterior fusions, and 3 (16.7%) pseudoarthroses in the aggressively reduced group (one each in the posterior instrumented, uninstrumented anterior, and uninstrumented 360 groups).

Overall there were 5 neurologic complications (7.9%), all occurring in patients that were actively reduced (26% of active reductions), of which 3 were permanent. There were 8 reoperations in the actively reduced group, and 6 reoperations in the minimally reduced group.

Conclusion: We found that aggressive reduction did not improve fusion rate, increased neurologic complications, and resulted in a higher reoperation rate.

Significance: Excellent outcomes are obtained without significant morbidity and minimally reduced treatment of Adolescent High-Grade Spondylolisthesis.

PAPER #75

Sagittal Global Balance and Health-Related Quality of Life in Lumbosacral Spondylolisthesis

Adil Harroud; Jean-Marc Mac-Thiong, MD, PhD; Julie Joncas; Hubert Labelle, MD

Canada

Summary: The purpose of this study is to determine the relationship between global sagittal balance and HRQOL (health-related quality of life). A total of 149 patients with adolescent lumbosacral spondylolisthesis were evaluated. An increase in positive sagittal balance was associated with a poorer HRQOL for patients with high-grade slippage, but not low-grade slippage. In patients with high-grade spondylolisthesis, global sagittal balance is related to HRQOL, independently from slip percentage and lumbosacral kyphosis. Global sagittal balance is an important parameter in the clinical evaluation of patients with spondylolisthesis.

Introduction: Many surgeons believe that global sagittal balance is an important aspect in the management of spondylolisthesis, but the evidence establishing its clinical impact is poor. Previous studies reported significant correlation between global sagittal balance and HRQOL in patients with adult spinal deformity or adult spondylolisthesis, but none has investigated this relationship in adolescent spondylolisthesis. The purpose of this paper is to determine if global balance parameters are clinically relevant and have an impact on HRQOL in adolescent lumbosacral spondylolisthesis.

Methods: A retrospective study of 149 consecutive unoperated patients presenting with lumbosacral adolescent spondylolisthesis at a single pediatric institution (117 low-grade and 32 high-grade) was performed. Two global sagittal balance parameters were measured on full spine standing lateral radiographs: spinal tilt (ST) and C7 plumb line deviation (C7P). All patients completed the SRS-30 questionnaire to assess HRQOL. Pearson's correlations were calculated between each radiological parameter and HRQOL.

Results: Both global sagittal balance parameters were related to SRS-30 total score. When grouped based on slip percentage, the correlation was absent in low-grade patients but remained significant in high-grade patients (r=0.354 for ST; r=-0.349 for C7P). The relation was strengthened when considering only high-grade patients with positive sagittal balance (r=0.533 for ST; r=-0.539 for

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C7P). Correlations for these patients remained significant when controlling for slip percentage and lumbosacral kyphosis (LSK).

Conclusion: In high-grade patients with spondylolisthesis, an increase in positive sagittal balance was related to a poorer SRS-30 total score, independently from slip percentage and LSK. Global sagittal balance should be assessed in the clinical evaluation of high-grade patients with spondylolisthesis.

Significance: Patients with high-grade spondylolisthesis tend to present poorer HRQOL in the presence of positive sagittal balance. Accordingly, reduction of the spondylolisthesis should be given consideration in these patients.

PAPER #76

Single Stage Reduction and Unilateral Transforaminal Lumbar Interbody Fusion for High Grade Isthmic Spondylolisthesis

Yasser ElMiligui, MD, FRCS; Wael Koptan, MD; Mohammad M. El-Sharkawi, MD; AbdElMohsen Arafa

Egypt

Summary: A prospective multicenter study of 44 patients with high-grade isthmic spondylolisthesis surgically treated with a single-stage limited decompression and direct instrumented reduction with or without unilateral Transforaminal Lumbar Interbody Fusion (TLIF). TLIF provided immediate stability and had superior clinical and radiological outcomes with significantly less complications.

Introduction: Several controversies exist over the most appropriate approach for managing high grade spondylolisthesis. The classic Interbody fusions are associated with a considerable degree of complications. The aim of this work is to determine the safety and efficacy of unilateral TLIF in managing high grade isthmic spondylolisthesis.

Methods: The study was conducted between 2000 and 2008 and included 44 patients with high grade isthmic spondylolisthesis (Meyerding grades III and IV). The mean age was 24y (range 17 - 38y). All patients had severe back and radicular symptoms that failed to conservative treatment. Eighteen were at L4/5 and 26 at L5/S1. Limited decompression and direct instrumented reduction was performed; 21 had additional unilateral TLIF (Group 1) and 23 had posterolateral fusion using autograft bone (Group 2). Patients were followed-up for an average of 4.5y (range 2 - 7y).

Results: The average Oswestry Disability Index and Visual Analogue Scale improved significantly more in Group 1. In Group 1 anterolisthesis improved from an average of 69% to 16% while in Group 2 it improved from an average of 64% to 19% at final follow up. Other parameters including improvement in disc space height, lumbar lordosis and angle of slip where significantly better in Group 1. None in Group 1 had an implant failure and its overall fusion rate was 94%. In Group 2, the average operative time, blood loss and hospital stay were significantly less but two patients had implant failure requiring revision and the overall complications were 6/23 patients.

Conclusion: Direct instrumented reduction and TLIF is an efficient option to treat high grade isthmic spondylolisthesis. It provided immediate stability and superior clinical and radiological outcomes.

PAPER #77

High-Grade Spondylolisthesis - Twenty-Year Experience at One Institution

Ali Al-Omari; Scott McKay; Lauren A. Tomlinson, Bachelor of Science; David A. Spiegel, MD; John P. Dormans, MD

USA

Summary: This abstract describes our institution's experience with three types of surgical treatment for high-grade spondylolisthesis. We reviewed 36 patients with high grade spondylolisthesis treated surgically with at least 1 year follow-up. Subjects were divided into three groups: insitu arthrodesis, arthrodesis with intraoperative reduction and posterior instrumentation, and arthrodesis with intraoperative reduction, wide nerve root decompression, sacroplasty, and posterior instrumentation with anterior column support (4-step). We found better deformity correction and rate of union in patients treated with the 4-step procedure.

Introduction: The optimal surgical treatment for high-grade spondylolisthesis remains unclear. This study reports our institution's experience with surgical treatment of high-grade spondylolisthesis.

Methods: A retrospective review of clinical data and imaging studies was performed in 36 cases of high-grade spondylolisthesis treated surgically. Patients were divided into three groups, namely 1) in-situ arthrodesis (n=8), 2) arthrodesis with intraoperative reduction and posterior instrumentation (n=6), and 3) arthrodesis with intraoperative reduction, wide nerve root decompression, sacroplasty, and posterior instrumentation with anterior column support (4 step procedure) (n=13).

Results: The average follow-up was 38 months (range 12-110 mos). In Group 1, 6/8 cases fused (75%), and 2 patients were revised for pseudarthrosis and deformity progression. Complications included 1 neurologic deficit (resolved), and 4/8 patients (50%) had persistent pain at latest follow-up. In group 2, a solid arthrodesis was achieved in 5/6 cases (83%), and complications included a gradual loss of correction was in 2 patients, one of whom required revision surgery, as well as one asymptomatic screw fracture and a single neurologic deficit (resolved). A single patient had pain at latest followup. In group 3, 12/13 cases fused (92%), and a single patient required revision for pseudarthrosis. Three patients had postoperative neurologic deficits (2 resolved, one had persistent weakness in dorsiflexion). Radiographically, group 3 had a better correction of slip angle, slip percentage, and sagittal pelvic balance.

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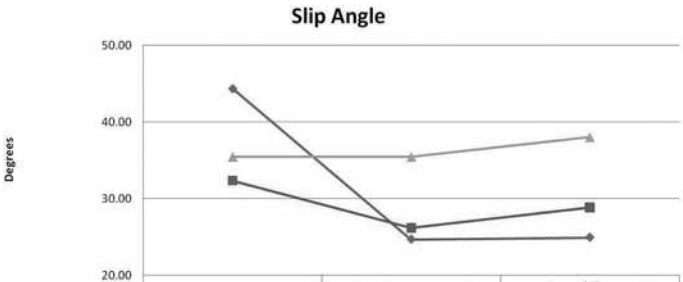
Conclusion: Patients treated with the 4-step approach (Group 3) achieved the best deformity correction and rate of union, although a single patient had a persistent neurologic deficit. Anterior column support at L5-S1, coupled with enhanced distal fixation, may help avoid deformity progression and pseudoarthrosis.



	preop	postop	latest follow-up
4-step	44.33	24.67	24.92
no anterior support	32.33	26.17	28.83
in situ	35.43	35.43	38.00

PAPER #78

Predictive Value of Tokuhashi Scoring Systems in Spinal Metastases, Focusing on Various Primary Tumor Groups: Evaluation of 448 patients in the Aarhus Spinal Metastases Database

Miao Wang, MD; Cody E. Bunger; Ebbe S. Hansen, MD, DMSc

Denmark

Summary: We conducted a prospective cohort study of 448 patients from the Aarhus Spinal Metastases Database to determine the predictive value of the Tokuhashi scoring system (T12) and its revised version (T15) for life expectancy in various primary tumors. Among the various cancer groups, the two scoring systems are reliable in prostate and breast metastases groups. T15 is recommended superior compared with T12 because of its higher accuracy rate.

Introduction: The life expectancy of patients with spinal metastases is one of the most important factors in selecting the treatment modality. Tokuhashi et al formulated a one point-cumulative-type prognostic scoring system with a total sum of 12 points for preoperative prediction of life expectancy in 1990. The scoring system was revised in 2005 to a total sum of 15 points based on the primary origin of spinal metastasis. There is lack of knowledge about specific predictive value in spinal metastases of various primary tumors.

Methods: This study included 448 patients with vertebral metastases underwent surgical treatment during Nov 1992 to Nov 2009 at the Aarhus University Hospital. Data were retrieved from the Aarhus Metastases Database. Scores based on the T12 and T15 scoring systems were calculated prospectively for each patient. We divided all the patients into different groups dictated by the site of their primary tumor. Predictive value and accuracy rate of the two scoring systems were compared in each cancer group.

Results: Both the T12 and T15 scoring systems showed statistically significant predictive value when the 448 patients was analyses in total (T12 P<0.0001; T15 P<0.0001). The accuracy rate was significantly higher in T15 (P<0.0001) than in T12. The further analyses by primary cancer groups showed that the predictive value of T12 and T15 was primary determined by the prostate (P=0.0003), and breast group (P=0.0385). Only T12 displayed predictive value in the colon group (P=0.0011). Neither of the scoring systems showed significant predictive value in the pulmonary (P>0.05), renal (P>0.05), and the miscellanies primary tumor groups (P>0.05). The accuracy rate of prognosis in T15 was significantly improved in prostate (P=0.0032), and breast group (P<0.0001).

Conclusion: Both T12 and T15 showed significant predictive value in patients with spinal metastases. T15 has a statistically higher accuracy rate than T12. Among the various cancer groups, the two scoring systems are reliable in prostate and breast metastases groups. T15 is recommended superior compared with T12 because of its higher accuracy rate.

Significance: <0.05

PAPER #79

Axial Ewing's Sarcoma Family of Tumors Carry a Significantly Less Favourable Prognosis as Compared with Non-Axial Locations. A Population Based Study in Finland in 1990-2009

Joni Serlo, MD; Ilkka Helenius, MD, PhD; Mika Sampo; Maija Tarkkanen

Finland

Summary: Outcomes of axial and non-axial ESFT patients were compared based on a national cancer register and medical records. Overall 5-year survival was 48% in axial and 70% in non-axial Ewing sarcoma patients. Surgical excision marginal, absence of metastasis, and neoadjuvant chemotherapy are other major prognostic factors.

Introduction: Ewing sarcoma family of tumors (ESFTs) is a group of rare soft tissue and bone malignancies with aggressive nature. The purpose of this study was to evaluate all Finnish patients with ESFT diagnosed in the time period of 1990-2009, to determine the 5-year overall- and event-free survival rates (OS and EFS) and to find out which factors affected most survival.

Methods: All patients (n=74) with ESFT diagnosed between 1990 and 2009 were identified from the Finnish Cancer Registry (it is obligatory to declare all cancer patients into this register based on our legislation) and their medical records were reviewed. Patients with insufficient information and patients with tumors in the head were excluded (n=10), leaving 64 patients for final analyses. Lesions primarily in the spine, pelvis or chest cage were defined as axial (n=30, mean age at surgery 16.2 years, range 8.1-32.9) and the rest as

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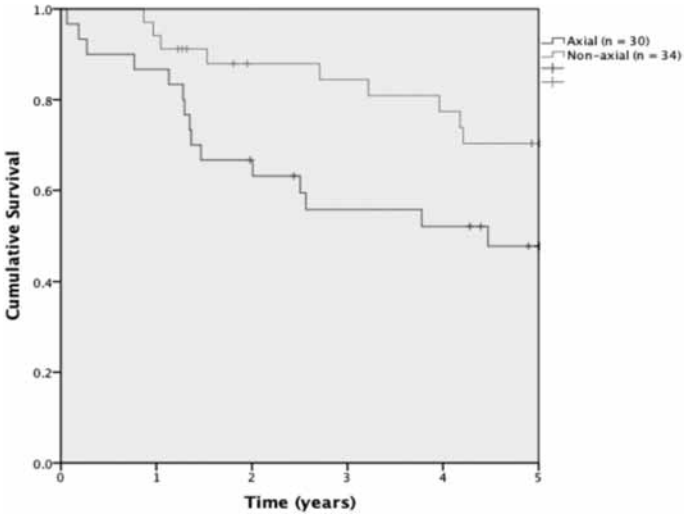
non-axial (n=34, mean age at surgery 18.7 years, range 0.4-48.0 years). OS and EFS rates were determined using Kaplan-Meier analysis.

Results: Cumulative 5-year OS for all patients was 60% and 5-year OS and EFS for patients with localized disease at diagnosis (n=48) were 66% and 57% respectively. Factors that improved 5-year OS with statistical significance in univariate analysis included localized disease compared to metastatic disease at diagnosis (5-year OS 66% vs. 40%, p=0.011), non-axial location of the primary tumor compared to axial location (5-year OS 70% vs. 48%, p=0.046), surgery with at least a marginal margin as opposed to no surgery or intralesional operations only (5-year OS 74% vs. 36%, p=0.009) and administration of neoadjuvant chemotherapy or not (5-year OS 67% vs. 46%, p=0.012).

Conclusion: Based on the findings of this population based study, the most significant prognostic factors for survival included non-axial site of the primary tumor, localized disease at diagnosis and surgical excision with adequate margin.

Significance: Axial ESFT carries significantly less favorable prognosis than non-axial (Level-II evidence).

Cumulative overall survival according to site of the primary tumor



PAPER #80†

A Genome Wide Association Study Identifies IL17RC as an Adolescent Idiopathic Scoliosis Locus

John P. Dormans, MD; Struan F. Grant, PhD; Norma Rendon Sampson, MS; Rosetta Chiavacci, BSN; Hakon Hakonarson

USA

Summary: A genome wide association study of adolescent idiopathic scoliosis identifies a missense mutation (S111L) within the IL17RC gene as a strongly associated locus with the trait.

Introduction: Untreated scoliosis, particularly in more severe cases, has a detrimental influence on health throughout life plus a negative socioeconomic impact with respect to work and marital status. Approximately three quarters of structural scoliosis is clinically classified as idiopathic, which is the most common spine deformity arising during childhood. One of the main sub-forms of the disorder is adolescent idiopathic scoliosis (AIS), which presents in children aged 10 to 16 years old. There is strong evidence for a genetic component to idiopathic scoliosis. Classical candidate gene studies have only achieved limited success in identifying genetic determinants of idiopathic scoliosis. Genome wide association studies (GWAS) have been revolutionizing the field of complex disease in the last 5 years, revealing multiple novel loci underpinning common disorders, to date, no GWAS has been reported for scoliosis. We therefore elected to perform a GWAS of adolescent idiopathic scoliosis(AIS)on subjects recruited from the Department of Orthopedic Surgery at the Children's Hospital of Philadelphia.

Methods: We genotyped ~550,000 single nucleotide polymorphisms(SNPs)with the Illumina Human Hap550 Genotyping BeadChip on our study population of 137 adolescent idiopathic scoliosis(AIS)cases of European ancestry and 2,126 controls.

Results: Following adjustment for local ancestry, four SNPs on chromosome 3p25.3 reached the strict threshold for genome wide statistical significance. The top signal at this locus, rs708567, is a common missense mutation(S111L) within the "interleukin 17 receptor C"(IL17RC)gene (P=1.18x10-9).The risk associated allele C confers an odds ratio of 2.28 i.e. more than doubles the risk of presenting with AIS.

Conclusion: A GWAS has identified an IL17RC missense mutation (S111L) as an AIS locus. Efforts are now underway to replicate this association further,test it for association in additional sub-forms of idiopathic scoliosis and to test its functional role in the pathogenesis of the trait.

Significance: This finding presents the potential opportunity for diagnostic applications and for novel therapeutic intervention for AIS.

PAPER #81†

Candidate Genes for Susceptibility of Adolescent Idiopathic Scoliosis Identified Through a Large Genome-Wide Association Study

Lesa M. Nelson, BS; Rakesh Chettier, MS; James W. Ogilvie, MD; Kenneth Ward, MD

USA

Summary: This genome wide association identified several new genetic loci contributing to AIS susceptibility. Identification of genes contributing to scoliosis should eventually lead to a greater understanding of the biology underlying AIS.

* Hibbs Award Nominee for Best Clinical Presentation † Hibbs Award Nominee for Best Basic Science Presentation

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PODIUM PRESENTATION ABSTRACTS

Introduction: AIS susceptibility genes (i.e. CHL1) have been previously identified using a genome-wide association study (GWAS). This study sought to identify additional genes associated with the susceptibility of AIS and using an independent GWAS examine whether reported associations were also seen in our study.

Methods: 2300 AIS patients were available and complete medical records describing the progression of their scoliosis were obtained. Confirmation of the diagnosis was confirmed after review of the records by a single surgeon (JWO). 1000 of the AIS patients and an additional 1000 ethnically matched controls with no known history of AIS were used in this GWAS analysis. 906,600 single nucleotide polymorphisms (SNPs) were genotyped using the Affymetrix HuSNP 6.0 microarray. Genotypes were determined using the Birdseed algorithm. Strict quality assurance criteria were used to ensure accurate genotyping and sample quality. Genomewide significance was defined as 5×10^{-8}.

Results: Three single nucleotide polymorphisms met genome wide significance for association with the susceptibility of AIS and were associated with genes on chromosomes 9, 10 and 12. The chromosome 9 SNP (rs 10758121, $p<2.83 \times 10^{-8}$) is located between the NEK7 and ATP6V1G3 genes. The SNP on chromosome 10 (rs 11190878, $p<2.45 \times 10^{-11}$) is located between the TLX1 and LBX1 genes. An additional SNP was supportive of this region, rs 7893223, $p<1.53 \times 10^{-7}$. The SNP on chromosome 12 (rs 7138732, $p<3.87 \times 10^{-8}$) is located near the PRICKLE 1 gene. An additional SNP was supportive of this region, rs 11181576, $p<2.59 \times 10^{-7}$. An additional 12 SNPs were also near genome wide significance ($p<8.19 \times 10^{-7}$) and could also identify susceptibility gene candidates. Association was not seen with other reported susceptibility genes.

Conclusion: This large GWAS study identified several candidate genes for AIS susceptibility in the tested population. The study failed to confirm previously reported gene associations. Based on these findings and other reports, AIS susceptibility is a complex genetic disorder that most likely involves multiple genes and pathways.

Significance: Identification of susceptibility genes through GWAS studies should eventually lead to a greater understanding of the biology underlying AIS.

PAPER #82†

Functional Assessment of Acute Local vs. Distal Transplantation of Human Neural Stem Cells Following Spinal Cord Injury

Robert E. Mayle, MD; Robert L. Smith, PhD; Ian Corcoran-Schwartz; Karthikeyan Ponnusamy; Glen Kajiyama, BA; Rayshad Oshtory, MD, MBA; Don Y. Park, MD; Ivan Cheng, MD

USA

Summary: 24 Long-Evans hooded rats underwent a contusion spinal cord injury. They were treated with human neuronal stem cells acutely either at the site of injury or intrathecally at a site distal to the injury through a separate laminotomy. Compared with controls, both groups demonstrated significant functional improvement, and there was no statistically significant difference between the local versus distal treatment groups.

Introduction: Previous studies have demonstrated functional recovery of rats with spinal cord contusions after transplantation of rat fetal neural stem cells adjacent to the site of injury. Our hypothesis was that the acute transplantation of human fetal neural stem cells (hNSCs) locally at the site of injury compared with distal intrathecal injection would lead to comparable functional recovery.

Methods: 4 groups of Long-Evans hooded rats were identified for this study: 2 experimental and 2 control. All subjects underwent a laminectomy at the T10 level. A moderate spinal cord contusion at the T10 level was incurred by use of the Multicenter Animal Spinal Cord Injury Study Impactor with a 10g weight dropped from a height of 25mm. Experimental subjects received a subdural injection of hNSCs adjacent to the site of injury, or an intrathecal injection of hNSCs through a separate laminotomy made in the mid-lumbar spine, distal to the site of injury. Control subjects received an injection of control media alone. Subjects were assessed following injury and then weekly for 6 weeks using the BBB Locomotor Rating Score.

Results: 24 subjects underwent spinal cord injury and injection, 6 in each group (local cells, local medium, distal cells, distal medium). A statistically significant functional improvement in subjects that received hNSCs injected either locally or distally to the site of injury was observed when compared to controls ($p=0.001$ and 0.004 respectively, see figure). There was no significant difference in functional improvement between subjects that received hNSCs either local or distal to the site of injury ($p=0.92$).

Conclusion: The acute transplantation of hNSCs into the contused spinal cord of a rat has lead to significant functional recovery of the spinal cord, when injected either local or distal to the site of spinal cord injury. The ability to achieve similar significant functional recovery through an intra-thecal injection of human neural stem cells distal to the site of SCI may considerably affect clinical treatment of SCI. Patients may be able to receive a potentially therapeutic injection of hNSCs through a traditional lumbar puncture in the acute phase after their injury.

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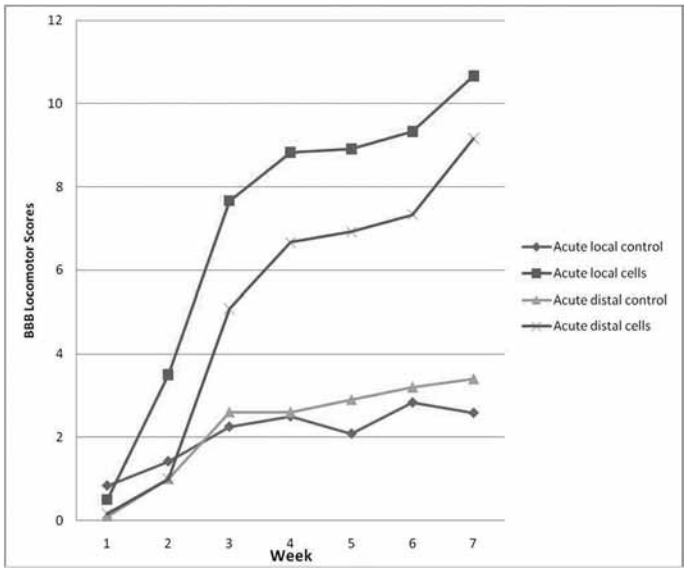
BBB locomotor scores by weekly assessment



PAPER #83†

Is the Abnormal Melatonin Receptor Expression in Girls with Adolescent Idiopathic Scoliosis a Quantitative Change?

Annie Po Yee Yim, MSc; Guang-quan Sun; Hiu Yan Yeung, PhD; Kwong Man Lee; Bobby KW Ng, MD; Yong Qiu; Jack C. Cheng, MD

Hong Kong

Summary: Melatonin signaling pathway dysfunctions and abnormal melatonin receptor expression have been reported in osteoblasts of AIS patients. . This study aims to study whether the abnormal MTNR1B expression in AIS girls was quantitative. The results suggested that abnormal MTNR1B expression in AIS girls is likely to be quantitative rather than qualitative. The study also suggested that the abnormal expression might due to problem in post-transcriptional process of MTNR1B expression.

Introduction: Melatonin signalling pathway has been suggested to be one of the key etiopathogenic factors. Previous report showed abnormal melatonin receptor 1B(MTNR1B) expression in AIS girls. However, it is necessary to clarify whether it is a quantitative or qualitative change in AIS girls. The present study was aimed to investigate the possible problem of MTNR1B expression in AIS.

Methods: Primary culture of osteoblasts from 26 AIS girls and 5 normal controls were obtained. Semi-quantification for both MTNR1A and 1B protein expressions was done by Western blotting. mRNA expression of the 2 receptors were quantified using TaqMan Real Time PCR. Mann Whitney test was employed to compare the expression level of receptor protein and mRNA between AIS girls and controls.

Results: Both MTNR1A and MTNR1B were found in the normal controls. Majority of AIS patients, the protein expression of MTNR1B was lower than normal controls and showed significant difference. While the protein expression MTNR1A was similar between AIS and healthy girls. However, no difference was found when comparing the mRNA expression of both MTNR1A and MTNR1B.

Conclusion: Melatonin signalling pathway dysfunction has been proposed to play a significant role in the eitopathogenesis of AIS. In this study with larger sample size, all AIS girls had relatively lower MTNR1B protein expression than controls. It suggested that the abnormality of MTNR1B expression was quantitative and pointed to a post-transcriptional problem with MTNR1B expression. Previous studies suggested the stoichiometry of MTNR1A and 1B affected their function. Further study along this line is warranted.

Significance: The result supported that melatonin receptor and related signaling pathways may play a role in the pathophysiology of AIS. Further studies on melatonin receptor and its related signaling pathways would provide a better understanding on the etiopathogenesis of AIS.

PAPER #84†

Generalized Gi Protein-Mediated Signal Transduction Impairment Occurs in Patients with Adolescent Idiopathic Scoliosis

Alain Moreau, PhD; Marie-Yvonne Akoume, PhD; Anita Franco, MSc

Canada

Summary: Functional analysis of cells derived from AIS patients revealed a signaling dysfunction affecting only receptors coupled to G inhibitory proteins (Gi) allowing their functional classification into three subgroups. Signal transduction of receptors mediated through interactions with Gs and Gq alpha subunits were not affected. Furthermore, the heritability of this defect was demonstrated in families with multiple AIS cases with the detection of the same degree of functional impairment in all affected family members.

Introduction: We have demonstrated initially a differential dysfunction of melatonin signaling through Gi proteins in different cell types isolated from AIS patients, leading to their stratification into three functional subgroups. Herein we examine the extent to which Gi protein-mediated signal transduction is disturbed in AIS patients, its heritability and the impact of estrogens.

Methods: The functional state of G protein coupled-receptors (GPCRs) was examined in lymphocytes from 387 consecutive AIS patients and 93 asymptomatic healthy children. Signal transduction of GPCRs was measured by cellular dielectric spectroscopy (CDS) in presence of varying concentrations of synthetic compounds that specifically initiate Gi, Gs or Gq protein-mediated signal transduction in presence or not of physiological doses of 17-beta estradiol.

Results: Gi protein mediated signal transduction was impaired in all GPCRs receptors specifically coupled to Gi proteins such as melatonin receptors, somatostatin

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receptor SST1, leukotriene receptor, lysophosphalipid receptor, cannabinoid type 2 receptor, serotonin 5-HT1 receptor, apeline receptor, adenosine A3 receptor and alpha2-adrenergic receptor while beta-adrenergic receptor and bradykinin B2 receptor respectively coupled to Gs and Gq proteins were not affected. Addition of physiological doses of 17-beta estradiol exacerbates the Gi signaling impairment with all GPCRs tested. The detection of the same pattern of response among affected family members confirmed the heritability of this differential Gi-coupled receptor signaling dysfunction in AIS.

Conclusion: We conclude that Gi protein signaling dysfunction in AIS is a generalized and systemic disturbance that can be regarded as a heritable trait. Moreover, estrogens crosstalk with GPCR signaling is most likely at the origin of the higher prevalence of AIS in girls and the incidence of this disease around puberty.

Significance: Classification of individuals by evaluating Gi-coupled receptor signaling with CDS is an advantageous procedure because it can be performed without prior knowledge of the specific mutated genes. Thus, targeting this defect can serve as a diagnostic procedure and a therapeutic avenue for AIS patients and population at-risk of developing AIS.

PAPER #85

Lenke 1C and 5C Spinal Deformities Fused Selectively - A Natural History of Uninstrumented Compensatory Curves

Ryan M. Ilgenfritz, MD; Burt Yaszay, MD; Tracey Bastrom, MA; Peter O. Newton, MD; Harms Study Group

USA

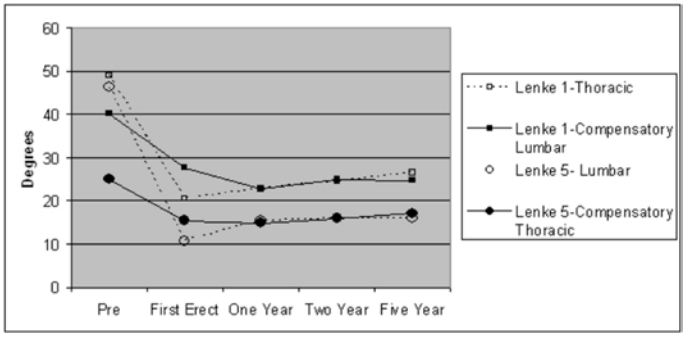
Summary: Patients with Lenke type 1C and 5C AIS spinal deformities that were fused selectively were reviewed, focusing on the natural history of uninstrumented compensatory curves over a five year post-operative period.

Introduction: Following a selective fusion for 1C and 5C AIS curve types, there is concern that uninstrumented compensatory curves will continue to progress over time. We analyzed the natural history of the uninstrumented compensatory curves over a 5 year post-operative period.

Methods: Lenke 1C and 5C AIS cases, prospectively collected from a multi-center study were analyzed. All patients underwent a selective fusion (1C only thoracic curve fused; 5C only thoracolumbar/lumbar curve fused). Pre-operative, first erect, 1-year, 2-year, and 5-year post-operative coronal, sagittal and axial (Perdriolle) radiographic outcomes were compared utilizing repeated measures ANOVA with Bonferroni post hoc comparisons ($p<0.05$).

Results: Twenty-four selectively fused Lenke 1C curves and 21 selectively fused Lenke 5C curves were available for review. Pre-operative compensatory curve Cobb angles were 40± 6° and 25 ± 9° respectively. In Lenke 1C curves, the uninstrumented compensatory lumbar curves corrected by 32 ± 16% ($p<0.001$) at first erect, 44 ± 17% correction at 1-year ($p=0.006$), 38 ± 15 % correction ($p=0.020$) at 2 years, and 39 ± 19% at 5 years ($p=0.792$). In Lenke 5C curves, the uninstrumented compensatory thoracic curves corrected by a mean of 37 ± 29% ($p<0.001$) at first erect, 42 ± 29% ($p=0.742$) at 1 year, 37 ± 29% ($p=0.184$) at 2 years, and 30 ± 23% ($p=0.412$) at 5 years. The relative magnitudes of the primary and compensatory curves in both Lenke 1C and 5C cases were different pre-op and at the first erect time point (4-6 weeks), then became and remained similar from 1 to 5 years postop (Figure). The sagittal and axial measure of the compensatory curve remained stable during the postop period. All patients at 5 years post-operative were Risser 4 or 5.

Conclusion: In Lenke 1C and 5C AIS deformity patterns fused selectively, the uninstrumented compensatory curves adjust to match the instrumented primary curve and do not seem to progress between 1 and 5 years post-operatively. Longer follow-up on a larger number of patients will be necessary in order to evaluate concern for progression of uninstrumented compensatory curves beyond 5 years post-operatively.



PAPER #86

Lumbar Spine is Stable after Selective Thoracic Fusion for Adolescent Idiopathic Scoliosis: A 20-Year Follow-Up

A. Noelle Larson, MD; Nicholas Fletcher, MD; B. Stephens Richards, MD

USA

Summary: Following selective thoracic fusion for adolescent idiopathic scoliosis with segmental instrumentation, spinal balance and correction of the lumbar curve remain stable at a mean follow-up of 20 years. Clinical outcome measures and physical exam findings were satisfactory, and similar to a comparison group undergoing long instrumented fusion.

Introduction: Selective thoracic fusion for the treatment of AIS preserves motion segments but leaves residual lumbar deformity. Long-term results of selective fusion using segmental fixation are limited.

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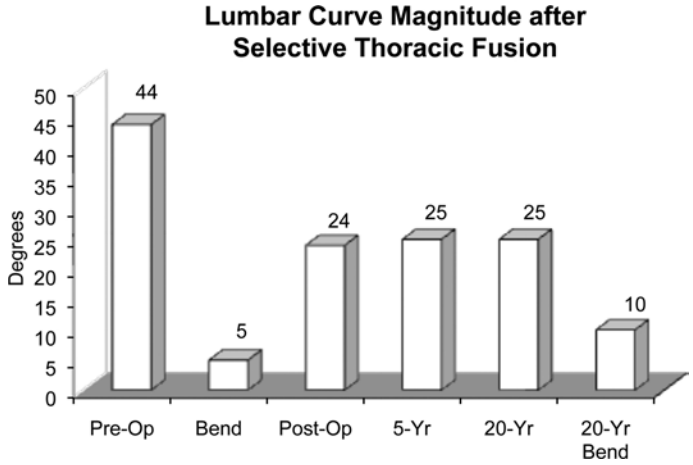
Methods: 19 AIS patients treated with selective thoracic fusion and 9 patients treated with a long fusion returned at a mean 20 years (range, 14- 24 years) post-operatively for radiographs, clinical evaluation, and outcome surveys (Short Form-12, Scoliosis Research Society-24, Spinal Appearance Questionnaire, Oswestry Disability Index, Visual Analog Score for pain and stiffness). Curve types were Lenke 1B, 1C, or 3C. All patients underwent posterior fusion with TSRH or Cotrel Dubosset (CD) hook-rod instrumentation.

Results: The selective thoracic fusion group had no significant progression in the lumbar curve magnitude and no worsening of L4 obliquity to the pelvis between initial post-operative and 20-year follow-up. Mean pre-operative lumbar curve magnitude (mean 44 degrees, range 32-64) corrected 43% on initial post-operative films versus 38% at latest follow-up. Mean L4 obliquity to the pelvis, trunk shift, sagittal balance, and coronal balance were stable over time. Outcome scores between the two groups were similar. Scores in the long fusion group, when compared to the selective group, were higher for two SRS domains: Self-Image after Surgery (p=0.005), Function after Surgery (p=0.0006).

Conclusion: The uninstrumented lumbar curve following selective thoracic fusion was stable over a mean 20-year follow-up, with no progression in magnitude or L4 obliquity with respect to the pelvis. Patients had good or excellent functional outcome scores with satisfactory results on the SRS-24 and Oswestry Disability Index. Those with selective fusions have outcome measures comparable to those with long fusions.

Significance: Following selective thoracic fusion for adolescent idiopathic scoliosis with segmental instrumentation, spinal balance and correction of the lumbar curve remain stable over time.

Mean lumbar curve magnitude was stable over time in the selective fusion group. Bending films taken pre-operatively and at latest follow-up show excellent preservation of lumbar spine motion.



PAPER #87

Is There a Better Alternative to a Randomized Control Design for Assessing the Efficacy and Effectiveness of Bracing in AIS?

Daniel Y. Fong, PhD; Kenneth M. Cheung, MD; Yatwa Wong; Wai Yuen Cheung, MD; Idy C. Fu; Evelyn E. Kuong; Kin C. Mak, MBBS, FRCS; Michael To, FRCSEd (Ortho); FHKCOS; FHKAM (Ortho); Keith D. Luk, MD

Hong Kong

Summary: With the support of the Scoliosis Research Society, we examined the feasibility of conducting a single-blind comprehensive cohort study that assesses both efficacy and effectiveness of bracing in AIS. The study incorporates a RCT and an option allowing patients to choose their desirable treatment. Besides, it also has a treatment exit plan for those with significant progression. Our study showed that it outperforms a conventional RCT in terms of recruitment ability.

Introduction: Current randomized controlled trials (RCTs) for assessing the efficacy of bracing in patients with adolescent idiopathic scoliosis (AIS) suffer from poor recruitment. Besides, patients who consent for randomization may be a highly selected group of individuals who really have no preference on treatment; thus may limit the assessment of effectiveness. Therefore, we aimed to determine the feasibility of an alternative study design, "the comprehensive cohort study" that can overcome the concerns of conventional RCTs.

Methods: AIS patients aged ≥10 years, had Risser sign between 0-II, and had a Cobb angle of 25° to <30° or 20° to <25° with 5° deterioration over the past 4 months were invited to join a RCT. Those declined were given an option to stay in the study, but choose whether they wish to be braced or observed. A randomization schedule was generated for all patients whether or not they joined the RCT; thus additional patients who made their own choice may also fit with the randomized choices. Blinded out-of-brace radiographic and psychosocial assessments were made. Compliance was assessed. For those without brace but had ≥6° curve progression or reached 30° were considered failures, and braces were offered. Patients were followed every 4 months.

Results: Over 1 year, there were 87 eligible patients, 68 (78%) patients (5 boys and 63 girls) with mean age of 12.5 years (range: 10 to 15 years) consented to participate with a median follow-up of 57 weeks. Of which, 19 (28%) patients accepted randomization with respectively 13 and 6 patients allotted to brace and observation. For others who declined randomization, 18 (37%) chose brace and 28 (57%) patients had their choice of treatment the same as that on the randomization schedule. Braced patients had a daily average of over 17 hours within the first year. 10 patients had ≥6° curve progression during follow-up.

Conclusion: This Comprehensive Cohort Study design has the potential to improve the rate of recruitment such that both efficacy and effectiveness of brac-

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ing in AIS can be assessed. Our preliminary study showed that it can be feasibly conducted with less recruitment burden. A larger scale study with longer follow-up is needed to address the question of efficacy and effectiveness of braces.

PAPER #88

Optimal Lowest Instrumented Vertebra to Avoid Adding-On or Distal Junctional Kyphosis for Thoracic Adolescent Idiopathic Scoliosis

Yongjung J. Kim, MD; Charla R. Fischer, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Oheneba Boachie-Adjei, MD; Jean-Luc Clement, MD; Munish C. Gupta, MD; Samuel K. Cho, MD

USA

Summary: A radiographic assessment of 521 thoracic major AIS patients who underwent PSSIF with a minimum 2-year follow-up demonstrated 14% prevalence of adding-on or distal junctional kyphosis. Open triradiate cartilage, lowest instrumented vertebra of less touching by center sacral line, and more proximal to neutral vertebra were identified as risk factors.

Introduction: To determine the optimal lowest instrumented vertebra (LIV) to avoid adding on (AO) or distal junctional kyphosis (DJK) following posterior segmental spinal instrumented fusion (PSSIF) of thoracic adolescent idiopathic scoliosis (AIS) with LIV at L2 or above.

Methods: A radiographic assessment of 521 thoracic AIS patients (average 14.7 years) who underwent PSSIF with a minimum 2-year follow-up (2-16.7 years) was performed. AO was defined as the distance from the center of the lowest instrumented vertebra to the center sacral vertical line > 3cm or coronal disc angle below the lowest instrumented vertebra > 10 degree and DJK was defined as sagittal disc angle below lowest instrumented vertebra > 10 degree at the ultimate follow-up.

Results: The prevalence of AO or DJK at the ultimate follow-up was 14% (72/521). Stable-1 LIV defined by center sacral line (CSL) passing between medial walls of the LIV pedicles had 9% (27/285), Stable -2 (between Stable -1 and -3) 15% (28/192), and Stable -3 (No touch of LIV by CSL) 19% (17/44) (p=0.000). Open triradiate cartilage had 43% (vs 13% among closed one, p=0.001). Neutral LIV had 11% (42/376), Neutral-1 (between Neutral and Neutral-2) 15% (8/55), and Neutral-2 (at least 2 verteba proximal to NV) 24% (22/90) (p=0.000).

Conclusion: The prevalence of AO or DJK at the ultimate follow-up following PSSIF of thoracic AIS with LIV at L2 or above was 14%. Open triradiate cartilage, LIV of less touching by CSL, and more proximal to NV were identified as risk factors.

Significance: Prevention of adding-on or distal junctional kyphosis is very important to prevent revision surgey or better long term outcomes.

PAPER #89

Distal Adding-On Phenomenon in Lenke 1A Scoliosis: Risk Factor Identification and Treatment Strategy Comparison

Yu Wang, MD, PhD; Cody E. Bunger

Denmark

Summary: Distal adding-on is often accompanied by unsatisfactory clinical outcomes and high risk of reoperation. However, very few studies have focused on distal adding-on and its attendant risk factors and optimal treatment strategies remain controversial. In this study, we proved that selection of lowest instrumented vertebra(LIV) was highly correlated with distal adding-on, and compared 5 different methods for determining LIV and found the best method.

Introduction: To identify risk factors for the presence of distal adding-on in Lenke 1A scoliosis and compare different treatment strategies.

Methods: All surgically treated AIS patients were retrieved from a single institutional database. Distal adding-on was defined as a progressive increase in the number of vertebrae included distally within the primary curve combined with either an increase of more than 5 mm in deviation of the first vertebra below instrumentation from the center sacral vertical line(CSVL), or an increase of more than 5°in the angulation of the first disc below the instrumentation at 1 year follow-up. Wilcoxon rank-sum test, Fisher's exact test and Spearman's correlation test were used to identify the risk factors for adding-on. A multiple logistic regression model was built to identify independent predictive factor(s). Five methods for determining lowest instrumented vertebra(LIV) were compared in both the Adding-on group and No adding-on group.

Results: Out of 278 patients reviewed, 45 met the inclusion criteria; 23 of these met the definition for distal adding-on, and were included in the Adding-on group. The remaining 22 patients were included in the No adding-on group. The average follow-up was 3.6 years. Age, SV-LIV difference , EV-LIV difference, and LIV+1 deviation from CSVL were significantly different ($p<0.05$) between the two groups, and were also found to be significantly correlated with the presence of adding-on ($p<0.05$). Multiple logistic regression results indicated that preoperative LIV+1 deviation from CSVL was an independent predictive factor. Among the five methods, choosing EV as LIV was nearly unable to prevent distal adding-on; choosing EV+1 as LIV resulted in fusing many more segments than necessary; only choosing DV as LIV showed satisfactory outcome from both perspectives.

Conclusion: In Lenke 1A type scoliosis, the selection of LIV is highly correlated with the presence of adding-on; incidence increases dramatically when the preoperative LIV+1 deviation from CSVL is more than10 mm. Choosing DV (the first vertebra in cephalad direction from sacrum with deviation from CSVL of more than 10 mm) as LIV may provide the best outcome as it not only prevents adding-on but also conserves more lumbar motion.

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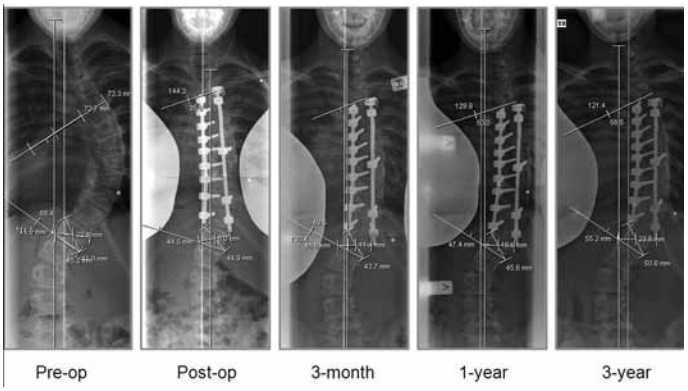
Significance: $p < 0.001$.

A 12- year- old girl with Lenke 1A scoliosis underwent surgical treatment and developed typical distal adding-on. Postoperative control radiograph showed that L1 deviation from the CSVL and Cobb angle were corrected from 22.4 to 6 mm and from 68.4°to 35.6, respectively. However, distal adding-on started soon after surgery; L1 deviation and Cobb angle increased progressively, eventually reaching 23.8 mm and 58.5 ° at 3-year follow-up.



PAPER #90

Spinal Deformity in Marfan vs. AIS: Learning from the Differences

Joseph P. Gjolaj, MD; Paul Sponseller; Suken A. Shah, MD; Peter O. Newton, MD; John M. Flynn, MD; Baron S. Lonner; Amer F. Samdani, MD; Michelle C. Marks, PT, MA; Philip Neubauer, MD; Tracey Bastrom, MA

USA

Summary: Marfan spine deformity can be corrected with similar blood loss and hospital stay to comparable AIS curves. Longer fusions, implant-related complications and reoperations are more common. Knowledge of these differences is important for planning surgery.

Introduction: Patients with Marfan syndrome commonly require spinal deformity surgery but practice guidelines and results are not as established as in idiopathic scoliosis. There has been no process comparison of the two groups in order to illustrate differences. Therefore we compared Marfan with matched AIS patients.

Methods: 34 adolescents with Marfan syndrome were matched 1:2 with AIS patients for age, gender and degree of major deformity. Mean age was 14+ 2 years. Mean curves were 51 degrees thoracic and 46 degrees lumbar. Mean follow up was 5.3 years for Marfan and 3.6 years for AIS.

Results: The Marfan patients had significantly more thoracolumbar kyphosis correction associated with the major curve. They were fused significantly more levels than the idiopathic patients (11.7 +2 vs 8.9 +3, $p<0.001$) and more often to the pelvis (5 vs 0; $p=0.01$). Three of the pelvis fusions were primary and two were secondary. There were 3 intraoperative CSF leaks in the Marfan group versus none in the AIS group. However, there was no significant difference in blood loss (total or per vertebra fused, 164cc/level vs 136 cc/level), neurologic deficit, hospital stay, percent correction, or infection rate. Marfan patients had more correction of preoperative sagittal imbalance (2.4 vs -0.6 cm, $p=0.035$). There were 3 instrumentation complications in the Marfan group (two broken screws and one screw dislodgement) versus one in the idiopathic group ($p=0.007$). There were 9 reoperations in the Marfan group. Three were early (one for spine fracture, one for screw pullout, one for decompensation) and 6 were late: 2 for add-on deformity, two for distal degeneration, two for pseudarthrosis. There were no reoperations in the AIS group. SRS-22 total (3.9 vs 4.5, $p=0.00$) and subscores ($p<0.015$) were significantly lower in Marfan patients.

Conclusion: Marfan patients differ in several ways from AIS. The surgical correction involves more levels and a more distal fusion, but no significant increase in blood loss or hospital stay as has been previously suggested. Surgery is associated with more correction of sagittal imbalance and more reoperations as well as instrumentation-related complications attributed to osteopenia, dysplastic pedicles and laminae.

PAPER #91

Results for a Randomized Prospective Study Comparing Thoracic Screws vs. Thoracic Hooks for Fixation in Adolescent Scoliosis (AS)

Lawrence L. Haber, MD; Joshua D. Hughes; Erika Womack, MSc

USA

Summary: A computer prospectively randomized patients with AS into two groups for thoracic fixation. Group 1 received hooks (n=18) and group 2 received screws (n=19). Between the groups, all preop and postop values were comparable ($p>0.05$). At final follow-up, the only parameters with statistically significant differences were major curve correction and rotation ($p<0.05$).

Introduction: To compare results of surgical treatment of AS using hooks vs pedicle screws for thoracic fixation in Lenke 1,2, and 3 curves.

Methods: A computer prospectively randomized patients into two groups for thoracic fixation. Group 1 received hooks (H) and group 2 (S) received screws; both received screws for lumbar fixation. All constructs were non-every level constructs. Only curves that bent to ≤40° were included. Parameters taken at preop, postop, and final follow-up (FFU) included Lenke classification, pain scales, SRS 30 surveys, Cobb angles, kyphosis and lordosis, and rotation. Paired and independent t-tests were used for comparisons.

Results: H and S had 18 and 19 patients respectively and a mean f/u of 26 (24-49) months. Mean levels fused for both groups was 9±1. Mean operative

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time for H was 252±58 minutes and for S was 298±57 minutes (p=0.007). Patients in both groups were discharged at a mean of 4±1 days.

For H, means for the following parameters preop, postop, and FFU were: major curve (MC) 58±8, 18±8, and 23±8; MC rotation 14±6, 9±5, and 11±5; lumbar curve 35±13, 13±11, and 13±12; kyphosis 33±14, 30±11, and 31±10; lordosis 64±16, 51±16, and 63±10; SRS 30 scores 90±11, 120±15, and 124±16.

For S, means for the following parameters preop, postop, and FFU were: MC 55±6, 15±7, and 14±6; MC rotation 15±4, 7±3, and 7±4; lumbar curve 31±8, 7±9, and 7±7; kyphosis 29±14, 27±5, and 25±5; lordosis 59±13, 55±10, and 57±10; SRS 30 scores 91±17, 121±15, and 119±16.

Neither group had fixation failures or major complications.

Conclusion: Between the groups, all preop and postop values were comparable (p>0.05). At FFU, the only parameters with statistically significant differences were MC correction and MC rotation (p=0.000 and p=0.039 respectively). However, lumbar curve correction was trending towards statistical significance (postop p=0.07, FFU p=0.052) There were no differences in SRS 30 scores.

Significance: This is the first randomized, prospective study of screw vs hook fixation in thoracic AS. Although better MC correction and rotation were maintained with pedicle screws, either screws or hooks can be used safely and with good results for thoracic fixation in flexible AS. Both also have equal outcomes in regard to patient satisfaction.

PAPER #92

Five Year Results for Lenke 1 or 2 Curves: Comparison of Anterior, Posterior Hybrid, and Posterior All Pedicle Screws

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USA

Summary: A paucity of data exists on 5 year outcomes of patients treated with either anterior (A), posterior hybrid (PH), or all pedicle screw (PS) constructs for patients with adolescent idiopathic scoliosis (AIS). We compare the radiographic and clinical outcomes of 222 patients with Lenke 1 or 2 curves treated with either A, PH, or PS constructs. Posteriorly treated patients demonstrate improved coronal correction, whereas anteriorly treated patients have more kyphosis. Early return to the OR was more common with PS constructs, whereas late returns occurred only in the A and PH groups.

Introduction: No previous report has compared 5 year results between A, PH, and PS constructs for patients with AIS. We compare the radiographic and clinical outcomes of AIS patients with Lenke 1 or 2 curves treated with either A, PH, or PS constructs.

Methods: A multicenter AIS database was retrospectively queried to identify 222 consecutive AIS patients who underwent spinal fusion for Lenke 1 or 2 curves. Radiographic analysis was compared between pre-op, 2-year, and 5-year time points. Chart review included scoliometer measurements, SRS questionnaire, and complications.

Results: Of the 222 patients identified, 127 were treated anteriorly and 95 posteriorly (PH=48, PS=47). Preoperative major thoracic Cobb was similar for the groups (A=51°, PH=53°, PS=53°, p=.56), with a trend toward greater % correction for the posterior groups at 5-year follow-up (A=51%, PH=60%, PS=60%, p=.07). Similarly, % correction of the compensatory lumbar curve was greater in the posterior groups (A=50%, PH=55%, PS=66%, p=.005). Preoperative kyphosis T5-12 was less in the anterior group (A=19°, PH=26°, PS=21°, p=.02), and was greater at 5-year follow-up (A=29°, PH=19°, PS=16°, p<0.01). Inclinometer readings and SRS scores were similar. Complications requiring a return to the OR occurred in 5 patients treated anteriorly (2 converted to PSF, 2 rod/screw breakage, one thoracoplasty, 4/5 between 2-5 yrs), 2 hybrid (1 for adding on, 1 thoracoplasty, both >2 yrs), and 3 in the pedicle screw group (3 asymptomatic misplaced screws).

Conclusion: At 5-year follow-up, AIS patients with Lenke 1 or 2 curves treated posteriorly demonstrated a trend toward greater coronal correction both of the instrumented and compensatory curves. Anteriorly treated patients fared better in the sagittal plane. SRS-22 scores were similar between groups. Early return to the OR for malpositioned instrumentation occurred more commonly in the PS group, whereas late returns were more likely in patients treated anteriorly or with hybrid instrumentation.

Significance: No previous study has compared the 5 year outcomes of AIS patients treated either anteriorly, with posterior hybrid, or with all pedicle screw constructs.

PAPER #93

Predictors of Long-Term SRS Total Scores in patients with Adolescent Idiopathic Scoliosis Treated Surgically

Leah Y. Carreon, MD, MSc; Jonathon M. Spanyer, MD; Steven D. Glassman, MD; Chelsea E. Canan, BA; Lauren O. Burke, BS; Charles H. Crawford, MD

USA

Summary: In a study of 135 young adults who had correction of their spinal deformity during adolescence, major surgery to fuse their spines did not seem to impair their functional outcomes; with mean scores of 51.4 for SF12PCS, 48.8 for SF12MCS and 4.0 for SRS22R Total. Regression analysis identified only smoking as a predictor of functional outcome. Interestingly, surgery type, number of levels fused, lowest instrumented vertebra and undergoing a revision surgery did not influence long-term functional outcomes.

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Introduction: The goal of treatment of adolescent idiopathic scoliosis is to prevent future problems associated with progression of the spinal deformity. This includes impaired pulmonary function and early spine degeneration. Few studies consider if the function of these patients are adversely affected by performing a major spine surgery with fusion in these young individuals. The purpose of this study is to determine variables that predict long-term functional outcomes in AIS patients treated surgically.

Methods: The surgical database was queried for all patients who had spine deformity correction between the ages 10 and 17 at a minimum of five years prior. Patients who had syndromes and intraspinal pathologies, such as tethered cord or syrinx, were excluded. After obtaining IRB approval, the patients were contacted by mail or telephone and the SRS22R and SF12 was administered. Standard demographic and surgical data were also collected. Regression analysis was performed to identify factors predictive of SRS-22R Total scores. Factors included in the analysis were prior bracing, age at surgery, Lenke type, surgery type (anterior, posterior, anteroposterior), number of levels fused, lowest instrumented vertebra, current smoking status and need for a revision surgery. The significance level was set at p=0.01.

Results: Data was available in 135 subjects. The mean age at surgery was 14.2 years and the mean age at follow-up was 26.6 years. The mean outcome scores were 51.4 for SF12PCS, 48.8 for SF12MCS and 4.0 for SRS22R Total score. Among the different variables, only smoking ($p<0.000$) was predictive of SRS22R Total Scores, accounting for 28% of the variability of the SRS22R Total score.

Conclusion: Young adults who had surgical correction of their spinal deformity during adolescence do not seem to have impaired functional outcomes despite undergoing major surgery to fuse their spines. Regression analysis identified only smoking as a predictor of functional outcome, which is expected even in the general population. Interestingly, surgery type, number of levels fused, lowest instrumented vertebra and undergoing a revision surgery did not influence long-term functional outcomes.

PAPER #94

Fusion Material vs. Outcome after Primary Posterior Spine Fusion with Instrumentation for Adolescent Idiopathic Scoliosis

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USA

Summary: We compared outcomes of autogenous v. allogenous bone graft v. fusion adjuvant in a retrospective analysis of prospectively gathered multicenter data on 461 children undergoing posterior spine fusion for AIS. We found few perioperative and no longer term significant differences in outcomes between fusion materials.

Introduction: It remains unclear whether allogenous bone graft or fusion adjuvants improve outcomes compared with traditional autogenous iliac crest for children undergoing operation for AIS. In a retrospective analysis of prospectively gathered multicenter data, we compared outcomes of autogenous (Au) v. allogenous (Al) bone graft v. fusion adjuvant (FA) for spine fusion in AIS.

Methods: We reviewed 461 prospectively enrolled children (8-18 yr) undergoing operation for AIS. Inclusion criteria were primary posterior operation and completed preop, 1 yr and 2 yr postop SRS-22 instrument. We compared 3 groups: Au, Al, FA. Outcomes were SRS-22, complications (infection, reoperation, other wound problems, and pseudarthroses), blood loss, length of hospital stay, operative time, PCA and epidural use. Differences in the various measures by patient group were assessed with analysis of variance (ANOVA) for continuous variables and Chi-Square or Fisher's Exact Test for categorical variables.

Results: 152 (33%) patients received Au, 199 (43.2%) Al, and 110 (23.8%) FA. Length of hospital stay (5.4 d FA, 4.9 d Au, 4.8 d Al, $p < 0.0004$), duration of epidural use (70.0 hr FA, 44.0 hr Au, 41.1 hr Al, $p = 0.0002$), and rate of PCA use (95.3% FA, 51.0% Al, 42.4% Au, $p < 0.0001$) were increased in the FA group, whereas operative time (231.8 min FA, 277.2 min Al, 278.7 min Au, $p < 0.0001$) and rate of epidural use (18.5% FA, 49.7% Al, 54.7% Au, $p < 0.0001$) were decreased in this group. Duration of PCA use (81.7 hr Au, 71.7 hr FA, 69.2 hr Al, $p = 0.0218$) was increased in the Au group. No differences were found among the groups for SRS scores, blood loss, and complications.

Conclusion: While differences were found in some peri-operative outcomes, no differences were found in other peri-operative outcomes or in longer term outcomes such as those measured by the SRS-22. Our study does not show a clear advantage of one fusion material over another.

PAPER #95

Ten Year Outcome of Patients Following Initial AIS Surgery: A Comparison of Single Surgery and Revision Surgery Patients

Daniel J. Sucato, MD, MS; Anna McClung, RN; Neil Saran, MD, MHSc, FRCSC; Dinesh Thawrani, MD; Sumeet Garg, MD; Jonathan R. Schiller, MD

USA

Summary: A single institution study analyzed patients 10 years following surgery for AIS comparing those who required a revision surgery to those who had only their initial operation. Improved coronal and sagittal plane correction was seen for both groups, If revision surgery was for progression of the curve, pseudo or implant failure, there was smaller final main curve magnitude than the single surgery group. Despite this, revision surgery still left patients with an overall worse SRS outcome score and ODI score.

Introduction: Although uncommon, revision surgery for adolescent idiopathic scoliosis (AIS) is necessary and seems to result in good overall results. There

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are no long-term studies comparing these patients to those undergoing a single surgery.

Methods: A single institution study of all patients who underwent a revision surgery for AIS were examined, had radiographs and completed an SRS-30 and Oswestry Disability Index (ODI) at a minimum of 10 years from surgery. A random selection of AIS patients who had a single surgery were used for comparison.

Results: There were 51 revision (Group R) and 60 single surgery (group SS) patients. Revision was for pain-26.9%, infection-23.9%, pseudo-16.4%, implant failure 11.9%, curve progression- 9.0%, miscellaneous-10.9%. The R and SS groups were similar in age at primary surgery (14.3 vs 14.3 years), BMI (20.9 vs 22.1 cm/kg2), % female (92.2% vs 91.7%). The average age at final follow-up was the same for the R (28.6 yrs) and SS (27.3 yrs) groups. There was no difference in preop major curve magnitude (60.1° vs 57.2°), but postop % correction (51.6 vs 58.1%) and final % correction (30.9 vs 45.7%) was less for the R group for the index surgery. There was no difference in coronal and sagittal balance between groups preoperatively or at final follow-up. If revision surgery was for progression of the curve, pseudo or implant failure, there was smaller final main curve magnitude in the R group (18.4 vs 26.4°) but no difference in coronal or sagittal balance. The SRS-30 total score (3.6 vs 4.0) and all SRS-30 domains were worse in the R group ($P<0.05$), and their level of disability, measured by the ODI was worse (19.2 vs 12.2) ($P=0.01$).

Conclusion: For patients undergoing revision surgery following initial surgery for AIS, patients demonstrate excellent coronal and sagittal balance at long-term follow-up. However, their overall functional outcome is worse than patients undergoing a single surgery and their disability is greater. In addition to the inconvenience and cost of revision surgery, the overall outcomes are worse at 10 years. Strategies to limit the incidence of complications and the need for revision surgery should be maximized to optimize long-term outcome.

PAPER #96

The Effects on the Lumbar Disc Degeneration of Spinal Fusion for Scoliosis Patients - A Minimum Ten-Year Follow -Up

Ayato Nohara; Noriaki Kawakami, MD; Kenji Seki, MD, PhD; Kazuyoshi MIyasaka, MD; Taichi Tsuji, MD; Tetsuya Ohara; Toshiki Saito; Kazuki Kawakami

Japan

Summary: This study was designed to evaluate the parameters causing lumbar disc degeneration (DD) in distal unfused segments in patients with scoliosis who had undergone corrective fusion more than 10 years earlier. DD was shown in 24.7% of the patients at 5 years after surgery, and in 55.9% at 10 years after surgery. The occurrence of DD was independent of the level of lower instrumented vertebra (LIV), an angle of L4 tilt greater than 7°, and max tilt greater than 10° after the operation.

Introduction: The purpose of this study was to evaluate the occurrence of DD in distal unfused segments in patients with scoliosis following more than 10 years follow-up, and to assess which parameters were related to the occurrence of DD in distal unfused discs.

Methods: This was retrospective study. One hundred nine patients (male 21, female 88) matched the inclusion criteria from 1990 to 1999: 1) less than 21 years of age at the time of surgery, 2) LIV from L1 to L4, 3) postoperative F/U more than 10 years. Patients with skeletal dysplasia, collagen disease, kyphosis, NF-1 were excludes in this study. Main curves, lumbar curves, angle of L4 tilt, and max tilt (defined as the highest tilting angle in lumbar vertebrae) at the time of surgery (preop) and during the postoperative (postop) follow-up (F/U), and final F/U were measured. DD were evaluated according to Pfirmann's grading system. The 109 patients were divided into 2 groups based on DD; DD(+) and DD(-).

Results: The average age at the time of the surgery was 14.1 yrs (6~20). The main curve of preop., postop., and final F/U were 62.7°, 24.6°, and 28.4°, respectively. Lumbar curves at each time were 36.5°, 13.4°, and 19.2°, respectively. L4 tilt was 7.5°, and max tilt was 11.3° after 10 years. DD on any unfused segments was observed in 24.7% at 5 years postop. and in 55.9% at 10 years. L5/S disc was degenerated in 53% at the time of postop. 10 years. DD was diagnosed in 36% on L1 (LIV), 46% on L2, 56% on L3, 60% on L4. The DD (+) group (61 patients) had an L4 tilt was 8.8° and max tilt was 13°. In DD (-)group (48 patients), L4 tilt of 6.5°, and the max tilt was 9.6°. There were significant differences in both L4 tilt and max tilt between DD(+) and DD(-).

Conclusion: This study indicated that DD on unfused lumbar segments at 5 years postop. were 24.7% and increased to 55.9% at 10 years. Although the level of LIV, L4 tilt more than 7°, and max tilt more than 10° was significantly associated with the occurrence of DD during the postoperative follow-up period.

PAPER #97

CT Evaluation of Vertebral Rotation Correction in Posterior Fusion for Thoracic Adolescent Idiopathic Scoliosis: Direct Derotation vs. Concave Rod Rotation

Mario Di Silvestre, MD; Francesco Lolli; Georgios Bakaloudis; Konstantinos Martikos; Francesco Vommaro; Elena Maredi

Italy

Summary: We reviewed 62 consecutive patients affected by AIS (Lenke type 1 or 2), treated by posterior fusion, to compare the vertebral rotation correction obtained with direct derotation procedure (DR) versus simple concave rod rotation (No-DR), using CT evaluation.

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The direct vertebral derotation procedure obtained significantly better final results, when compared to simple concave rod rotation, both concerning correction of apical vertebral rotation (DR 63.4% vs No-DR 14.8%; $p<0.05$) and magnitude of MT curve (61.3% vs 52.4%; $p<0.05$).

Introduction: Aim of our study is to compare the results obtained with direct derotation procedure versus simple concave rod rotation in thoracic AIS posterior surgery, using pedicle screw-only construct.

Methods: Sixty-two consecutive patients affected by AIS (Lenke type 1 or 2), treated by posterior fusion with pedicle screw-only instrumentation, between 2005 and 2008 at one single institution, were included. The rotation angle (RAsag) of the apical vertebra was measured on pre-operative and last follow-up axial CT. Two groups were identified: a direct vertebral rotation group using Lenke's procedure (DR group; n=32 patients) and a simple concave rod rotation group (No-DR group; n=30 patients). There were no statistical differences between the 2 groups, in terms of age, Risser's sign, curve patterns, Cobb main thoracic (MT) curve magnitude and flexibility, extension of fusion, offset measurements on the coronal plane and sagittal pre-operative contour.

Results: At an average follow-up of 3.7 years (range, 2.3 to 4.2), the DR group compared to the No-DR one showed a significantly better final correction of apical vertebral rotation (DR 63.4% vs No-DR 14.8%; $p<0.05$) and a greater final correction of Cobb MT curve magnitude (61.3% vs 52.4%; $p<0.05$) with better maintenance of initial correction (-1.7° vs -1.9°; ns). Concerning the coronal balance, there was the same trend of better results in the DR group, with less final apical MT vertebra translation (DR 2.2 cm vs No-DR 4.1 cm), greater overall change (preop-final) of lower instrumented vertebra (LIV) coronal tilt (-14.9° vs -11.1°; $p<0.05$) and better final global coronal balance (ns). The T5-T12 kyphosis angle was lower at final follow-up in DR group (14.5° vs 16.5°). At the latest follow-up, SRS-30 and SF-36 findings were similar between the two groups. The complication rate was higher in No-DR group (13.3% vs 9.3%), related in 2 cases to thoracoplasty, never used in DR group patients.

Conclusion: The direct vertebral derotation procedure obtained significantly better final results, when compared to simple concave rod rotation, both concerning correction of apical vertebral rotation and magnitude of MT curve. However, both techniques were found to be satisfying from patients perspective.

PAPER #98 - WITHDRAWN

PAPER #99

Corrective Tethering for Scoliotic Deformity: Impact on Growth Plate Histology and Vertebral Dysplasia in an Established Porcine Model

Allen Leung, MD; Frank Schwab, MD; Benjamin Ungar; Ashish Patel, MD; Edward Chay; Bertrand Moal, MS; Jean-Pierre C. Farcy, MD; Virginie Lafage, PhD

USA

Summary: There is growing interest in non-fusion treatment for severe Adolescent Idiopathic Scoliosis. In an established Porcine Scoliosis Model correction was achieved through the placement of a unilateral tether. This histological study demonstrated no significant decrease in growth parameters in a correction branch vs. an uncorrected branch. These findings are consistent with previous CT analysis, demonstrating preservation of growth potential in the correction branch.

Introduction: Non-fusion technology may offer correction of severe Adolescent Idiopathic Scoliosis through growth modulation. In an established Porcine Scoliosis Model (PSM), CT analysis demonstrated three dimensional correction through modification of vertebral morphology following placement of a mechanical tether, with continued overall growth. This study seeks to gain additional insight into the impact of the tether on affected vertebrae via histological analysis.

Methods: This was an IACUC approved study. Scoliosis was induced in 9 immature Yorkshire pigs per PSM protocol. Once ~50° coronal Cobb was reached, one branch had release of the deforming tether (TR, n=4), while a second branch had tether release and placement of an anterior corrective tether (AC, n=5). After 20 weeks of observation, pigs were euthanized, spines extracted, and histological slides of growth plates were prepared. Growth plate analysis included the following parameters: proliferative zone height, hypertrophic zone height, and cell heights in the hypertrophic zone. Comparisons were performed using t-tests between the left side (concave aspect of scoliosis) and right side (convex; side with corrective tether) within each group and between groups.

Results: No significant differences were found in TR between the left and right sides for any parameter. In AC, the proliferative zone height was significantly smaller on the left side vs. the right side ($p<0.01$); no significant differences were found in AC between the left and right sides in terms of the other parameters. No significant differences were found for any parameters between TR and AC on either the right or the left side.

Conclusion: Concerns about mechanical tether correction center on potential growth cessation due to damaged growth plates. No significant decrease in any of the parameters measured in AC (with corrective tether) compared to TR. These histological findings are consistent with previous CT analysis demonstrating preservation of growth potential in both TR and AC.

* Hibbs Award Nominee for Best Clinical Presentation † Hibbs Award Nominee for Best Basic Science Presentation

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PAPER #100

Sagittal Balance in Thoracolumbar or Lumbar Congenital Spinal Deformity with a Minimum Ten-Year Follow-Up after Surgery

Teppei Suzuki; Koki Uno, MD, PhD; Hiroshi Miyamoto, MD; Yoshihiro Inui; Noriaki Kawakami, MD; Taichi Tsuji, MD

Japan

Summary: We evaluated the long term surgical outcomes of 31 patients with congenital thoracolumbar or lumbar kyphoscoliosis and kyphosis in a multicenter study. In most cases the correction of scoliosis and kyphosis was well maintained and the plus sagittal balance was improved for over 10 years after surgery.

Introduction: Retrospective analysis of long term radiographic outcomes in a multicenter study.The purpose of this study is to evaluate the long term surgical outcomes of 31 patients with congenital thoracolumbar or lumbar kyphoscoliosis and kyphosis, especially in the sagittal balance.

Methods: Between 1989 and 2001, 31 patients treated with anterior and/or posterior spinal fusion. There were 16 females and 15 males. Diagnoses included congenital kyphoscoliosis(n=16) and kyphosis(n=5) in the thoracolumbar or lumbar spine. Average age at the initial surgery was 11.8 ± 6.2 years. Average follow-up was 13.1 ± 3.1 years. The changes in Cobb angle of the scoliosis and the segmental kyphosis, lumbar lordosis and the sagittal balance was examined.

Results: Average Cobb angle of scoliosis were 46 ± 12 degrees before surgery, 23 ± 12 degrees after surgery, and 25 ± 14 degrees at final follow-up. Average Cobb angle of the segmental kyphosis was 38 ± 19 degrees before surgery, 23 ± 18 degrees after surgery, 23 ± 14 degrees at final follow-up respectively. Average Cobb angle of the lumbar lordosis was 55 ± 26 degrees before surgery, 44 ± 20 degrees after surgery, 45 ± 18 degrees at final follow-up. Average sagittal balance were 10 ± 30 mm before surgery, 11 ± 30 mm after surgery, and 5 ± 37 mm at final follow-up. Five patients underwent additional surgery due to the decompensation of the unfused segments and one patient underwent additional surgery due to the pseudarthrosis.

Conclusion: In most cases the correction of scoliosis and kyphosis was well maintained and the plus sagittal balance was improved for over 10 years after surgery.

Significance: To our knowledge, this paper is the largest series of the long term follow-up study for the congenital thoracolumbar or lumbar kyphoscoliosis and kyphosis.

PAPER #101

Comparative Analysis of Pedicle Screw Fixation Only vs. Osteotomy with Pedicle Screw Fixation in Congenital Scoliosis - More than Five Years Follow-Up

Se-Il Suk, MD; Jin-Hyok Kim; Dong-Ju Lim; Seung-Hyun Choi; Jae-Min Jeon; Sung-Soo Kim, MD

Republic of Korea

Summary: Segmental pedicle screw fixation has been proved to be effective in correction and long term maintenance in spinal deformity. Osteotomy is good a method of curve correction in severe scoliosis or fixed deformity. However, there is no study that compares of the results of segmental pedicle screw fixation only versus screw fixation combined with posterior vertebral osteotomy in congenital scoliosis.

Introduction: To evaluate retrospective outcomes of segmental pedicle screw fixation with or without posterior vertebral osteotomy in congenital scoliosis with a minimum 5-year follow-up.

Methods: 126 patients with congenital scoliosis/kyphoscolisis subjected to segmental pedicle screw fixation were analyzed. There were 69 males and 57 females with average age at the time of operation was 13.8 years (3 ~ 61). The minimum follow-up was 5years (5 ~ 13). There were two groups, A and B and both groups had pedicle screw fixation. Group A included osteotomy in 84 patients (posterior vertebra column resection 72, pedicle subtraction osteotomy 9; segmental resection 2). The 42 patients in Group B had segmental pedicle screw fixation only.

Results: The preop coronal curve was 40° (1° ~ 116°) in the group A and 45° (6° ~ 100°) in the group B. The correction rate was 67 % in group A and 55 % in group B with a significant difference ($P < 0.05$). The preop kyphosis of 35° was improved to 11° in group A and 13° to 15° in group B. Postop coronal balance was well maintained in both groups. Postop adding-on deformity occurred in 8.3% (n=7) in group A and 9% (n=4) in group B. Revision operation was performed in 7.1% (n=6) in group A and 9% (n=4) in group B. There were no major neurological or visceral complication in either group. Whole bleeding amount and operation time was longer in group A ($P<0.05$). Younger patients had better deformity correction, fewer osteotomies and shorter fusions in group A ($P<0.05$).

Conclusion: In congenital scoliosis, an acceptable deformity correction can be obtained with segmental pedicle screw fixation only, but better correction may be achieved when combined with posterior vertebra osteotomy.

* Hibbs Award Nominee for Best Clinical Presentation † Hibbs Award Nominee for Best Basic Science Presentation

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PODIUM PRESENTATION ABSTRACTS

PAPER #102

Long-Term Clinical Outcomes of Surgical Treatment for Non-Idiopathic vs. Idiopathic Scoliosis: Minimum 21 Years Follow-Up

Tsutomu Akazawa, MD; Shohei Minami; Toshiaki Kotani, MD, PhD; Kazuhisa Takahashi

Japan

Summary: Long-term clinical outcomes in patients following surgical treatment for non-idiopathic vs. idiopathic scoliosis were similar at minimum 21 years follow-up. However, the percentage of marriage was significantly lower in patients with non-idiopathic scoliosis versus idiopathic scoliosis (39.6% vs. 69.6%, $p<0.01$).

Introduction: Several reports indicate that patients with idiopathic scoliosis exhibit good long-term outcomes after surgery. However, long-term surgical outcomes for non-idiopathic scoliosis patients are largely unknown. The purpose of this study was to determine the long-term clinical outcomes for patients surgically treated for non-idiopathic versus idiopathic scoliosis.

Methods: Six hundred and two patients surgically treated for scoliosis from 1968-1988 were included in this study. The SRS-22 Questionnaire, Roland-Morris Disability Questionnaire (RDQ) and our own questionnaire (a survey of marital status and history of childbirth) were used for evaluating long-term clinical outcomes. Fifty-six (18.5%) of the 303 non-idiopathic scoliosis (Non-IS) patients and eighty (26.8%) of the 299 idiopathic scoliosis (IS) patients answered the questionnaires, and respondents included 111 females and 25 males with a mean age of 47.0 years and a mean follow-up period of 31.1 years (range 21-41 years). Fifty-six Non-IS subjects included 25 congenital, 11 neuromuscular and 20 syndromic scoliosis patients.

Results: In Non-IS and IS groups, mean SRS-22 domain scores were 4.1 vs. 4.2 for function, 4.3 vs. 4.3 for pain, 2.8 vs. 2.9 for self-image, 3.6 vs. 3.8 for mental health and 3.2 vs. 3.5 for satisfaction (respectively). The mean RDQ score was 3.4 in Non-IS and 2.4 in IS patients. There were no significant between-group differences in any SRS-22 or RDQ domain. The percentage of married patients was significantly lower in the Non-IS group versus the IS group (Non-IS: 39.6% vs. IS: 69.6%, $p<0.01$).

Conclusion: Health-related quality of life and low back pain in patients surgically treated for non-idiopathic and idiopathic scoliosis were equivalent. However, the percentage of marriage was significantly lower in non-idiopathic scoliosis patients.

PAPER #103

Congenital Scoliosis: A Single Insitution Experience with Long-Term Follow-Up

Daniel J. Sucato, MD, MS; Anna McClung, RN; James Shaha; Andrew S. Matthys, BA; Neil Saran, MD, MHSc, FRCSC

USA

Summary: A large single institution review of 139 patients with congenital scoliosis at a minimum of 5 years from surgery demonstrated overall similar major curve correction and incidence of complications for patients with isolated hemivertebra, 3-4 hemivertebra±bar and those with a jumbled spine. However, the incidence of coronal imbalance was greater for those patients who had a greater portion of the spine affected with a jumbled spine.

Introduction: Congenital scoliosis is a challenging spinal deformity to treat surgically. There are few studies which have analyzed a large cohort of patients to determine the long-term outcome of these patients.

Methods: An IRB-Approved retrospective review of a consecutive series of patients who had congenital scoliosis from a single institution was performed. The medical record was carefully reviewed to determine demographic information, the surgical procedure, and complications. The radiographs were reviewed to determine the type of congenital scoliosis, and standard coronal and sagittal measurements were performed. All patients had a minimum of 5 year follow-up.

Results: There were 139 patients who had surgery between 1980 and 2004. The average age at surgery was 9.5 years and the average age at follow-up was 24.2 years. Neural axis abnormalities were noted in 31 (22.3%). There were a similar distribution of males and females (51.6 vs 48.4%). The procedures were posterior fusion-63, anterior/posterior fusion-49, hemivertebra excision 7, anterior fusion 13, hemiephysiodesis 4 and miscellaneous 3. Only 55.4 and 10.8% of patients had SSEP or MEP baseline data. The patients were divided into 3 groups; Group HB-multiple hemivertebra±bar (n=28), H-single hemivertebra (n=35), J-Jumbled Spine-(several congenital abnormalities) (n=75). There were no differences in the three groups with respect to major curve correction at 2 years and 5 years postoperatively, however, good coronal balance was seen more often in the HB (75.0%, 67.9%), and H (75.0%, 67.7%) than the J (56.3%, 58.0%) group using C7-CSVL and trunk shift measurements, respectively. There were no differences between groups with respect to neurologic complications, incidence of pseudoarthrosis, or curve progression.

Conclusion: Patients with congenital scoliosis undergoing surgical treatment overall have good outcomes with respect to curve correction, however, greater involvement of the spine with respect to congenital abnormalities may lead to greater coronal plane imbalance at a minimum of 5 years. Careful consideration of fusion levels and amount of correction is necessary to achieve a balanced patient.

* Hibbs Award Nominee for Best Clinical Presentation † Hibbs Award Nominee for Best Basic Science Presentation

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PODIUM PRESENTATION ABSTRACTS

PAPER #104

Effect of Root Section and Induced Hypotension on Spinal Cord Displacement Limits during Spine Surgery. Experimental Study in Pigs

Gabriel Piza Vallespir, MD, PhD; Carlos Barrios; Jesús J Burgos Flores, PhD; Elena Montes; Gema De Blas, MD, PhD; Carlos Correa; Cesar Perez-Caballero; Fernando Dominguez; Jorge Collazos, MD, PhD; Ignacio Regidor, MD, PhD; Eduardo Hevia, Dr; Alberto Caballero, MD; Ignacio Sanpera, MD, PhD

Spain

Summary: This is an experimental study to assess the amount of displacement allowed by thoracic spinal cord before the onset of evoked-potential changes. Cord may be displaced safely a distance equivalent to more than its width, and these limits may be increased by adjacent nerve root section. However, induced hypotension dramatically reduces the tolerance of the cord to displacement.

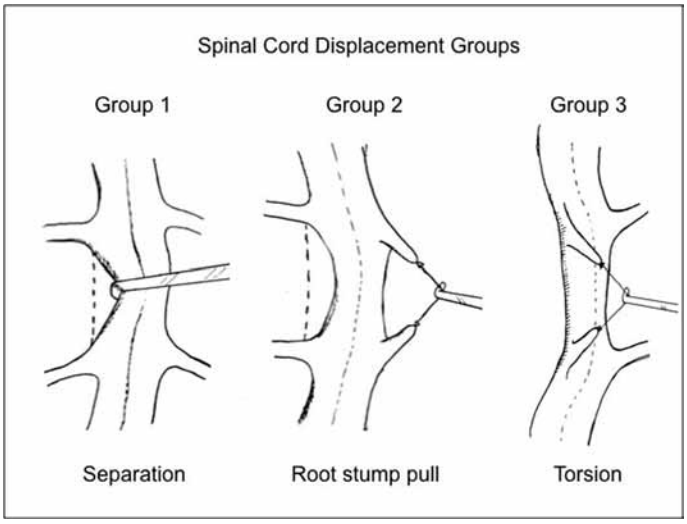
Introduction: The correction of severe spinal deformities by isolated posterior approach involves cord manipulation. It is often combined with hypotensive anesthesia to decrease blood loss. Ways to increase the tolerance of the cord to displacement and the influence of hypotension on it has never been assessed.

Methods: Experimental study on 12 domestic pigs. Three groups were established according to the method of displacement: separation (group 1, n=4), root stump pull (group 2, n=4) and torsion (group 3 n=4). Successive records of spine-to-spine motor evoked potential were obtained while the displacement was measured. The displacing force was released immediately after neurophysiologic changes appeared (increase of latency and/or decrease of amplitude). The test was repeated after sectioning the adjacent nerve roots. The experiments were firstly carried out under normotension and afterwards under hypotension (mean blood pressure 45 mmHg).

Results: The spinal cord width in the study area was 7.2±1 mm. Group 1: evoked potential changes appeared with displacement of 10.1±1.6 mm with roots unharmed and 15.3±4.7 mm after section of four adjacent roots ($p < 0.01$). After hypotension, changes appeared at 4 ± 1.2 mm ($p<0.01$). Group 2: evoked potential disturbance at 20.0±4.3 mm, which increased to 23.5±2.1 mm ($p < 0.05$) after cutting the two contralateral roots. When the test was performed with hypotension, changes appeared at 5.3±1.2 mm ($p<0.01$). Group 3: cord allowed torsion of 95.3°±9.2 increasing to 112.4°±7.1 if the contralateral roots were cut. When the test was carried out with hypotension, changes appeared at 20°±6.2 ($p<0.01$).

Conclusion: In an experimental model, it is possible to displace the thoracic spinal cord a distance superior to spinal cord width without suffering neurophysiologic changes . The limits of cord displacement increase by sacrifice of adjacent nerve roots. Hypotension has a dramatic effect on the tolerance of the cord to displacement before the appearance of evoked-potential changes.

Significance: Induced hypotension during cord manipulation may increase the risk of neurological injury and probably should be avoided.



PAPER #105

Post-Operative Hyperalgesia and Nerve Root Inflammation Following Posterolateral Arthrodesis with rhBMP-2. An in vivo Rat Study

Anton E. Dmitriev, PhD; Lyubov Tsytsikova, BSc; Rachel E. Gaume, BS; Ronald A. Lehman, MD; Aviva Symes

USA

Summary: Post-operative radiculitis following segmental arthrodesis with rhBMP-2 has been reported, yet the mechanisms remain unknown. In the current rodent study we have shown that BMP-2 causes local inflammatory response in the dorsal root ganglion, leading to a transient manifestation of functional pain in the rat.

Introduction: Despite clinical observation, the mechanisms behind rhBMP-2 associated post-operative radiculitis remain undefined. Our group has recently shown that rhBMP-2 triggers spinal cord scarring and inflammation when applied near a penetrating lesion. Therefore, we hypothesized that exogenous BMP-2 infiltrates the dorsal root ganglion (DRG) and elicits a response leading to functional changes resulting in pain.

Methods: A total of thirty-three (33) rats underwent a right side L5-6 posterolateral arthrodesis using either rhBMP-2 or saline control on a collagen sponge (ACS). Animals were divided into two follow-up groups: 1week (n=16) and 4weeks (n=16). Postoperatively, mechanical hyperalgesia was checked using the Von Frey test performed at 1, 3, 7, 10 days, and once weekly thereafter. Gait was assessed using the digital walkway system. At the respective survival time-points, rats were perfused and the DRG and spinal cords analyzed for

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inflammatory markers and pain pathway neuropeptides using immunohistochemistry (IHC).

Results: Functionally, no differences in postoperative right hind limb pain were detected on day 1. However, by day 3, rats receiving rhBMP-2 became significantly more sensitive to right paw poking compared to saline controls ($p<0.05$). Mechanical hyperalgesia persisted through day 7 ($p<0.05$). In addition, BMP-2 treated rats exhibited a decrease in right hind toe spread compared to controls on days 3 and 7 ($p<0.05$), demonstrating extremity pain according to this model. Functional tests at later time-points revealed no differences between the groups ($p>0.05$). At 1 week, IHC analysis of the L4 and L5 DRGs revealed a pronounced inflammatory response (ED-1) in the BMP-2 group compared to controls ($p<0.05$). Interestingly, in the dorsal horn of the spinal cord there were no differences in neuropeptide expression levels between the groups.

Conclusion: Despite preserving the facet joint intra-operatively, and not exposing the DRG directly to the protein, we observed a significant inflammatory reaction within the ganglion in rats receiving BMP-2. This correlated with significant functional pain. It appears that the transient post-operative allodynia may be triggered by the BMP-2 induced inflammatory cascade.

PAPER #106

Treatment of Chronic Spinal Cord Injury with Skin-Derived Precursors Differentiated into Schwann Cells (SKP-SCs) Promotes Axonal Regeneration and Functional Recovery

Peggy Assinck; Shaalee Dworski; Joe Sparling; Di Leo Wu; Gregory J. Duncan, BSC; Jie Liu, MD; Brian K. Kwon, MD, PhD, FRCSC; Wolfram Tetzlaff, MD, PhD

Canada

Summary: While much excitement exists around stem cells for spinal cord injury (SCI), the efficacy of this approach has almost exclusively been demonstrated with "subacute" transplantations within 1-2 weeks of injury. Here, using a rodent model of "chronic" SCI, we test the transplantation of Schwann cells derived from stem cells in the skin (Skin-Derived Precursor-Schwann Cells, or "SKP-SCs"). We demonstrate that SKP-SCs transplanted 8 weeks post-injury integrate into the chronic lesion site, facilitate axonal regeneration, and promote functional recovery.

Introduction: Cell transplantation has emerged as an exciting therapeutic approach for spinal cord injury (SCI), with a myriad of stem cells and other cellular substrates showing promising results in animal studies. Many questions remain unanswered, however. Firstly, the vast majority of cell transplantation studies are performed in subacute models of SCI (1-2 wks post-injury). Efficacy in chronic models of SCI (6-12 wks post-injury) is rare, and thus the applicability of this approach for chronic SCI patients is questionable. Also, the best candidate cell to use for transplantation after SCI is unknown. Many cells transplants would require immunosuppression to prevent rejection. Schwann cells derived from skin precursor cells (SKP-SCs) are appealing because they may be derived autologously (ie. from the patients' own skin). Here, we evaluate SKP-SCs in a chronic model of thoracic SCI.

Methods: A T9/10 contusive SCI was induced in Sprague Dawley rats using the IH Impactor. The animals recovered over the ensuing 8 weeks, at which time they were randomized to receive a transplant of SKP-SCs or media control. Behavioral recovery was then assessed until post-injury week 27; the animals were sacrificed 2 weeks later and their spinal cords were evaluated histologically.

Results: Animals treated with SKP-SCs elicited a trend towards higher hindlimb locomotion scores, which reached significance in week 19, 21, and 23. The SKP-SCs integrated into the host tissue, modified the glial scar, and created a lesion site permissive to axonal regeneration, as evidenced by the massive extension of myelinated axons through the transplant. The pathological thickening of the bladder wall characteristic of a neurogenic bladder was also reduced.

Conclusion: SKP-SCs transplanted 8 weeks post-injury survive and bridge the chronic SCI injury site, facilitate axonal regeneration and remyelination, and promote hindlimb locomotor recovery.

Significance: Success with cell transplantation approaches in experimental models of chronic SCI is rare. Our results highlight the potential of SKP-SCs (which may be derived autologously, obviating the need for immunosuppresion) as a transplantation strategy for thousands of chronically injured SCI patients.

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).

PAPER #107

The Study Concomitance of Cervical Myelopathy and Scoliosis: A PearlDiver Study

Chang Hwa Hong; Steven Takemoto, PhD; Benjamin Young, BS; Michael H. Weber, MD, PhD; Serena S. Hu, MD

USA

Summary: The incidence of cervical symptoms are more higher in adult scoliosis patients.

Introduction: Adult spinal deformity is three-dementional deformity of the thoracolumbar spine. Cervical spondylotic Myelopathy is the result of the direct compression of the spinal cord resulting in its dysfunction. Concordance of deformity and Myelopathy diagnoses and associated surgeries are compared in national private payer(PP) and Medicare(MC) datasets.

Methods: The PearlDrive database contains 11 million PP subjects enrolled from 2004-2009 and 38 million MC enrolled from 2005-2008. A surgical spine

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PODIUM PRESENTATION ABSTRACTS

ontology that defined ICD-9 diagnosis and CPT procedure codes in terms used by surgeons was used to identify cases with cervical myelopathy, radiculopathy or deformity diagnoses, and to classify surgical procedures as cervical or thoracolumbar.

Results: A total 5,774,865 subjects (69% MC) had a diagnosis of interest: 82% with cervical myelopathy (or Radiculopathy), 23% with deformity, and 5.1% had both during the periods of observation. Surgical prevalence was 6% for patients with cervical myelopathy, 32% for deformity and 3% for patients with both diagnoses. Interestingly, 37% of cervical surgery patients without a deformity diagnosis had surgery involving the thoracolumbar spine, but only 2% of deformity patients without cervical diagnosis had cervical surgery. Of the MC cases diagnosed with derformity, 23% also had cervical myelopathy compared to 19% for PP subjects (P, Pearson chi2 <0.001). On the other hand, a higher fraction PP cases with lumbar surgery also received cervical surgery compared to MC cohort (43 vs 38%, P<0.001).

Conclusion: A national sample of nearly 6 million subjects indicates approximately 20% of the adult deformity population also experience cervical Myelopathy and 40% having surgery on the thoracolumbar spine also had cervical surgery.

Significance: This study suggests cervical clinical diagnoses and surgical planning should be considered for complex adult deformity patients.

PAPER #108

Preoperative Vitamin D Deficiency in Adults Undergoing Spinal Deformity Surgery

Geoffrey E. Stoker, BS; Jacob M. Buchowski, MD, MS; Keith H. Bridwell, MD; Lawrence G. Lenke, MD; Lukas P. Zebala, MD

USA

Summary: Hypovitaminosis D (serum 25-hydroxyvitamin D <32 ng/mL) was identified in 54% of 83 consecutive adults undergoing ≥5-level fusion for spinal deformity correction.

Introduction: Although past authors have demonstrated no correlation between bone mineral density (BMD) and Cobb angle, fusion, and complication rate in adult scoliosis patients, no studies have been performed to characterize preoperative vitamin D abnormality in adults undergoing spinal deformity surgery.

Methods: Serum 25-hydroxyvitamin D levels were measured prospectively in 83 consecutive adults undergoing spinal deformity surgery (≥5-levels) at a single institution. Statistical analysis was performed and subsets were compared with Fisher's and Mann-Whitney U tests.

Results: The mean age and BMI of the 83 included patients were 55.6±14.9 years and 26.7±4.8 kg/m2, respectively. Every subject was Caucasian, and 75% were female. The majority of patients (55%) had a history of previous spine surgery. Sacropelvic fixation was utilized in 69%. Constructs spanned an average of 12.1±4.6 levels. The mean vitamin D level was 31.7±13.3 ng/mL. Of 83 patients, 54% were vitamin D inadequate (<32 ng/mL) and 18% were deficient (<20). There was no difference in mean vitamin D level (p=0.134) or rate insufficiency (p=0.182) in patients undergoing primary vs. revision surgery. As expected, BMD was lower in the presence of hypovitaminosis D (p=0.016). The mean age was lower (p=0.022) and more patients were <50 years old (p=0.007) in the vitamin D-inadequate subset compared to normals. Similarly, the mean age was lower (p=0.003) and more patients were <50 years old (p<0.001) in the subset without previous vitamin D supplementation compared to the subset with prior supplementation.

Conclusion: Alarmingly, preoperative hypovitaminosis D was present in majority (54%) of patients undergoing spinal deformity surgery. Our finding that younger patients are at greater risk for hypovitaminosis D may be due to the heightened awareness of the risks of osteoporosis in the elderly driving them to increase vitamin D intake.

Significance: Since vitamin D deficiency may predispose to fracture and pseudarthrosis, we advocate vitamin D supplementation in patients with hypovitaminosis D. Although advanced age is a well established risk factor for vitamin D abnormality, young adults with spinal deformity should not be overlooked, as those <50 years of age may be less likely to have undergone supplementation.

PAPER #109

The Effect of Body Mass Index on Adult Idiopathic Scoliosis Patients Older than 30 Years

Ming Li; Zi-Qiang Chen, MD; Xiaodong Zhu

China

Summary: A retrospective study to find out the effect of body mass on surgical treatment in adult idiopathic scoliosis. The results showed that overweight adult idiopathic scoliosis patients had a larger thoracic kyphosis and thoralumbar kyphosis before surgery and a higher degree of postoperative pain. However, BMI did not affect the outcomes of surgical correction for coronal and sagittal scoliotic deformity. Although overweight patients were liable to develop hypertension before operation, the postoperative complication rate was not significantly affected.

Introduction: Obesity has reached epidemic proportions globally, and is a major contributor to the global burden of chronic disease and disability. As overweight increases the stress load on the body and accelerates degeneration of the spine with age increasing, it may also influence orthopedic surgery of scoliosis. Also, preoperative comorbidities, which are more common in adults than in adolescents, may increase perioperative complications. To the best of our knowledge, there is no report about effects of BMI on surgical treatment of adult idiopathic scoliosis patients.

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Methods: Idiopathic scoliosis patients older than 30 years were studied. The patients were divided into overweight group (BMI>=23) and non-overweight group (BMI<23). Preoperative, postoperative first erect and final follow up radiographic measures, perioperative data, Oswestry disability index (ODI) and Visual analogue scale(VAS) were reviewed and compared.

Results: 71 patients (58 women and 13 men; mean 42.9±12.2 years) with a minimum of 2-year follow-up were included. No significant difference was found in radiographic measures, perioperative data, preoperative comorbidities and postoperative complications except for a larger preoperative thoracic kyphosis (p=0.000) and thoralumbar kyphosis (p=0.002), and a higher morbidity of hypertension (p=0.004) in the overweight group. Postoperative ODI and VAS improved significantly in both groups as compared with those before operation. Postoperative ODI of the overweight group was significantly higher than that of the non-overweight group (p=0.022).

Conclusion: Overweight adult idiopathic scoliosis patients had a larger thoracic kyphosis and thoralumbar kyphosis before surgery and a higher degree of post-operative pain. However, BMI did not affect the outcomes of surgical correction for coronal and sagittal scoliotic deformity. Although overweight patients were liable to develop hypertension before operation, the postoperative complication rate was not significantly affected.

Significance: The effect of body mass on surgical treatment in adult idiopathic scoliosis was showed. BMI did not affect the outcomes of surgical correction for coronal and sagittal scoliotic deformity.

PAPER #110

Can We Predict Post-Operative Functional Improvement Based On Preoperative Health-Related Quality Of Life Scores In Patients Undergoing Spine Surgery?

Siddharth B. Joglekar; Kimberly Heckmann, BSN; Amir A. Mehbod, MD; Ensor E. Transfeldt, MD; Robert B. Winter, MD

USA

Summary: We investigated the relationship between preop and postop Oswestry Disability Index (ODI) scores or Neck Disability Index (NDI) scores, and Short-Form 36 (SF-36) scores in order to detect if one can predict the functional improvement in after surgical intervention from preop data?

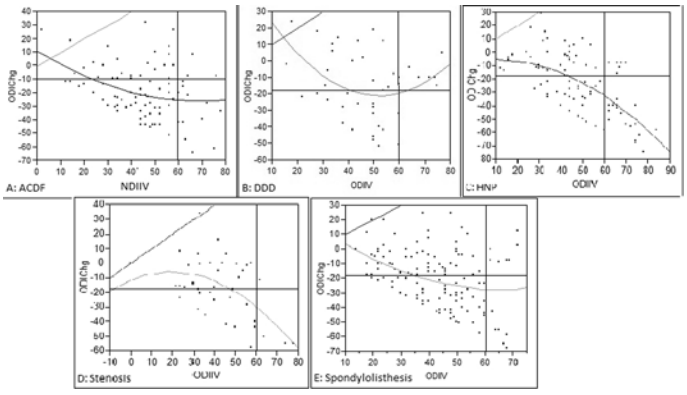
Introduction: Health related quality of life (HRQOL) measures are widely used for measurement of functional outcomes and disability. Little is known regarding their utility in predicting improvement following spine surgery.

Methods: 404 adult patients who had undergone spine surgery during the calendar year of 2008 at a single center were included. Preop and postop HRQOL scores were studied. Reoperations or surgeries for tumor, trauma, or infection were excluded. Also excluded were postop complications such as wound infection or neurological injury. Regression analysis was used to study the effect of various factors including type of surgery, age, gender, BMI, workmen's compensation, litigation, smoking and preop HRQOL scores on outcomes one year after surgery. Receiver Operating Curve analysis and regression models were used to detect the ability of preop ODI/NDI and SF-36 scores to predict final ODI.

Results: Herniated disc patients had the most improvement in ODI (mean 23.6) and the degenerative disc disease (DDD) patients the least (mean 16.7). Greater ODI improvement was associated with greater baseline ODI, lower BMI, higher SF-36 PCS and higher SF-36 MCS. Patients with an underlying litigation trended to have a greater improvement but there was no effect due to gender, smoking status or age. Patients with ODI > 60 at baseline were less likely to have a substantial clinical benefit (SCB) as compared to those with an ODI < 60. The group showing no improvement had a higher percentage of DDD (16.2% vs 9.6%) patients when compared to the group showing improvement in ODI.

Conclusion: Higher preop ODI, SF-36 PCS and SF-36 MCS scores were predictive of SCB in ODI score after surgical intervention. While lower BMI is significantly correlated with improvement in disability other patient factors such as age, sex and smoking status did not seem to affect final outcomes. Surgical intervention for DDD is likely to have a higher number of patients who fail to have symptomatic improvement. Patients with DDD, who have crippling levels of preop disability (ODI >60), are less likely to SCB. "Lumbar Fusion" should not be studied as a single entity as the outcomes vary considerably depending on various factors including the underlying diagnosis.

X Axis has the initial visit ODI/NDI whereas the Y axis has the ODI/NDI change. The horizontal line indicates the substantial clinical benefit whereas the vertical line demonstrates the threshold for crippling disability. The curved line demonstrates the spread of the data.



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PODIUM PRESENTATION ABSTRACTS

PAPER #111

High Dose Tranexamic Acid Reduces Blood Loss in Complex Pediatric Spine Deformity Surgery

Ra'Kerry K. Rahman, MD; Woo-Kie Min, MD, PhD; Yutaka Nakamura, MD, PhD.; Lukas P. Zebala, MD; Brenda A. Sides, MA; Keith H. Bridwell, MD; Lawrence G. Lenke, MD

USA

Summary: High dose tranexamic acid(TXA) effectively reduced intraoperative blood loss when compared to placebo(544cc vs. 930cc). Neither operative time nor levels fused accounted for this difference. No patient receiving TXA had a complication referable to its use.

Introduction: Large volume blood loss is a known adverse consequence of complex pediatric spine surgery. Intraop anti-fibrinolytics, such as tranexamic acid(TXA), have been reported to reduce blood loss at low doses in adult surgery. The role of high dose TXA for complex pediatric spine patients is undetermined. Study purpose: Determine if high dose tranexamic acid(TXA) is safe and efficacious in the pediatric population undergoing complex spine surgery.

Methods: 65 pts undergoing complex pediatric spinal deformity surgery were analyzed at a single center. Data were reviewed for three groups: TXA n= 21 pts; control n= 23; aprotinin n= 21. TXA pts received high dose tranexamic acid (10 mg/kg maintenance and/or 100mg/kg bolus). Data for the control group was taken from 1997 - 2000. This period immediately precedes constant antifibrinolytic use. Aprotinin (1998 - 2001) served as a historical control given its proven published efficacy. TXA has been used in complex patients at a high dose since 2006. Surgeons for all three groups were the same. Primary variables were: EBL, PreOp hematocrit, and Postop hematocrit. Secondary variables were: operative time, age, and intraoperative complications. Complex pediatric spine was defined as AIS curve magnitude > 75, neuromuscular, or syndromic etiology. The mean fusion levels were 12, 14, 13 for placebo, TXA, and aprotinin, respectively.

Results: Intraop blood loss(EBL) for TXA group (μ= 544cc) was significantly less compared to placebo (μ=930cc)p =0.02. EBL for aprotinin group (μ=545cc) was significantly less compared to placebo (p=0.03). No difference was observed for EBL between TXA and aprotinin(p=0.86). Operative time was not significantly different for TXA & aprotinin vs. Placebo(p=0.07& 0.37) No significant difference was found for TXA vs. Placebo for levels fused(p=0.68), age (p=0.06), preop hematocrit(p=0.08) or postop hematocrit(p=0.21) There were no intraop or postop complications for the TXA group.

Conclusion: High dose TXA effectively reduces EBL in complex pediatric spinal deformity patients. EBL reduction was similar to that observed with aprotinin; however, aprotinin is no longer available for use due to concerns of nephrotoxicity. No intraop or postop complications were experienced with high dose TXA.

PAPER #112

The Use of Antifibrinolytics Substantially Reduces Blood Loss During Surgery for Cerebral Palsy Scoliosis

Suken A. Shah, MD; Arjun Dhawale; Paul Sponseller; Tracey Bastrom, MA; Geraldine I. Neiss, PhD; Petya Yorgova; Peter O. Newton, MD; Burt Yaszay, MD; Harry L. Shufflebarger, MD; Peter G. Gabos, MD; Kirk W. Dabney, MD; Freeman Miller, MD; Harms Study Group

USA

Summary: A prospective multicenter study of 84 pediatric patients who underwent surgery for scoliosis secondary to cerebral palsy revealed that when normalized to patient size, antifibrinolytic agents resulted in a 45% decrease in blood loss during fusion and instrumentation procedures.

Introduction: Scoliosis surgery in children with cerebral palsy (CP) is associated with substantial blood loss. The purpose of this study was to evaluate the safety and efficacy of antifibrinolytic agents(AF) on blood loss during these procedures.

Methods: A multi-center, prospective study was conducted of 84 consecutively enrolled pts (age <18 yrs) with CP who underwent PSF and instrumentation as part of their spinal deformity correction. Estimated blood loss was expressed as a percent of blood volume (EBL/BV), and normalized for weight (cc/kg). The use of AF agents was noted (tranexamic acid, aminocaproic acid, aprotinin, or none) and based on surgeon randomization. EBL in these groups was compared utilizing analysis of covariance (controlling for deformity magnitude) with Bonferroni post hoc comparisons ($p<0.05$).

Results: The avg preop major deformity (kyphosis or scoliosis) was 82 ± 27° and mean age at surgery was 14.4 ± 2.6 yrs. The groups were well matched - there was no difference between groups in preop major deformity, age, use of pelvic fixation or segments fused. The avg vertebral levels fused was 16.7 (range 15-18) and 95% of the pts had pelvic fixation. Of the 84 pts, 44 received AF, and 40 received no AF agent (NAF). The total EBL averaged 1684 ml ± 1117 for the AF group and 2685 ml ± 1712 for the NAF group, p=0.002. Normalized blood loss was significantly less in the AF group (48± 30 cc/kg) vs. NAF (87 ± 60 cc/kg), $p<0.001$. EBL as a ratio to blood volume (%BV) in the AF group was significantly lower (70%) than the NAF group (125%, $p<0.001$). No difference was found among the 3 AF agents (p=0.8). There was more cell salvage transfusion in the NAF group, but no significant differences were found in total transfusion of allogenic products or individual components. There were trends for shorter ICU and inpatient length of stay in the AF group. There were no adverse effects reported due to the use of AF.

Conclusion: Blood loss associated with surgery for CP scoliosis procedures was found to be significantly reduced with the use of an antifibrinolytic agent, with no adverse effects. When normalized to patient size and blood volume, the

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use of antifibrinolytics resulted in a 45% reduction in EBL associated with these complex procedures.

PAPER #113

Cement Augmented Pedicle Screw Fixation In Osteopenic Patients: Minimum Two-Year Follow-Up Of 1,454 Pedicle Screws

Cagatay Ozturk, MD; Ahmet Alanay; Meric Enercan; Selhan Karadereler; Mehmet Tezer; Azmi Hamzaoglu, MD

Turkey

Summary: Cement augmentation of pedicle screws in osteoporotic and osteomalacic patients provides rigid fixation and prevents implant failure.

Introduction: The purpose is to analyse the results of pedicle screw fixation augmented by vertebroplasty using PMMA in osteopenic (osteoporosis, osteomalacia) patients requiring spine surgery.

Methods: A retrospective analysis of 130 patients who had cement augmented pedicle screws was performed. X-rays were analyzed to determine cement leakage, pedicle screw loosening (more than 2mm halo sign around the screw), pull-out and migration. Lung x-rays were evaluated for cement emboli. Surgical technique included standart vertebroplasty technique. Prior to cement injection, mechanical aspiration of the vertebral bodies was done through working cannula to decrease the pressure inside vertebral body. Screws were inserted immediately after cement injection.

Results: There were 1454 cement augmented pedicle screws with a mean follow-up of 48 (24-108) months. The average age of the patients (92 F, 38M) was 69,6 (45-90) years. Diagnosis was degenerative spinal stenosis in 89, trauma in 27, infection in 10 and tumor in 4 patients. Mean number of cement augmented screw per patient was 20 (range 4 to 32) . Extravasation of cement was seen in 27 patients, none in spinal canal. Acute hypotension was observed immediately after cement injection in 15 patients. Preoperative mean pulmonary arterial pressure of 35mm/Hg was elevated to 48 mm/Hg in first postop day and decreased to 42 mm/Hg at the third postop. Pulmonary x-rays revealed cement emboli in 8 (6%) patients and 4 had respiratory problems. All had CTs to confirm the emboli. All patients with cement emboli had secondary prophylactic anticoagulant treatment. There was no screw loosening, migration or pull-out detected in the follow-up x-rays. There was no fracture at the augmented levels. None of the patients had reintervention due to implant failure. Nine superficial infections were treated by debridement and antibiotic therapy.

Conclusion: Cement augmentation of pedicle screws in osteoporotic and osteomalacic patients provides rigid fixation and prevents implant failure. Cement leakage outside the canal can occur but usually asymptomatic. Pulmonary cement emboli can be a problem and should be monitored carefully.

Significance: -

PAPER #114

Analysis of Direct Cost for Four Diagnostic Categories of Adult Spinal Deformity (ASD)

Michael F. O'Brien, MD; Richard Hostin, MD; Chantelle Freeman, BS; Neil Fleming, PhD; Gerald Ogola, MS; Rustam Kudyakov, MD, MPH; Kathleen M. Richter, MS, MFA, ELS; Jay T. deVenny, MBA; Nanette Myers, MBA; Christopher P. Ames, MD; Sigurd H. Berven, MD; International Spine Study Group

USA

Summary: The direct costs of surgical treatment for Adult Spinal Deformity (ASD) compares favorably to other complex surgical procedures. There is an increasing direct cost of surgery with increasing age, increasing length of fusion and fusions to the pelvis. The direct cost of Revision surgery is the second least expensive surgery and should therefore not preclude its consideration based solely on an economic perspective.

Introduction: ASD can be categorized into one of four groups: Primary Idiopathic Scoliosis (PIS), Primary Degenerative Scoliosis (PDS), Primary Sagittal Plane Deformity (PSPD), and Revision (R). The surgeries performed for these pathologies may vary due to the type or magnitude of the surgery undertaken, age, diagnosis, associated co-morbidities and complications. Consequently, it is reasonable to expect variations in direct cost of care.

Methods: A single center, prospective surgical database was used to identify 213 consecutive ASD patients treated between 2008 and 2010. Patients were assigned to one of four diagnostic categories based on preoperative radiographs and history: PIS, PDS, PSPD, and R. Cost analysis was based on hospital data and included only direct costs (DC) incurred for the episode of surgical care. Data were analyzed between the four groups.

Results: The surgical treatment of PDS was most expensive followed in decreasing order by PSPD, R and PIS ($p= 0.01$). DC trended towards significance with increasing age. This was statistically significant in the PIS group ($p=0.001$). In PIS, the DC for surgical treatment was significantly higher for patients >60 yo than for patients <30 yo ($p<0.01$) but was not significantly higher for patients 30-60 yo than for patients <30 yo. Among PIS patients, the percent fused to pelvis also increased with age ($p<0.01$). Adjusting for total levels fused and fusion to pelvis, DC was $20,449 higher for patients >60 yo than for patients <30 yo ($p=0.02$). For each additional level fused, DC increased by $3,796 ($p<0.01$). Fusion to pelvis resulted in a $19,223 increase in DC ($p<0.01$).

Conclusion: The DC for surgical treatment of ASD compares favorably to other complex surgical procedures such as Left Ventricular Assisted Device whose mean DC at our institution is $203,810. The DC of ASD procedures ranged from a mean of $67,949 - $86,277. There is an increasing DC of surgery with increas-

* Hibbs Award Nominee for Best Clinical Presentation † Hibbs Award Nominee for Best Basic Science Presentation

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PODIUM PRESENTATION ABSTRACTS

ing age, increasing length of fusion and fusions to the pelvis. The DC of surgery for PDS is highest and the DC for PIS lowest. The DC of Revision surgery is the second least expensive surgery and should therefore not preclude its consideration from a purely economic perspective.

PAPER #115

Risk Factors and Natural Course of de Novo Degenerative Lumbar Scoliosis in a Community-Based Cohort: The Miyama Study

Shunji Tsutsui; Atsunori Watanuki; Hiroshi Yamada; Keiji Nagata; Yuyu Ishimoto; Yoshio Enyo; Noriko Yoshimura; Munehito Yoshida

Japan

Summary: Degenerative lumbar scoliosis (DLS) is one of the most prevalent disorders in the aging spine. Although some authors have reported the etiology of DLS, there has been controversy regarding the prediction of the progression of de novo DLS (DNDLS). In a prospective longitudinal community-based cohort study, the rotation of L3 in concomitant with the degenerative changes of lumbar spine might result in DNDLS. Although the incidence of DNDLS increases with the age, the magnitude of scoliosis was not progressive.

Introduction: Degenerative lumbar scoliosis (DLS) is one of the most prevalent disorders in the aging spine. Although some authors have reported the etiology of DLS, there has been controversy regarding the prediction of the progression of de novo DLS (DNDLS). The purpose of this study was to investigate risk factors and natural course of DNDLS by using a community-based cohort.

Methods: Subjects (N=400) were selected by sex and age from a list of 1,543 district residents, born from 1910 to 1949, with 50 men and 50 women selected from each age decade. Radiographic examinations of the lumbar spine in anteroposterior and lateral views were performed in 1990 and repeated in 2005 and 2008. DNDLS was defined as newly developed scoliosis (Cobb≥10° and progression ≥5°) in 2005 or 2008.

Results: Evaluation of radiographic surveys was completed for 200 of the 400 participants in 2005 and for 154 in 2008. 12 subjects had DLS at baseline. DNDLS was found in 33 inhabitants in 2005 and 24 in 2008. None of them showed further progression of scoliosis, and their scoliotic angles were less than 30° throughout the survey. In the radiographic investigation, lateral slippage and rotation of L3 and lateral osteophyte difference at L3/4 were statistically significantly larger in the subjects with DNDLS than in those without DNDLS at baseline ($p<0.01$). Logistic regression analysis, which was performed with the occurrence of DNDLS as an objective factor, demonstrated that the rotation of L3 was the significant risk factor for DNDLS (odds ratio; 13.95, 95% confidence interval; 4.05-52.34, $p<0.0001$).

Conclusion: In the initial stage of degenerative change of lumbar spine, asymmetric degenerative change of intervertebral discs occurs usually in the lower lumbar spine, followed by the compensation of upper lumbar levels to maintain spinal balance. Once the rotatory change of the L3 vertebra occurs, this compensation might break down, leading to scoliosis. Although the incidence of DNDLS increases with the age, the magnitude of scoliosis was not progressive.

PAPER #116

Can Patients Reliably Work Long-Term after Fusion for Adult Deformity?

Dennis Crandall, MD; Kenneth Schmidt, MD; Jan Revella, RN; Michael S. Chang, MD; Jason Datta, MD; Terrence Crowder, MD; Dustin Revella, BA; Ryan McLemore, PhD

USA

Summary: Average 5 year follow-up of consecutive working adults undergoing fusion compared 36 long fusions for deformity to 64 patients with 1-2 level fusions for degenerative disease. Excluded: workers comp, students, unemployed, retired. Long-term outcomes and work status are similar for both groups, with improved VAS and ODI after surgery ($P<0.01$). Short fusion patients had more pre-op pain, were more likely to work sedentary jobs, and 95% were working long-term; 89% of deformity fusions patients were working, with similar outcomes.

Introduction: The ability of patients with adult spinal deformity to return to work after surgery has not been well studied. We compared clinical and radiographic results from workers undergoing short segment fusions (SSF) vs. long segment fusions (LSF) for deformity, studying outcomes, work status and work type long-term.

Methods: A retrospective review of 100 consecutive patients from a surgical database showed 36 LSF and 64 SSF patients age 46 (range 19 - 60 years) who were working before surgery. Excluded: workers comp, students, unemployed, retired. LSF diagnoses: adult idiopathic scoliosis-22, degenerative scoliosis-5, kyphosis (Scheuermanns, degenerative, post-traumatic)-10. Length of fusion for LSF patients averaged 9.6 levels (range 4 - 15 levels). SSF diagnoses: degenerative disease, spondylolisthesis; SSF were 1-2 levels only (average 1.4 levels). Work type defined: sedentary, medium, heavy. Patient pain was compared using the sign test. ODI was compared using paired t-tests, Anderson-Darling was used to verify normalcy. Return to work rates were compared using Fisher's Exact Test.

Results: At average follow-up 70 months (24-106 months), 61 of 64 (95.3%) SSF and 32 of 36 (88.9%) LSF patients were working. Return to work averaged 25 weeks for LSF, 17 weeks for SSF patients. SSF group had more pre-op pain and worked more sedentary jobs (61% vs. 39%). VAS improved LSF: 5.2pre-op to 2.5 at 2 years($p=0.004$); SSF: 6.3 pre to 2.5 at 2 years ($p<0.001$). ODI improved for LSF: 32.4 pre-op to 22.7 at 2 years($p=0.0042$); SSF improved 44.7 pre-op to 21.3 at 2 years ($p<0.001$). Pain med use

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declined for both groups. There was no difference between SSF and LSF groups in ability to return to work(p=0.247).

Conclusion: Workers undergoing fusion for spinal deformity have less pre-op pain and can reliably return to work and remain working long-term similar to SSF patients. Long-term outcomes and work status are similar for LSF and SSF patients.

Significance: Deformity patients can be assured they have an excellent chance to return to work and remain working long-term after LSF.

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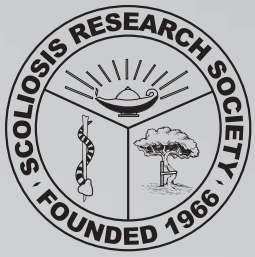

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ELECTRONIC POSTER ABSTRACTS

E-POSTER #201

Does 25° and Risser 0-2 Still Constitute Reasonable Bracing Criteria? Decisions using Traditional Criteria Compared to the Digital Maturity Stage System

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USA

Summary: While Risser grade has the status of tradition and familiarity, the recently-studied digital skeletal maturity staging (DMS) is more specific during the long Risser 0 phase with the potential to accurately target patients at high risk for curve progression.

Introduction: Standard bracing criteria are Risser 0-2 with a curve of 25+ degrees or 20° with documented 5° progression. However, recent studies found maturity staging using hand radiographs are more closely tied to peak height velocity and curve changes over time than the Risser grade. (Sanders et al. 2007) Additionally, the combination of digital maturity stages (DMS) and Cobb angle was highly predictive of eventual curve progression to surgical indications. (Sanders et al., 2008) We evaluated the correspondence between Risser and DMS in an independent sample, and then examined how using the DMS would change decisions to brace relative to the Risser-based method.

Methods: We used data from 327 subjects enrolled in the Bracing in Adolescent Idiopathic Scoliosis Trial (BrAIST). Risser grade and DMS were compared using the Spearman correlation. Each subject was "indicated" for bracing using the traditional Risser/Cobb angle criteria and the criteria suggested by Sanders et al. of 20° at DMS 2 and 30° at DMS 3. Agreement between indications was calculated using the kappa statistic.

Results: DMS ranged from 1-8 and Risser from 0-5. Risser and DMS were moderately related (Spearman r=0.55). 98% of subjects at DMS 2 were Risser 0 or 1, but subjects at Risser 0 had DMS ranging from 2 to 6. Conversely, DMS 3, corresponding to the timing of the PHV, occurred during Risser 0 11%, and Risser 1 87% of the time.

Agreement between the decision systems was low (kappa = 0.20). 241 subjects (74%) met Risser criteria compared to 135 (41%) who met the DMS criteria.

Conclusion: The correlation between Risser and DMS is moderate, but when combined with the Cobb angle to select patients at high-risk of curve progression, the two decision systems frequently result in different treatment plans. Using curve magnitude with DMS would reduce the incidence of bracing by 33%.

E-POSTER #202

Post-Operative Trunk Imbalance following Posterior Spinal Fusion is Associated with Progressive Subjacent Disc Wedging in Adolescent Idiopathic Scoliosis

Ying-Chuan Zhao; Ming Li

China

Summary: The purpose of this study was to investigate which radiographic parameters immediately after posterior spinal fusion for adolescent idiopathic scoliosis best correlate with subjacent disc wedging at a minimum 2-year follow-up.

Introduction: The purpose of this study was to investigate which radiographic parameters immediately after posterior spinal fusion for adolescent idiopathic scoliosis best correlate with subjacent disc wedging at a minimum 2-year follow-up.

Methods: Sixty-four consecutive adolescent idiopathic scoliosis patients who underwent posterior pedicle screw-only instrumentation were studied retrospectively Preoperative and postoperative radiographs were obtained to measure various parameters regarding global coronal, shoulder, sagittal and regional balance. Specific correlation of these parameters to selected 2-year postoperative disc wedging and lowest instrumented vertebra (LIV) tilt and translation were analyzed

Results: The average disc angle changed from 4.59±4.75 preoperatively to 1.46±2.82 at 2-weeks and 2.81±6.43 at 2-years postoperatively. Two-year postoperative disc angle significantly correlated with 2-week postoperative disc angle, C7 plumbline relative to the posterior superior corner of the first sacral vertebra (C7-SSEP) distance and LIV-center sacral vertical line (CSVL) distance ($r2 = 0.7433$, $P<0.0001$). Two-year postoperative LIV tilt significantly correlated with 2-week postoperative LIV tilt, T12-LIV lordosis, LIV-CSVL distance and C7-CSVL distance ($r2=0.8879$, $P<0.0001$). Two-year postoperative LIV-CSVL significantly correlated with 2-week postoperative LIV-CSVL distance and disc angle ($r2 = 0.6104$, $P<0.0001$).

Conclusion: In summary, the two-year postoperative disc wedging, LIV tilt and LIV translation occurred most often when disc wedging and LIV deviation or obliquity existed immediately postoperatively.

Significance: Our study has identified a potential indicator for adolescent idiopathic scoliosis repair. Preoperative surgical planning and intraoperative correction are important to avoid subjacent regional imbalance after scoliosis fusion.

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ELECTRONIC POSTER ABSTRACTS

E-POSTER #203

Variability of t-EMG Threshold at Concavity and Convexity in Apex Segments of Thoracic Scoliosis. Its Correlation with Pedicle-Dural Sac Distance

Gema De Blas, MD, PhD; Carlos Barrios; Ignacio Regidor, MD, PhD; Elena Montes; Jesús J Burgos Flores, PhD; Gabriel Piza Vallespir, MD, PhD; Eduardo Hevia, MD

Spain

Summary: Stimulation EMG threshold variability at concavity and convexity in apex segments was studied in 23scoliotic patients who underwent posterior fusions using pedicle thoracic screws. At CC, t-EMG threshold values from 8 to 14 mA could not discriminate screw malposition. At CV, this range was wider (11-19 mA). At the three apex vertebrae, the average pedicle-cord distance was significantly lower at CC than at CV. There was a correlation between pedicle-cord distance and t-EMG values only at the CC side.

Introduction: Whether the t-EMG stimulation threshold depends on pedicle bony integrity or on the distance to neural tissue remains elusive. Studying pedicle screws at the concavity (CC) and the convexity (CV) at the apex segments of scoliotic curves is a good model to address this issue since the spinal cord is displaced to the CC in these patients.

Methods: A total of 23 patients who underwent posterior fusions using 358 pedicle thoracic screws were reviewed. All patients presented main thoracic scoliosis (average: 58.3°). Every patient underwent a preoperative MRI exam, where the distances from the spinal cord to the pedicles of the concave and convex sides at three apex vertebrae were measured. The accuracy of the screw placement was tested at surgery by the t-EMG technique. Screws with t-EMG threshold values below 12 mA were by intra-operative fluoroscopy. Twenty-three screws were removed because of clear signs of malposition. Postoperative CT scans were used in all patients to detect screw malpositioning of the final 335 screws.

Results: According to post-op CT scans, 44 screws (13.1%) showed different malpositions, but only 11 (3.2%) were completely inside the spinal canal. In well-positioned screws, EMG thresholds from the CC showed statistically significantly lower values than those registered at the CV (21.1±8.2 vs. 23.9±7.7 mA, $p<0.01$). At CC, t-EMG threshold values from 8 to 14 mA could not discriminate screw malposition. At CV, the range for uncertain screw malposition was wider, 11-19 mA. At the three apex vertebrae, the average pedicle-spinal cord distance was 2.2±0.7 mm at CC side and 9.8±4.3 mm at CV ($p<0.001$). There was a correlation between pedicle-dural sac distance and t-EMG threshold values only at the CC side.

Conclusion: Independent of the screw position, average t-EMG thresholds were always higher at the convexity in the apex and above the apex regions, presuming that the distance from the pedicle to the spinal cord plays an important role in electrical transmission.

Significance: The t-EMG technique has low sensitivity to predict screw malpositioning and cannot discriminate between medial cortex breakages and complete invasion of the spinal canal.

E-POSTER #204

The Influence of Brace Treatment on the Pulmonary Function Test in Adolescent Idiopathic Scoliosis

Bin Yu, MD; Yipeng Wang, MD; Guixing Qiu; Jianguo Zhang; Jianxiong Shen, MD

China

Summary: A retrospective study on the influence of brace treatment on the pulmonary function tests (PFTs) in adolescent idiopathic scoliosis (AIS) showed preoperative brace treatment can reduce the actual values and the percentage of actual value and predicted value of FVC and FEV1 in thoracic AIS. The total length of brace treatment and sagittal Cobb angle of the thoracic curve may be the influential factors of the FVC and FEV1.

Introduction: To analyze the influence of brace treatment on the PFTs in AIS, a retrospective study was performed.

Methods: Preoperative PFTs were evaluated in 349 patients. The predicted value, the actual value and the ratio of actual and predicted value of FVC and FEV1 were recorded. The patients were classified into two groups: group A-with preoperative brace treatment, 90 cases; group B-no preoperative brace treatment, 259 cases. Compare the differences of the PFTs between the 2 groups.

Results: The predicted values of FVC and FEV1 in group A and group B were 3.30L and 3.34L, 2.81L and 2.83L, respectively. There was no significant difference between the 2 groups (all $P>0.05$). The actual values of FVC and FEV1 in group A and group B were 2.64L and 2.90L, 2.39L and 2.62L, respectively. The percentage of actual value and predicted value of FVC and FEV1 in group A and group B were 80.4% and 86.9%, 85.5% and 92.7%, respectively. The patients with preoperative brace treatment had significant lower values (all $P<0.05$). This difference was significant in patients with a primary thoracic curve ($P<0.05$), while not in patients without a primary thoracic curve ($P>0.05$). In the 61 patients with a primary thoracic curve and preoperative brace treatment, there were negative correlation between the total length of brace treatment and the percentage of actual value and predicted value of FVC and FEV1 ($r=-0.424$, $P=0.017$; $r=-0.385$, $P=0.032$) and positive correlation between the sagittal Cobb angle of the thoracic curve and the percentage of actual value and predicted value of FVC and FEV1 ($r=0.593$, $P=0.000$; $r=0.597$, $P=0.000$).

Conclusion: Preoperative brace treatment can reduce the actual values and the percentage of actual value and predicted value of FVC and FEV1 in thoracic AIS. The total length of brace treatment and sagittal Cobb angle of the thoracic curve may be the influential factors of the FVC and FEV1.

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ELECTRONIC POSTER ABSTRACTS

Significance: This study showed that preoperative brace treatment can reduce the actual values and the percentage of actual value and predicted value of FVC and FEV1 in thoracic AIS. The total length of brace treatment and sagittal Cobb angle of the thoracic curve may be the influential factors of the FVC and FEV1.

E-POSTER #205

In-vivo Evaluation of Bone Micro-architectures in Adolescent Idiopathic Scoliosis Using High Resolution pQCT

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Hong Kong

Summary: This is a case-control study comparing bone micro-architecture profiles between AIS girls and age and gender-matched normal controls

Introduction: AIS is a prevalent condition associated with low bone mass. In-depth quantitative assessment of bone quality and micro-architectures was previously hampered by invasive natures of investigations. With advancement in bone micro-imaging techniques and availability of high resolution pQCT(XtremeCT), we evaluated bone micro-architectures with XtremeCT in AIS and compare that with age and gender-matched normal controls.

Methods: 124 AIS girls at their first presentation without prior treatment and 115 normal controls were recruited. Cobb angles were measured with standard standing radiographs and XtremeCT parameters including cortical bone morphometry, volumetric bone mineral densities (vBMD in mg/cc) and trabecular bone micro-architectures of the non-dominant distal radius were measured with XtremeCT.

Results: The mean ages for AIS and controls were 13.03 and 12.98 years old respectively (p=0.45). The mean Cobb angle for AIS was 22.6°(SD = 6.4). The mean values of XtremeCT parameters showing differences between AIS and controls were: vBMD of Trabecular Area (AIS:144.58 , Controls:152.21, p=0.033), vBMD of Meta-trabecular Area (AIS:217.59 , Controls:226.43, p=0.016), "Bone Volume/Trabecular Volume" ratio (AIS:0.120 , Controls:0.127, p=0.034), Trabecular Number per mm (AIS:1.67 , Controls:1.76, p=0.003) and Trabecular Separation in mm (AIS:0.538 , Controls:0.505 , p=0.005). Except for Trabecular Separation, they were all lower in AIS indicating deranged bone structures in AIS.

Conclusion: This is the first report describing the differences in radiographic bone micro-architecture profiles between AIS and controls. The results complied with our previous findings of low bone mass and further indicated deranged bone structures in AIS. This could play an important role in disease initiation or progression in AIS. The exact biomechanical process and how this is related to the etiopathogenesis of AIS warrant further studies.

This study is supported by Research Grant Council of Hong Kong Government(Project no:467808 & 468809)

Significance: This study demonstrates the association between AIS and deranged bone structures which may play an important role in the etiopathogenesis of AIS and further studies are warranted for in-depth investigation into this issue.

E-POSTER #206Ω

Would CoCr Rods Provide Better Correctional Forces than Stainless Steel or Titanium for Rigid Scoliosis Curves?

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USA

Summary: While rigid rods have the ability to exert high forces on the spine, they also have the highest potential of plastic deformation. Ti may continue to apply correction forces on the spine after the construct is in place, however, the speed of fusion will overcome these forces and render the rods ineffective. CoCr rods have the ability to achieve the best intraoperative correction otherwise anterior releases might be required.

Introduction: The ability of the rod to achieve and hold the correction is a key factor while selecting rod material in the scoliosis surgery. In this study we've attempted to determine 1) if rods retain their shape after implantation into rigid spine, 2) loads that different rod materials (SS, Ti and CoCr) can produce on the spine.

Methods: In the 1st experiment, rods were pre-contoured to various tangential angles and reduced sequentially onto unilateral rigid block simulating 11 segmental spinal construct. Set screws were tightened until rod is fully seated, then loosened and the residual rod contour angle was measured, compared with original & analyzed for each material.

In the 2nd experiment pre-contoured rods were used to reduce onto the synthetic-rigid spine with load cell attached to the most apical screw. Load was measured and compared among the different materials.

Results: All the rods deformed plastically, at 20°, only Ti rods were able to maintain almost 90% of their original curve. SS and CoCr rods deformed significantly at 20° and their % plastic deformation correlated to the degree of bend. For the 30° pre-bend CoCr rods, the intraoperative reduction force was 42% higher than the Ti and 10% than SS rods which significantly reduced by adding the screws in between the proximal end & reducing those screw first.

Conclusion: While rods with high rigidity have the ability to exert high forces on the spine, they also have the highest potential of plastic deformation in a highly rigid spine. Ti will continue to apply correction forces on the spine after the construct is in place, however, the speed of fusion will soon overcome these forces and render the Ti rods ineffective postoperatively. Hence CoCr rods, have the ability to achieve the best intraoperative correction and if correction with CoCr rods is not achieved, then anterior releases might be required. Therefore,

determining curve flexibility and selecting of appropriate rod size & stiffness and or surgical releases should be considered in highly rigid curves.

Significance: This study quantifies the difference in the force generated by the three rod materials used in scoliosis surgery and shape retention of rods used for the correction of extremely rigid curves.

E-POSTER #207

Frontal or Sagittal Spinal Imbalance Does Not Affect Quality of Life Two Years after Posterior Spinal Instrumentation and Fusion for Adolescent Idiopathic Scoliosis

Michael G. Vitale, MD, MPH; W.G. Stuart Mackenzie, BS, MS II; Hiroko Matsumoto, MA; Nicholas D. Colacchio, BA; Daniel J. Sucato, MD, MS; B. Stephens Richards, MD; Mark A. Erickson, MD; James O. Sanders, MD; Lawrence G. Lenke, MD; David P. Roye, MD; Brendan A. Williams, AB

USA

Summary: Although curve correction by posterior spinal instrumentation and fusion (PSIF) for adolescent idiopathic scoliosis (AIS) is correlated with improved self-image and quality of life (QOL), this study demonstrates that coronal or sagittal imbalance at 2 years does not negatively affect self-perception or QOL.

Introduction: Literature suggests that curve correction by PSIF for AIS is correlated with improved self-image and QOL. Despite segmental fixation with modern techniques, ~20% of patients have significant spinal imbalance after PSIF. This study aims to investigate the influence of sagittal and coronal balance on QOL and self-perception 2 years following PSIF for AIS.

Methods: Review of a multicenter database identified 761 patients who underwent PSIF with minimum 2 years follow-up. Scoliosis Research Society-30 (SRS-30) and Spinal Appearance Questionnaire (SAQ) scores were compared in patients with and without imbalance. Coronal imbalance was defined as > ±2cm deviation of the C7-plumbline from the central sacral vertical line. Sagittal imbalance was defined as > ±2cm deviation of the C7-plumbline from the posterior-superior corner of the S1 vertebra.

Results: Major preop Cobb angle was positively correlated with both an improvement in self-perception and QOL. Body Mass Index (BMI) was positively correlated with increased pain and improved QOL. While statistically significant, the relationships with Cobb angle and BMI were quite small and potentially clinically insignificant. In contrast, spinal imbalance at 2 years postop did not correlate with change or absolute magnitude of either SRS-30 or SAQ scores.

Conclusion: Moderate spinal imbalance is currently considered to be >2cm deviation in either the coronal or sagittal planes, and the presence of coronal or sagittal imbalance at 2 years does not negatively affect self-perception or quality of life.

Significance: Care must be taken interpreting this data, as although AIS patients did not report issues with QOL or self-perception 2 years following PSIF, our definition of imbalance may not be fully correct and spinal imbalance may have long-term implications beyond two years. However, if these findings persist with longer follow-up, surgical strategies including the choice of more extensive levels of fusion may need to be revisited.

E-POSTER #208

Unintended Change in Physiological Lumbar Lordosis and Pelvic Tilt after Posterior Spinal Instrumentation and Fusion: How Much is Too Much?

Frank J. Schwab, MD; Nicholas D. Colacchio, BA; Hiroko Matsumoto, MA; Virginie Lafage, PhD; Evan D. Sheha, BS; David P. Roye, MD; Michael G. Vitale, MD, MPH; Brendan A. Williams, AB

USA

Summary: Patients who undergo posterior spinal instrumentation and fusion (PSIF) for adolescent idiopathic scoliosis (AIS) commonly loose lumbar lordosis (LL) which is associated with a concomitant increase in pelvic tilt (PT).

Introduction: Spino-pelvic relationship highly influences sagittal balance. This study investigates the effect of decreased LL after PSIF on the change in PT. Furthermore, this study examines the patient-specific relationship between LL and pelvic incidence (PI), testing the hypothesis that lumbar spinal fusion resulting in "mismatched LL" is associated with increased PT.

Methods: Query of a prospective multicenter database identified 155 AIS patients at least 2 years after PSIF with lowest instrumented vertebra between L2-L5. LL (T12-S1), LL within fusion (LLIF), LL below fusion (LLBF), sagittal balance (SB), PT, and PI at preop and 2 years postop were measured. Change in PT was compared between patients with "appropriate" or "inappropriate" LL as defined by the relationship between LL and PI. Appropriate LL was defined by both the relationship commonly used in clinical practice (LL = PI+10), and a research driven model from the literature (LL = 0.56PI + 33.43). Health related quality of life measures (HRQOL) were also examined.

Results: 38% of patients had loss of LL 2 years after PSIF. Patients with loss of LL had a significantly higher rate of increased PT than patients without loss of LL (73% vs. 40%, $p<0.0001$). In multiple regression, change in LL, LLIF and change in SB all had significant predictive effect on PT ($p<0.001$, $R2=0.21$). Using either the clinical practice definition or the research driven model, patients with LL < 2SD (12°) from predicted were more likely to have increased PT ($p=0.046$ and $p=0.027$, respectively). There were no significant associations between changes in LL or PT and HRQOL.

Conclusion: Iatrogenic loss of LL commonly occurs in lumbar fusion for AIS. This loss of LL is strongly associated with a reciprocal increase in PT. As such,

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ELECTRONIC POSTER ABSTRACTS

spinal fusion can have unintended effects on sagittal alignment which may have unknown consequences in the future.

Significance: Correlation between HRQOL and adequate LL (defined as LL proportional to a patient-specific PI) has been established in the adult population. The possible implications of poor sagittal balance after PSIF for AIS warrants continued attention and investigation.

E-POSTER #209

Pediatric Pedicle Screw Placement Using 3D Image-Guided Navigation is Safe and Accurate

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USA

Summary: Image-guided navigation and intraoperative CT imaging are new tools to aid in the safe, accurate placement of pedicle screws. In a consecutive series of 50 pediatric patients, 984 pedicle screws were placed with a 96.4% accuracy rate and no complications due to screw malposition.

Introduction: Navigation systems are now available as an adjunct to fluoroscopy and anatomic techniques for pedicle screw placement. This study reports the accuracy of open pedicle screw placement in pediatric patients using image-guided navigation and intraoperative CT.

Methods: Between 2007-2010, 984 pedicle screws were placed for spinal deformity correction in a consecutive series cohort of 50 pediatric patients. Mean patient age was 14.4 years (range, 7-18). Underlying diagnoses included idiopathic or neuromuscular scoliosis (43), Scheuermann's kyphosis (3), other (4). Intraoperative CT (O-arm) was performed to establish reference points for the computerized navigation system (Stealth). Screws were placed under real-time navigation guidance and then imaged. Need for screw redirection or removal based on the intraoperative CT is the primary outcome measure for this study.

Results: 984 pedicle screws were placed in pediatric patients using real-time navigation. Based on intraoperative CT, 35 screws (3.6%) were revised (27 redirected, and 8 removed), representing a 96.4% accuracy rate. Screw malposition was most common at T6-T8 (see Figure). No patients returned to the OR for screw malposition.

During the study period, 1511 screws were placed in adult patients using the same image guidance system. 28 screws (1.8%) were revised intraoperatively due to malposition on CT imaging for a 98.2% accuracy rate. Thus, the accuracy in screw placement was higher in the adult versus the pediatric population (chi-square, $p=0.008$). Kosmopolous et al. found a lower accuracy rate (86.6%) in adult non-navigated screws ($p<0.0001$) and a comparable rate in adult navigated screws (93.7%). Further, our navigated pediatric screw accuracy rate (96.4%) is somewhat higher than the 94.9% accuracy rate reported for non-navigated pediatric screws in a recent meta-analysis ($p=0.03$).

Conclusion: We report 96.4% accuracy in pediatric pedicle screw placement based on intraoperative 3D imaging and navigation, which is higher than reported accuracy rates for non-navigated screws.

Significance: Pedicle screw placement in children using image-guided navigation resulted in no identified complications and is a promising technique for improving the safety of pedicle screw placement.

E-POSTER #210

Long-term Functional Results after Anterior Surgery with Screwed/Plate Construct for Treatment of (AIS): Correlation between Results and Sagittal Balance

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France

Summary: Based on a monocentric series of operated AIS, the objective of this study was to report the influence of sagittal balance on the long-term functional outcome after an anterior spinal arthrodesis. Outcomes were studied with a minimum follow-up of 15 years (mean follow-up: 22 years). Anterior spinal surgery for Lenke I,V have predictable long-term functional results with good sagittal and coronal corrections. Better functional results were obtained in patients who maintained and found a more anterior sagittal balance in time.

Introduction: Based on a monocentric series of operated AIS, the objective of this study was to report the influence of sagittal balance on the long-term functional outcome after an anterior spinal arthrodesis.

Methods: One hundred and eleven patients were operated on with titanium shaped anterior plates between 1975 and 1993. Thirty-five patients, 6 males and 29 females, were available for review with complete clinic and radiographic assessment. Clinical outcomes were assessed using the SRS-30 Questionnaire (French Canadian version) and the Oswestry disability index. Long films enabled to evaluate the curve correction, coronal and sagittal balances including pelvic parameters. Clinical results were analyzed and correlated to radiographic findings.

Results: Average age of patients at time of surgery was 14.5 Years. Curves were classified as type 1 in 24 cases and type 5 in 11 cases according to Lenke. Mean pre-op Cobb angle was 44° (16-80) and 11° (0-50) after surgery. Mean C7 plumb line value which was located 34 mm behind the superior anterior aspect of the S1 body was not modified after surgery. Average follow-up was 21 years (16-31). The average SRS 30 score was 3.8/5 and correlated with the ODI score (13.8%). A 4.5° global kyphosis evolution was observed equally in the spine fusion and into the adjacent levels and a mean anterior translation

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of the C7 plumb line of 8 mm associated with an increase of 3° of the pelvic retroversion. The best results of the functional score were observed in patients who had the anterior translation of the C7 plumb line ($p<0.005$).

Conclusion: Anterior arthrodesis offers good long-term functional outcome. After the surgery, the frontal alignment was well restored and sagittal balance was not changed. The C7 plumb line is one of the major component to evaluate sagittal balance. Its "normal" range of value is not defined yet. However, we noticed the better functional results with patients who found a more anterior new balance status with time.

E-POSTER #211

Single-Pulse vs. Pulse-Train Screw Stimulation Technique. A Comparative Study while Monitoring of Thoracic Pedicle Screws Placement in Scoliosis Surgery

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Spain

Summary: Two different techniques of EMG-thresholds were compared during scoliosis surgery. Both single-pulse screw stimulation (SPS) recording EMG-response in the corresponding myotome, and high frequency pulse-train stimulation (PTS) technique with EMG recording in the lower limbs were assessed. Invasion of the spinal canal was confirmed by postoperative CT scan in 29 of the 244 screws. PTS technique with high-frequency stimuli (30 mA) was found to be more accurate than the SPS technique for detecting screws invading the canal (86.2% versus 10.3%).

Introduction: The classic technique of intraoperative neurophysiologic monitoring to detect malposition of thoracic pedicle screws uses single-pulse stimulation (SPS), recording EMG-response in the corresponding myotome. Recently, it has been hypothesized that its reliability in detecting screws located inside the spinal canal could increase using a pulse-train stimulation (PTS) technique with a high frequency stimuli and EMG recording in the lower limbs.

Methods: Thirteen patients undergoing scoliosis surgery with thoracic pedicle screws were monitored using first evoked potentials obtained by electrical SPS screw stimulation and thereafter with PTS. The position of the screws within the pedicles was postoeraptively assessed by CT scan.

Results: Invasion of the spinal canal was confirmed in 29 of the 244 placed screws. The classic SPS technique detected only 3 (10.3%) of these screws using a previously established threshold limit of 12 mA. The PTS technique detected 25 of 29 (86.2%) malpositioned screws when the proposed threshold of 30 mA was attended, with a negative predictive value of 97.7% but with a high rate of false positive results. When setting a threshold of 15 mA, the positive predictive value decreased to 64.2%. Both techniques detected slightly better those screws encroaching the canal at levels far away from the apex of the scoliotic curve.

Conclusion: Intraoperative monitoring of thoracic pedicle screws with high-frequency stimuli trains was found to be more accurate than the SPS technique for detecting screws invading the canal. We recommend using both techniques since the PTS cannot detect root injuries. We propose a stimulation threshold for the PTS technique of 15 mA to identify screws invading the canal, and an uncertainty range of 15-30 mA to be complemented with intraoperative imaging techniques.

Significance: PTS technique marks a step further in the improvement of neurophysiologic monitoring during spine surgery when using pedicles screws. Although PTS seems to be more accurate in detecting misplaced screws than classic SPS, both techniques in combination should be recommended since the PTS is unable to detect root injuries.

E-POSTER #212

Kyphosis Restoration Or Maintanence In Patients With Lenke Type I Scoliosis Treated By Pedicle Screw Construct: Is It Really Impossible By Using 5.5 mm Titanium Rods?

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Turkey

Summary: Correction of scoliosis by cantilever technique followed by segmental derotation and insitu bending by using 5.5 mm rods provided a significant correction and restoration in thoracic kyphosis.

Introduction: Many studies have shown excellent coronal plane correction by using all pedicle screw constructs. However, same papers have shown difficulty in restoration of kyphosis when pedicle screws were used with 5.5 mm titanium rods. The aim of this study is to evaluate the radiographic results in sagittal plane in Lenke type 1 curves treated by pedicle screw construct and 5.5 mm titanium rods.

Methods: One hundred thirty one patients (14M:117F) with a diagnosis of thoracic idiopathic scoliosis of Lenke type I corrected by polyaxial pedicle screw fixation with 5.5 mm titanium rod were retrospectively analyzed for deformity correction and sagittal plane restoration. Mean age at the time of procedure was 14.9 (10-19) years. Correction of the curve was performed either by cantilever correction, or rod rotation followed by segmental derotation and in situ bending maneuvers. BAVD has not been used as a correction method in any of the patients. Radiographic measurements included coronal thoracic curve Cobb angle, T2-T12 kyphosis, T12-S1 lordosis and CSVL to S1 distance. Proximal junctional kyphosis (PJK) was determined by measuring the kyphosis between upper instrumented vertebrae and the one above. More than 10 degrees kyphosis was accepted as PJK.

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ELECTRONIC POSTER ABSTRACTS

Results: Average follow-up was 64 (range; 24 to 148) months. Preoperative thoracic kyphosis of 20° and the lumbar lordosis of 32° were improved to 33° and 47°, respectively, at the most recent follow-up ($p<0.05$). The preoperative thoracic curve of 50° was corrected to 10° (79% correction, 2% loss of correction) at the most recent follow-up ($p<0.05$). The noninstrumented lumbar curve of 32° was corrected to 9° (70% correction, 4% loss of correction) at the most recent follow-up. There was no junctional kyphosis at the most recent follow-up. Forty-five percent of patients had preop sagittal plane decompensation (more than 2cm) preoperatively while 14% had at the final follow-up.

Conclusion: Correction of scoliosis by cantilever technique followed by segmental derotation and insitu bending by using 5.5 mm rods provided a significant correction and restoration in thoracic kyphosis. We conclude that the amount of correction in kyphosis depends more on the technique rather than the rod diameter or type.

Significance: -

E-POSTER #213

Discriminative Properties of the SAQ Compared to the SRS22R

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Summary: The SAQ is sensitive and responsive to change as evidenced by the large effect size for both the Expectations and Appearance domains and the Total Score. The effect sizes are larger than that for any of the SRS domains including Appearance and Total scores.

Introduction: The Scoliosis Appearance Questionnaire (SAQ) has been found to be a valid and reliable measure in patients with Adolescent Idiopathic Scoliosis (AIS), whether they are observed, braced or had surgery. A new factor analysis and scoring system has been recently published that has been shown to be applicable over all Lenke types and had greater correlation to curve magnitude than SRS Appearance and Total score. However, the discriminative properties of the SAQ in comparison to the Scoliosis Research Society-22R instrument (SRS-22R) have not been fully studied. The purpose of this study is to determine the responsiveness to change of the SAQ instrument in patients with AIS undergoing surgical correction of their deformity.

Methods: From a prospective multi-center database, 126 AIS patients who underwent correction of their spinal deformity with complete SAQ and SRS-22R data at baseline and two-year follow-up were identified. Discriminative properties of the SAQ domains (Expectations, Appearance and Total) and SRS domains (Appearance, Activity, Pain, Mental, Satisfaction and Total) were compared by computing the effect size (ES) and the standardized response mean (SRM). The larger the ES and SRM, the more sensitive to change the measure is. Effect sizes larger than 0.8 are considered large.

Results: The SAQ Total had the largest ES (1.8) and SRM (1.5). This was followed by the SAQ Appearance with an ES of 1.7 and SRM of 1.4, and the SAQ Expectations with an ES of 1.5 and SRM of 1.2. Among the different SRS domains, only the Appearance (ES=1.2, SRM=1.1), Satisfaction (ES=0.8, SRM=0.6) and Total scores (ES=0.8, SRM=0.9) had effect sizes that were considered large. The SRS Mental domain had a moderate effect size (ES=0.3, SRM=0.3), while the Activity (ES=0.0, SRM=0.0) and Pain (ES=0.2, SRM=0.2) domains had small effect sizes.

Conclusion: The SAQ is sensitive and responsive to change as evidenced by the large effect size for both the Expectations and Appearance domains and the Total Score. The effect sizes are larger than that for any of the SRS domains including Appearance and Total scores.

E-POSTER #214

Role of Intervertebral Release and Three-Column Spinal Osteotomy in Corrective Surgery for Degenerative Thoracolumbar/Lumbar Spinal Deformity in Patients over 60 Years of Age

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Summary: Consecutive 27 patients over 60 years of age with degenerative thoracolumbar/lumbar spinal deformities were prospectively enrolled in this observational cohort study. Correction rate of scoliosis was significantly higher in posterior spinal fusion (PSF) with intervertebral release (IVR) than in non-IVR. Whereas, bending correction index of kyphosis was significantly better in 3-column spinal osteotomy (3CO) than in non-3CO. Although PSF with IVR or 3CO is major invasive procedure, rigid and imbalanced deformities in the elderly were effectively corrected without severe complications.

Introduction: Aim of this study was to investigate merits and demerits of intervertebral release (IVR) and 3-column spinal osteotomy (3CO) in posterior spinal fusion (PSF) for the elderly with spinal deformity.

Methods: Consecutive 27 patients (average age: 67 years, range: 60-76) who underwent PSF for degenerative thoracolumbar/lumbar spinal deformities were prospectively enrolled in the observational cohort study. There were 14 patients with scoliosis and 13 with kyphosis. Preop Cobb angle of scoliosis and kyphosis was 50.6 +/- 11.0° and 38.9 +/- 18.9°, respectively. Preop coronal and sagittal global balance evaluated by C7 plumb line deviation was 40 +/- 37mm and +104 +/- 80mm, respectively. Efficacy of IVR or 3CO for deformity correction was evaluated by correction rate (CR) and bending correction index (BCI). BCI is calculated by dividing degree of surgical correction by degree of bending correction.

Results: A mean follow-up period was 20 (12-45) months. Cobb angle and CR of scoliosis at follow-up was 16 +/- 11° and 72 +/- 15% in IVR, whereas 26

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+/- 8° and 40 +/- 17% in non-IVR. There was statistically significant difference in CR between the two procedures (p=0.01). CR of coronal balance in IVR (82 +/- 41%) was significantly higher than CR in non-IVR (29 +/- 42%) (p=0.02). BCI of scoliosis was 1.4 +/- 0.5 in IVR and 1.2 +/- 0.3 in non-IVR (p=0.73). Whereas, BCI of kyphosis in 3CO (2.9 +/- 2.1) was significantly higher than that in non-3CO (0.9 +/- 1.2) (p=0.03). Final sagittal Cobb angle of the thoracolumbar (T10-L2) and lumbar spine (T12-S1) was +4 +/- 4° and -48 +/- 7° in 3CO and +16.3 +/- 12° and -33 +/- 14° in non-3CO, respectively. Sagittal alignment of thoracolumbar/lumbar spine was significantly better in 3CO than in non-3CO ($p<0.05$). Complication was junctional problem in 6 patients, surgical site infection in 2, transient radiculopathy in 1. There is no permanent paralysis and perioperative death.

Conclusion: Although PSF with IVR or 3CO is major invasive procedure, rigid and imbalanced deformities in the elderly were effectively corrected without severe complications.

E-POSTER #215

Lower Cortical Bone Mineral Density is Associated with Abnormal Osteopontin Level in Adolescent Idiopathic Scoliosis

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China

Summary: Recent reports showed lower BMD and higher osteopontin level separately. In this paper, osteopentin level was significant correlated with year since menarche. AIS girls had significant higher osteopontin level than healthy girls. With retarded increase of cortical BMD, osteopontin level was associated with cortical BMD in AIS but not with healthy girls. The association of osteopontin with abnormal cortical BMD suggested that OPN might play a significant role in affecting the cortical bone mineral acquisition in AIS girls.

Introduction: Many studies have shown the presence of low bone mineral density in girls with adolescent idiopathic scoliosis (AIS). Recent reports have also found higher plasma osteopontin level in AIS. As osteopontin (OPN) was known to play important role in bone mineralization, it was speculated that abnormal OPN level may be related to the low bone mass found in AIS. The present pilot study aimed to study the association between bone mineral density (BMD) and OPN level in AIS girls.

Methods: Clinical and anthropometric parameters of 45 AIS girls at their first presentation and 20 healthy sex, age and maturity matched controls were recorded. Plasma OPN level was quantified with ELISA. The non-dominant distal radius BMD (trabecular and cortical) was measured with high resolution peripheral quantitative computed tomography. Comparison between AIS and healthy girls and correlation of different parameters were conducted with multivariate regression analysis.

Results: AIS and healthy girls were similar in age and sexual maturity. OPN level was significant correlated with year since menarche (YSM). AIS girls had significantly higher OPN level than healthy girls by 99ng/mL after adjusted for YSM (p=.047). In healthy girls, cortical BMD was significantly increased 81.3mgHA/year following the increase in YSM. However, the increase of BMD in AIS girls is significantly slower at 54.0mgHA/year (p=.004). The cortical BMD of AIS was also lower than that of healthy girls. OPN level was found to be associated with cortical BMD in AIS but not with healthy girls.

Conclusion: OPN is one of the major non-collagen proteins for bone mineralization. At puberty, bone mineralization continues after the cessation of longitudinal growth especially in cortical bone. The retarded cortical bone mineral acquisition of AIS girls is likely to be resulting from abnormal regulation of bone metabolism. The association of OPN with abnormal cortical BMD suggested that OPN might play a significant role in affecting the cortical bone mineral acquisition in AIS girls. Further investigation on the mechanism of enhanced OPN expression in circulation and lower cortical BMD could help to shed further understanding on the etiopathogenesis of AIS.

E-POSTER #216

Surgical Outcomes of Long Spinal Fusions for Scoliosis in Patients with Rheumatoid Arthritis

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Summary: The management and outcomes of surgery for thoracolumbar scoliosis in patients with rheumatoid arthritis (RA) is not known. Our experience with long spinal fusions (≥9 levels) in RA patients demonstrates high complication and revision rates.

Introduction: Outcomes of long spinal fusions for scoliosis in patients with rheumatoid arthritis (RA) are not known. Our objective was to document surgical outcome and complications associated with the management of scoliosis in patients with rheumatoid arthritis.

Methods: Retrospective review of prospectively collected data from 2000 - 2009 for patients with RA who underwent long spinal fusions for scoliosis. Our inclusion criteria were: RA, nine or higher vertebral levels fused and a diagnosis of degenerative or idiopathic scoliosis. We excluded patients that had eight or fewer levels fused, non-RA patients and patients who did not have scoliosis. Demographics, co-morbidities, levels fused, complications and revisions were recorded.

Results: Ten consecutive RA patients who met the inclusion criteria were identified. There were 9 females and 1 male. Average age at surgery was 65.6 (40.5-81.9). There were 0 smokers and 1 patient with diabetes mellitus. Average follow up was 40.3 month (0.03 - 88.5). 6 cases were index spinal fusions

ELECTRONIC POSTER ABSTRACTS

and 4 cases were revisions. All patients had degenerative scoliosis, 8 had lumbar stenosis and 2 had kyphosis. RA medications used included 8 oral steroids, 7 disease modifying antirheumatic drugs (DMARDs) and 1 biologic DMARD. There were an average of 10.5 levels fused (9 -17). 8 cases were posterior only and 2 were combined anterior/posterior. Average estimated blood loss was 3.1L (1.3 - 5). Average hospital length of stay was 14.2 days (5 -55). 12 complications in 8 patients included: incidental durotomy (2), pseudoarthrosis (2), epidural hematoma (2), post-op death 2nd to respiratory failure (1), distal junctional kyphosis (1), pulmonary embolism (1), respiratory failure requiring tracheotomy (1), neurologic deficit(1), deep infection (1). 7 patients required a revision procedure.

Conclusion: Long spinal fusions in patients with RA are associated with high rates of complications and revisions.

Significance: This is the first study documenting surgical outcomes following the management of scoliosis in patients with rheumatoid arthritis.

E-POSTER #217

Are Patients Participating in Sports After Posterior Spine fusion for Adolescent Idiopathic Scoliosis? Distal Level of Fusion Correlates With Postoperative Activity Level

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USA

Summary: Associations between clinical, surgical, and demographic variables predicting level and rate of return to organized athletic activity after posterior spinal fusion for adolescent idiopathic scoliosis (AIS) were assessed. In active adolescents, distal level of fusion, Lenke classification and SRS-22 score were each independent predictors of postoperative return to athletic activity postoperatively.

Introduction: Current validated scoliosis outcome instruments demonstrate a significant "ceiling" effect and it is therefore difficult to demonstrate differences in activity outcomes between adolescent patients undergoing spinal fusion. This study evaluated which clinical, surgical and radiographic variables are most closely correlated with return to athletic activity in patients with adolescent idiopathic scoliosis after undergoing posterior spinal fusion and instrumentation (PSFI).

Methods: 42 patients with AIS who met inclusion criteria who underwent PSFI at a tertiary care academic orthopaedic institution by a single surgeon over a thirteen year period were analyzed for predictors of return to pre-surgical athletic activity levels. Data was collected by chart and radiograph review, patient interview, and postoperative SRS-22 outcomes instrument. Postoperative return to athletic activity at the same or higher level of competition compared with preoperative level of athletic activity was recorded as the primary outcome variable.

Results: At an average of 5.5 years follow-up, 25 patients (59.5%) had returned to sports at an equal or higher level of physical activity. Postoperative athletic participation included a wide variety of sports and ranged from recreational to university varsity-level. Lower distal level of fusion was inversely correlated with return to activity at the same or higher level postoperatively. Patients were 36.7% less likely to return to athletic activity for each distal vertebra included in the fusion starting at T11 (Odds Ratio = 0.633, P=0.039). Fusion to L4 was correlated with a 20% return to preoperative activity level (Fig. 1). In addition, Lenke classification and postoperative SRS-22 score were each independent predictors of postoperative return to athletic activity postoperatively.

Conclusion: In this retrospective cohort study, distal level of fusion showed a stepwise decline in medium-term return to athletic activity after posterior spinal fusion for AIS.

Significance: This data suggests that distal level of fusion may be a reliable predictor of return to athletic activity, and may help guide patients and families regarding appropriate expectations after PSFI for AIS.

Figure 1. The relationship between distal level of spinal fusion and percent of patients who returned to athletics at the same or higher level of competition is marked by a stepwise decline in return to activity with each distal segment fused. Odds Ratio = .633 P = 0.039

E-POSTER #218

Surgical Treatment for Proximal Junctional Kyphosis After Adult Spinal Deformity Surgery. Minimum TwoYear Follow-Up Study

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USA

Summary: 26 patients who underwent revision surgery for PJK were retrospectively investigated to describe the causes of PJK and the radiographic and clinical outcomes of surgical correction.

Introduction: Thoracolumbar proximal junctional kyphosis (PJK) is an important complication and cause for revision surgery in adult deformity surgery. The purpose of this study is to describe the causes of PJK and the radiographic and clinical outcomes of surgical correction of PJK in adult spinal deformity.

Methods: Retrospective analysis of a consecutive series of patients treated with surgery for adult spinal deformity. Cause of PJK was determined from preoperative radiographs. Predictor variables for recurrence of PJK include comorbidities, and radiographic measures. Clinical outcomes measures included patient self-assessment with the SRS-30.

Results: A query of the integrated data repository (2135 consecutive surgeries between 2004-2007) identified 26 patients (73% female, mean age 62) who underwent revision surgery for symptomatic proximal junctional kyphosis at the

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thoracolumbar junction. Reasons for revision surgery included back pain (81%), sagittal imbalance (31%), and neurological deterioration (39%). Anterolisthesis above the upper instrumented vertebra was present in 15% and 96% had an adjacent vertebral fracture. The upper instrumented vertebra was fractured in 35%, above this vertebra in 54%, and below in 8%. Surgical strategies for correction of PJK included Smith-Peterson osteotomy in 81% and pedicle subtraction osteotomy in 27%.

No patient required subsequent revision during the follow-up period, the PJK recurrence rate was 31%. Osteoporosis, and lager global sagittal balance at follow-up were associated with PJK recurrence.

Mean SRS-30 total scores in subjects were 75 preoperatively, and 85 at follow-up. There is no significant difference between patients with/without PJK recurrence.

Conclusion: Most cases involve a fracture at or adjacent to the upper instrumented vertebra. Patients with osteoporosis, a high pelvic incidence before revision surgery, and global sagittal imbalance after revision surgery may be at risk for recurrence of PJK.

Significance: Surgical outcomes of surgical correction of PJK in adult spinal deformity was acceptable. Most cases involve a fracture at or adjacent to the upper instrumented vertebra.

E-POSTER #219

Post-operative CT Assessment of Interbody Fusion Two Years After Thoracoscopic Scoliosis Surgery

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Summary: The relationship between radiologic union and clinical outcome in thoracoscopic scoliosis surgery is not clear, as apparent non-union of a spinal fusion does not always correspond to a poor clinical result.

Introduction: The aim was to evaluate CT fusion rates 2yrs after thoracoscopic surgery, and to explore relationship between fusion scores and rod diameter, graft type, fusion level, implant failure, and lateral position in disc space.

Methods: Cohort of 44 patients undergoing thoracoscopic scoliosis correction. Discectomies performed at instrumented levels and defect packed with autograft (n=14), or allograft (n=30). Instrumented with 4.5mm (n=24) or 5.5mm (n=20) single titanium anterior rod and vertebral body screws. Fusion quality and implant integrity evaluated 2yr following surgery using low-dose CT. At each disc space, left, right and mid-sagittal CT reconstructions were generated and graded using Sucato 4-point scale (based on calculated percentage fusion across disc space).

Results: Fusion scores measured for 259 disc spaces in 44 patients. Rod diameter had strong effect on fusion score (mean score 2.12±0.74 for 4.5mm Ti, 1.41+0.55 for 5.5mm Ti, 1.09+0.36 for 5.5mm Ti-alloy). Mean fusion scores for autograft and allograft subgroups were 2.13±0.72 and 2.14±0.74. Fusion scores highest in middle of implant construct, dropping off 20-30% toward upper and lower ends. Fusion scores adjacent to rod (2.19±0.72) significantly higher than contralateral side (1.24±0.85). Levels where rod fracture (1.09±0.67 vs 1.76±0.80) and where top screw pullout occurred (1.25±0.60 vs 1.83±0.76) had lower CT fusion scores.

Conclusion: Rod diameter (larger), intervertebral level (proximal or distal), lateral position in disc space (further from rod) and rod fracture or top screw pullout have reduced fusion scores, while graft type (autograft or allograft) does not affect scores. Rod fractures did not necessarily occur in patients with lower fusion scores. It is possible that with a stiffer 5.5mm rod, less bony fusion mass is required for a stable construct. Taken with results of previous studies on this cohort, we propose that moderate fusion scores on the Sucato scale secure successful clinical outcomes in thoracoscopic scoliosis surgery.

E-POSTER #220

Validation of the SRS-Schwab Adult Deformity Classification

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USA

Summary: While classifications in the pediatric population are well established, there is still a need for a complete classification for adult spinal deformity. A previous classification system has been revised to include pelvic parameters, which have shown marked correlation with HRQOL measures in recent studies. Initiated by the SRS Adult Deformity Committee, this study demonstrates that the proposed new adult spinal deformity classification system is clear and has excellent intra- and inter-rater reliability and agreement.

Introduction: A classification of adult spinal deformity (ASD) can serve several purposes, including: a) consistent characterization of a clinical entity, b) a basis for comparing different treatments, and c) recommended treatments. While scoliosis classifications in the pediatric population are well established, an ASD classification is still being developed. A previous classification system has met with clinical relevance, but did not include pelvic parameters, which have shown marked correlation with HRQOL measures in recent studies. Based upon a Scoliosis Research Society effort, this study seeks to determine if the proposed new ASD classification system is clear and reliable.

Methods: Initiated by the SRS Adult Deformity Committee, this study used a classification system previously published by Schwab, revised to include pelvic

ELECTRONIC POSTER ABSTRACTS

parameters. Modifier cutoffs were determined using HRQOL data analysis from a multi-center database of adult deformity patients. 9 readers graded 21 pre-marked cases twice each, approximately one week apart. Inter- and intra-rater reliability and inter-rater agreement were determined for the curve type and each modifier separately. Fleiss' Kappa was used for reliability measures, with values of 0.00-0.20 considered slight, 0.21-0.40 fair, 0.41-0.60 moderate, 0.61-0.80 substantial, and 0.81-1.00 almost perfect agreement.

Results: Inter-rater Kappa for curve type was 0.80 and 0.87 for the two readings respectively, with modifier Kappas of 0.75 and 0.86, 0.97 and 0.98, and 0.96 and 0.96 for PI-LL, PT, and SVA, respectively. By the second reading, Curve type was identified by all readers consistently in 66.7%, PI-LL in 71.4%, PT in 95.2%, and SVA in 90.5% of cases. Intra-rater Kappa averaged 0.94 for Curve Type, 0.88 for PI-LL, 0.97 for PT, and 0.97 for SVA across all readers.

Conclusion: Data from this study show that there is excellent inter- and intra-rater reliability and inter-rater agreement for curve type and each modifier. The high degree of reliability demonstrates that applying the classification system is easy and consistent. Greater Kappa values in the second set of readings also demonstrate a learning curve in application of the classification system.

E-POSTER #221

Use of Quantitative Ultrasound (QUS) for Predicting Curve Progression in Adolescent Idiopathic Scoliosis - A Prospective Cohort Study of 294 Cases Followed Beyond Skeletal Maturity

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Hong Kong

Summary: We evaluate the use of QUS for predicting curve progression in AIS

Introduction: The main challenge in managing AIS is to predict curve progression so that appropriate treatment can be given. Previous investigation confirmed Bone Mineral Density(BMD) as a significant prognostic factor. It is desirable if a radiation-free modality can be used in lieu of BMD for AIS subjects. Quantitative ultrasound(QUS) is useful for assessing bone density and quality. The objective of this study was to evaluate the use of QUS in predicting curve progression in AIS.

Methods: This was a prospective cohort study on 294 AIS girls between 11-16 years old. They were followed beyond skeletal maturity for curve progression defined as an increase of Cobb angle≥6°. Three calcaneal QUS measurements were done at baseline, namely BUA(Broadband Ultrasound Attenuation), VOS(Velocity of Sound) and SI(Stiffness Index). BMD, Age, Menarchal Status and Cobb angle were also recorded. Logistic regression model was used for evaluating their prognostic values for AIS progression.

Results: The mean age at baseline was 13.4 years old(SD=1.23). 73(24.8%) were pre-menarchal and the mean Cobb angle was 26.3°(SD=8.2). The average follow up was 3.4 years(SD=1.57). Initial univariate analysis indicated all independent variables had p <0.2. Subsequent logistic regression analysis indicated the p-values of their regression coefficients were: Age(p<0.001), Menarchal Status(p<0.001), Cobb(p=0.008), BMD(p=0.084), BUA(p=0.722), VOS(p=0.112) and SI(p=0.027). SI, Age, Menarchal Status and Cobb were retained in the final prediction model. The adjusted odds ratio of curve progression for Z-score of SI 0 was 2.00(95% CI: 1.08 - 3.71) indicating deranged bone quality was related to curve progression. The area under the ROC curve was 0.831(95% CI: 0.785 - 0.877).

Conclusion: SI is an independent and significant prognostic factor for AIS. SI could be considered for estimation of progression risks and treatment planning especially when DXA is not available.

This study is supported by Research Grant Council of Hong Kong Government (CUHK4498/06M)

Significance: QUS can be used for predicting curve progression in AIS. The prognostic value of QUS may indicate the role of deranged bone quality in the etiopathogenesis of AIS and further studies on this are warranted.

E-POSTER #222Ω

rhBMP-2 and Modern Surgical Techniques Significantly Reduce the Pseudarthrosis Rate in Long Fusions to the Sacrum for Complex Adult Spinal Deformity

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USA

Summary: A surgical technique of aggressive local bone graft harvesting combined with an average of 10 mg BMP/posterior level and pedicle screw fixation resulted in only 1 pseudarthrosis in upper thoracic to sacrum adult deformity fusions. This rate is much lower than prior published rates for these difficult adult deformity fusions. No local or systemic complications were attributed to BMP use and Health Related Quality of Life scores improved significantly for this patient cohort.

Introduction: Pseudarthrosis (PA) rates up to 30% have been reported in adult spinal deformity fusion to the sacrum. This study assessed outcomes of upper thoracic (T2-T5) to sacrum spinal fusion (UT SF) with BMP and modern surgical techniques in adult deformity surgery.

Methods: We analyzed a single-center prospective cohort of 48 patients (47 F) with primary UT SF from 2002-2008 at mean f/u of 2.7 years (2-5.1 yrs). Study inclusion criteria were minimum mean 5 mg BMP/ level and mean 1.7 fixation points/level. The study had a return rate of 84% (8 pts < 2-yr f/u, 1 pt died from cancer). Fusion was done with autograft/local bone (no iliac crest

harvest), allograft and BMP. PA was diagnosed as implant failure. 40 patients had additional oblique x-rays or CT scan for fusion assessment. SRS scores, ODI and complications were recorded.

Results: The cohort averaged 61.7 years (43.1-80.9 yrs) with a BMI of 26.4 (18.7-46.1). SF averaged 15.2 posterior (mean 1.9 fixation points/level) and 1.5 anterior (71% of patients; 79% TLIF) levels. BMP averaged 12.1 mg/posterior and 9.7 mg/anterior level. Major coronal curve correction averaged 59%. Mean surgical time was 493 minutes (330-660 min) with a mean EBL of 1.7 liters (0.3-4.7 L). Mean hospital stay was 9.9 days (6-36 days). 1 patient (2.1%) developed a pseudarthrosis. This patient had a T2-sacrum PSF (5 mg BMP/posterior level) with L5-S1 TLIF (12 mg BMP) and presented with pain/broken rods at L3-L4 at 1.6 year f/u. Revision surgery confirmed L2-L5 PA treated with BMP/allograft. 8 patients had intraoperative complications (6 minor, 2 major). 23% had a major acute perioperative and 10% had a long-term complication. There were no local or systemic complications due to BMP. Mean improvements in SRS self-image (1.6), satisfaction (1.5), pain (0.8), subscore (0.7), mental health (0.5) and ODI (-14.2) were significant.

Conclusion: BMP, aggressive local bone graft harvest and pedicle screw fixation may be a competitive alternative to PSF with ICBG. This technique resulted in a 2.1% pseudarthrosis rate in 48 adult deformity fusions. No complications were directly attributable to BMP use. HRQOL scores significantly improved and overall complication rate was consistent with established norms.

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).

E-POSTER #223

Post-Operative Trunk Mobility is Better With the Anterior Approach vs. Posterior in Thoracolumbar Scoliosis

Michelle C. Marks, PT, MA; Tracey Bastrom, MA; Maty Petcharaporn, BS; Randal R. Betz, MD; Harry L. Shufflebarger, MD; Baron S. Lonner; Suken A. Shah, MD; Peter O. Newton, MD

USA

Summary: Pre- and post-operative measurements in 64 adolescent idiopathic patients with thoracolumbar scoliosis revealed that post-operative trunk motion loss and subsequent motion restoration is better with the anterior vs. posterior approach. Shorter fusions and posterior muscle sparing may contribute to the better flexibility following the anterior approach. Comparison of trunk flexibility between the 2 approaches is novel, and we acknowledge this is only one component in the comparison of the two approaches and further investigation is warranted.

Introduction: This study evaluates post-operative trunk flexibility, an important outcome variable to consider with each surgical approach option (anterior vs posterior), for thoracolumbar (ThL) adolescent idiopathic scoliosis (AIS).

Methods: Trunk flexibility measurements, radiographic measurements, and SRS questionnaire data were obtained pre-operatively and 1 & 2 years post-operatively on patients with ThL AIS enrolled in a multi-center, prospective study. Forward flexion (FWD FLX) was assessed via modified Schober's method (the distance between C7 and S1 in upright standing versus maximum flexion). Lateral Flexion (LAT FLX) motion was assessed via fingertip to floor measurement in upright standing versus maximum lateral bending. These techniques exhibit good convergent validity of postoperative motion and lowest instrumented vertebrae. Data was compared between anterior spinal fusion (ASF) and posterior spinal fusion (PSF) approaches across time points using a repeated measures ANOVA ($p=0.05$).

Results: 64 patients who had undergone selective ThL spinal fusion (upper instrumented vertebrae T8 or below) for ThL scoliosis were included yielding 41 ASF and 23 PSF. Pre-op curve magnitude and trunk flexibility was similar for both approaches. Length of fusions was 1 level longer in PSF. Motion loss at 1 yr was similar in FWD FLXN, but greater for PSF in LAT FLXN. Motion restoration at the 2 yr time point with ASF was statistically greater than with PSF (Fig. 1.). Curve correction at 1 & 2 years was: ASF 66% & 67%, PSF 58% & 57%, respectively ($p<0.05$). Sagittal T10-L2 was ASF 6° kyphosis, PSF 4° lordosis ($p<0.05$). There were no differences in post-op SRS scores.

Conclusion: This study found ASF in ThL AIS results in better post-operative trunk flexibility, perhaps a result of shorter fusion and posterior muscle sparing.

Significance: Further investigation is warranted in the comparison of ASF vs PSF approaches for ThL AIS.

Fig. 1. Trunk motion in cm (upright - maximum bending) at each time-point for ASF and PSF.

E-POSTER #224

A New Look at the Clinical and Biomechanical Modes of Failure and Surgical Methods to Improve Pedicle Screw Fixation in the Osteoporotic Spine

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USA

Summary: Biomechanical lab study in synthetic osteoporotic bone and human cadaveric vertebrae quantifying the failure mode of pedicle screws in osteoporosis and identifying surgical strategies that improve fixation in osteoporotic adult deformity patients.

Introduction: Adult deformity patients commonly have concomitant osteopenia /osteoporosis. Obtaining and maintaining correction with pedicle screw constructs remains difficult owing to frequent failure at the bone/screw interface. These investigations sought to clarify the modes of failure for pedicle screws in such patients and to quantify the effects of surgical techniques that might improve fixation.

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ELECTRONIC POSTER ABSTRACTS

Methods: Part I: 20 human cadaveric osteoporotic vertebrae were instrumented with 6.5 x 40mm pedicle screws. In half, the screws were placed parallel to the superior endplate; the remaining screws were angulated cranially 20 degrees toward the endplate. Subgroups had 1.5ml of calcium phosphate cement injected into the pilot hole before screw placement. Part II: 40 synthetic osteoporotic cancellous bone blocks were fashioned to represent thoracolumbar vertebrae and were instrumented with 6.5 x40mm pedicle screws. Half were augmented with 1.5-2.0ml cement; half not augmented (NA). Subgroups had pilot holes pre-tapped to depths of 10mm (5), 20mm (5), 30mm (5), or 40mm (5). A mixed-mode load (flexion moment, pullout, and shear) was applied to each until failure. Screw and bone motion was measured with a high-resolution optical device.

Results: In all tests, screw toggle preceded significant pullout failure and cement augmentation significantly increased resistance to failure. Part I: Mean failure load of NA screws parallel to endplate was 268.17 N; those angled cranially failed at mean 417.95 ($p<0.05$). When cement augmentation was used, mean failure occurred at 694.70 N for parallel screws vs. 1099.78 N for angulated screws ($p<0.05$). Part II: for all NA subgroups there was a clear and significant ($p<0.05$) decrease in failure load for greater pre-tapping depths. For all subgroups augmented with cement failure loads increased for greater depths of pre-tapping.

Conclusion: The typical mode of failure for pedicle screws in osteoporotic bone appears to be toggle before pullout. Use of cement augmentation significantly increases failure resistance, as does the placement of screws angled toward the superior endplate. Pre-tapping holes in osteoporotic bone can decrease fixation, unless augmentation cement will be used, in which case tapping enhances fixation.

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E-POSTER #225‡

Adding-On Phenomenon in Selective Posterior Thoracic Fusion for Lenke Type 1A Curve Pattern: Are There Some Risk Factors?

Mario Di Silvestre, MD; Francesco Lolli; Georgios Bakaloudis; Konstantinos Martikos

Italy

Summary: Adding-on phenomenon can occur after selective fusion in thoracic scoliosis.

We retrospectively reviewed 37 adolescents affected by a single thoracic Lenke 1A (King type III, IV) curve.

At a mean follow-up of 4.2 years the thoracic curve presented a correction of 58.4%, and the lumbar curve of 52.4%. In 7 cases (18%) an "adding on" phenomenon occurred. All patients presented a Lenke 1A-King IV curve with the distal fusion level being two or more levels proximal to the SV.

Introduction: Adding-on phenomenon can occur after selective fusion in thoracic scoliosis. Aim of our study is to determine risk factors for the adding-on phenomenon in single thoracic curves with a compensatory curve not crossing the midline (Lenke 1A, King III and IV) with reference to the standing stable vertebra (SV), after posterior fusion.

Methods: We retrospectively reviewed 107 AIS patients surgically treated by means of selective thoracic fusion using segmental pedicle screw-only instrumentation, between 2000 and 2005 in a single Institution. In the present study we included 37 adolescents, 30 females and 7 males, with average age of 16.3 years (range, 10 to 22 years), affected by a single thoracic Lenke 1A (King type III, IV) curve. The lowest instrumented vertebra was L3 in one, L2 in 14, L1 in 15, T12 in 6, and T11 in 1 case, corresponding to the SV -3 in five, SV -2 in 14, SV -1 in 14, to the SV in 3 and to the SV +1 in one patient.

Results: At a mean follow-up of 4.2 years (range, 2.8 to 5.1) the thoracic curve presented a correction of 58.4% (from 62.3° to 26.6°), and the lumbar curve of 52.4% (from 38.1° to 18.1°), whereas average apical thoracic vertebra's displacement improved from 2.3 cm to 1.7 cm. Frontal balance improved from 1 cm to 0.4 cm. In 7 cases (18%) an "adding on" phenomenon was found: all patients presented a Lenke 1A-King IV curve with the distal fusion level being two or more levels proximal to the SV. This phenomenon was correlated with the King IV curve ($p= 0.043$; Chi-square test) and the only predictive parameter for its onset was the LIV-SV difference (Odds ratio =0.093; with a confidence interval of 0.008 to 1).

Conclusion: In thoracic curves with a compensatory curve not crossing the midline with two levels or more discrepancy between end vertebra and stable vertebra (Lenke 1A, King III and IV), the distal fusion level shorter two or more levels than the stable vertebra can present a high risk of postoperative "adding on" phenomenon.

E-POSTER #226

Outcomes and Complications of Minimally Invasive Correction for Adult Degenerative Scoliosis

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USA

Summary: Adults with minimally invasive correction of spinal deformity show positive outcomes.

Introduction: Minimally invasive surgery has been increasingly used for the correction of spinal deformity. The object for this study is to analyze complication rates and outcomes in 45 patients with degenerative scoliosis treated with minimal invasive correction and fusion.

Methods: We performed a retrospective chart review of 45 patients who received minimally invasive surgical correction for adult degenerative scoliosis at

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3+ levels. All patients had two-stage reconstruction surgeries separated by a 4-6 weeks. Stage 1 involved a lateral lumbar interbody fusion and stage 2 required percutaneous spinal fusion and AxiaLIF at L5-S1. VAS pain scores as well as Oswestry Disability Index (ODI) were collected pre- and post-op. Pre-op and post-op Cobb angles as well as sagittal profile with the C7 plumb line were also measured. Perioperative complications were also analyzed.

Results: The present study included 12 males and 37 females with an average age of 53.4 years. Average levels of fusion were T10-S1 in 80% cases and L2-S1 in the residual cases. Estimated blood loss for the stage I was 52 (±15) ml and 213 (±112) ml for stage II. The mean operative time for stage I was 160 (±100) min and stage II was 269 (±130) min. The mean length of hospital stay for stage I was 2.0 (±1.0) days and stage II was 3.2 (±1.4) days. The preoperative Cobb angle was 36°, which corrected to 9° post-op. The C7 plumb line sagittal profile averaged 6.2 cm pre-op and corrected to 1.7 cm after surgery. The mean pre-op VAS=8.20 and post-op=3.01. The mean ODI score at pre-op was 50.3% and 8.5% at post-op. There was a significant decrease in VAS and ODI post-op ($p<0.001$). Superficial wound complications were identified in 6 patients (13%). There were no documented vascular or rectal bowel complications.

Conclusion: Our analysis of 45 patients receiving minimally invasive correction for degenerative scoliosis show very low complication rates overall. Patients also demonstrate excellent correction of coronal and sagittal plane deformity post-op. VAS and ODI scores also show significant decrease postoperatively, providing support for the positive outcomes of this minimally invasive approach.

E-POSTER #227

Post-Operative Changes in Coronal Balance after Surgical Correction of Adolescent Idiopathic Scoliosis using Pedicle Screw Constructs

Julien Leroux; Jean-Marc Mac-Thiong, MD, PhD; Hubert Labelle, MD; Stefan Parent, MD, PhD

France

Summary: We reviewed the coronal balance of 102 children who had posterior spinal fusion for adolescent idiopathic scoliosis (AIS) using pedicle screw constructs. Spontaneous correction in coronal balance was observed after surgery within the first 3 postoperative months. Therefore after 3 months, revision surgery can be contemplated if major coronal imbalance is still present.

Introduction: Achieving adequate spinal balance is very important after posterior spinal fusion for adolescent idiopathic scoliosis (AIS). Spinal balance can potentially change after surgery but this has not been studied extensively. Revision surgery may be required to correct postoperative coronal imbalance. The aim of the current study is to investigate the changes in coronal balance after posterior spinal fusion for AIS using pedicle screw constructs.

Methods: We reviewed the X-Rays of all patients who had posterior spinal fusion for AIS using pedicle screw constructs between January 2006 and October 2009, with a 1-year minimal follow-up. Coronal balance was measured from postero-anterior X-Rays at 1 week, 6 weeks, 3 months, 6 months, and 1 year after surgery. Paired Student t tests were used to compare the coronal balance between postoperative visits.

Results: A total of 102 patients were included. There was a significant improvement in mean coronal balance between 1 week (31,3mm) and 1 year (25,9mm) ($p<0,01$), and between 6 weeks (28mm) and 1 year ($p<0,05$) after surgery. There was no difference between 3 or 6 months and 1 year after surgery.

Conclusion: This study suggests that spontaneous improvement in coronal balance tends to stabilize 3 months after a posterior spinal fusion for AIS using pedicle screws. Clinicians can expect most of the spontaneous correction of coronal balance during the first 3 post-operative months. Therefore 3 months after surgery, major coronal imbalance is not likely to correct spontaneously, and revision surgery can be contemplated.

E-POSTER #228

Two to Four Year Functional Outcomes of Minimally Invasive Surgery (MIS) for Adult Spinal Deformity

Neel Anand, MD; Sheila Kahwaty, PA-C; Babak Khandehroo, MD; Eli Baron, MD

USA

Summary: MIS deformity correction using a combination of 3 techniques affords excellent outcomes with reduced morbidity

Introduction: Traditional surgery for adult deformity is associated with significant blood loss & morbidity.

Methods: Consecutive series of patients with > 2 year f/u who underwent MIS Correction of adult deformity including degenerative (25), idiopathic (6), and post laminectomy scoliosis (6). All underwent this using all/combination of 3 MIS techniques: Lateral Transpsoas discectomy/interbody fusion(37), AxiaLIF L5-S1 interbody fusion(18) and segmental multilevel percutaneous pedicle screw fixation(35). 35 patients were staged: lateral fusion first 1st followed by posterior instrumentation/fusion including AxiaLIF done 3 days later. 2 patients had stand-alone lateral fusions. Fusion was augmented with local bone, rh-BMP2 & DBM at each interbody space and in facets. Radiographs, VAS, treatment intensity scores, ODI & SF-36 were assessed preop & at each postop visit.

Results: Mean age was 67. Mean f/u was 34 months with > 3 yrs f/u in 18 patients. Mean Blood loss & surgical time was 366 cc & 225 min for the lateral fusion with 247 cc and 239 mins respectively for the posterior fusion including AxiaLIF.

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ELECTRONIC POSTER ABSTRACTS

21 patients had transient thigh dysaesthesias for 2 to 6 weeks; 2 patients had quadriceps palsy that resolved within 6 months. 1 patient required removal of a proximal screw at 12 months after fusion was confirmed; 1 had a proximal screw fracture with solid fusion. 1 patient needed decompression for heterotopic ossification; 2 for persistent stenosis. 1 patient is since deceased of Renal failure; 1 patient developed an unrelated cerebellar hemorrhage that was evacuated with no residual effect. 2 patients with stand-alone lateral fusions developed nonunions and were posteriorly instrumented at 9 months and 1 year postop.

Mean pre-op Cobb was 22 degrees; postop was 7 deg. Global coronal & sagittal balance were maintained at final f/u. All patients had solid arthrodesis on plain films. This was was confirmed on CT in 26 patients. No patient had iliac fixation. No failures of sacral screws or sacral fractures were noted.

Conclusion: 3 MIS techniques allow correction of Adult Scoliosis, with low pseudarthrosis rates & improved functional outcomes

Significance: MIS techniques may afford surgical options & improved quality of life for the treatment of adult scoliosis

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E-POSTER #229

Incidence/Association of Spondylolisthesis and Adolescent Idiopathic Scoliosis (AIS)

Ronald A. Lehman, MD; Lawrence G. Lenke, MD; Kathy Blanke, RN; Ensor E. Transfeldt, MD; Hubert Labelle, MD; Stefan Parent, MD, PhD; Jean-Marc Mac-Thiong, MD, PhD

USA

Summary: This the first study in 25 years depicting the true incidence/association of spondylolisthesis and AIS. We found that 4.4% of AIS patients requiring surgical correction had concomitant spondylolisthesis. However, there was a much more significant percentage of patients presenting with spondylolisthesis having associated scoliosis (asymptomatic =19.7, symptomatic=29.2%). Patients presenting with either AIS or spondylolisthesis require evaluation for both conditions.

Introduction: The association of spondylolisthesis and AIS has never been thoroughly evaluated. Increasingly, patients needing fusion for AIS may complain of low back pain, and have spondylolisthesis detected on the lateral radiographs. We set out to determine the true prevalence of spondylolisthesis and AIS.

Methods: Using a prospective, multicenter database we analyzed several groups of patients to determine the incidence of spondylolisthesis and AIS. Groups included, I - AIS patients needing fusion (n=1132); II - symptomatic spondylolisthesis requiring fusion (n=66); and III asymptomatic patients with spondylolisthesis (n=149). All preoperative radiographs were evaluated by an independent research nurse who analyzed specifically for the presence of AIS and spondylolisthesis.

Results: We found 1132 patients with AIS, of which 1076 had adequate radiographs. For this group (Group I), there were 47 cases with concomitant spondylolisthesis for an incidence (i) of 4.38%. In Group II, we had n=66 patients (only 48 had scoliosis radiographs) with symptomatic spondylolisthesis requiring fusion, we found 14 patients with true scoliosis (i=29.2%), and those with sciatic scoliosis (n=9; i=13.6%). There were 142 patients with adequate x-rays in Group III, with 28 having true scoliosis (i=19.7%) and 13 with sciatic scoliosis (i=9.2%).

Conclusion: We personally evaluated every radiograph of 1266 patients using a prospectively, collected database. We found the relative prevalence of spondylolisthesis in AIS requiring fusion was 4.38%. The prevalence of scoliosis in symptomatic spondylolisthesis patients requiring arthrodesis surgery was 29.2%. For asymptomatic spondylolisthesis patients, 19.7% of patients had concomitant scoliosis. Due to the high incidence of scoliosis in patients presenting with spondylolisthesis, evaluation for both conditions should be considered.

E-POSTER #230

Prevalence and Risk factors for Pseudarthrosis after Lumbar Pedicle Subtraction Osteotomy (PSO) in Adult Spinal Deformity

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USA

Summary: The prevalence of pseudarthrosis after adult lumbar PSO was 10.5 % (18/171). Prior pseudarthrosis from previous surgery, including at the PSO site, prior decompression in the lumbar spine, prior radiation to the lumbar spine and presence of inflammatory disease/neurologic disorders were identified as risk factors. SRS and ODI scores improved after pseudarthrosis repair.

Introduction: We assessed the prevalence, risk factors, and clinical outcomes for pseudarthrosis after a lumbar pedicle subtraction osteotomy (PSO). To our knowledge, this is the largest PSO series ever evaluated for pseudarthrosis.

Methods: A retrospective review of prospectively collected data on 171 consecutive adult deformity patients undergoing a lumbar PSO by 2 surgeons at a single institution was analyzed with a minimum 2yr F/U. Pseudarthrosis was confirmed by radiographic instrumentation failure, loss of sagittal alignment and intraoperative confirmation.

Results: 18 (10.5%) out of 171 pts developed pseudarthrosis after a PSO. 11 of the 18 pts (6.4% all pts/61.1% of all 18 pseudos) had pseudarthrosis at the PSO site, L3 being the most common site, other locations: L-S junction (4/18), TL junction (2/18) and upper thoracic spine (1/18). Preop pseudarthrosis level

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was a predictor of postop level of pseudarthrosis (93%). 15 of 18 pts (83%) had no interbody fusion directly above and/or below the PSO site. 16 of 18 (88%) pts had a history of pseudarthrosis at the time of PSO surgery; 2/3 pts who had prior radiation to the lumbar spine developed pseudarthrosis. Most pseudarthroses occurred within the first 2 years (n=13/18), between 2-5yrs (n=3/18) and >5yrs (n=2/18) postop. Prior pseudarthrosis (P<0.0001), pseudarthrosis at the PSO site (P<0.0001), prior decompression in the lumbar spine (P=0.0037), prior radiation to the lumbar spine (P<0.0001) and presence of inflammatory/neurologic disorders (P<0.0036) were identified as risk factors. All 18 pts with pseudarthroses required revision surgery (posterior-only n=12, A/P n=6) due to loss of sagittal alignment/pain. The mean pre-revision SRS score was 85, post-revision was 95 (P=0.0166), and the mean pre-revision ODI score of 42.5 improved at post-revision to 34.5 (P=0.0203).

Conclusion: The overall prevalence of pseudarthrosis after lumbar PSO was 10.5% with 11/18 (61%) occurring at the actual PSO site. Prior pseudarthrosis at the PSO site or other regions of the lumbar spine, prior laminectomy in the lumbar spine, prior radiation to the lumbar spine and preop inflammatory/neurologic disorders were all risk factors. SRS and ODI scores improved significantly following pseudarthrosis repair.

E-POSTER #231

Validation of EOS 3D Reconstruction Accuracy Against CT

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USA

Summary: Scoliosis is a 3D deformity; still 3D morphological analyses are rare. The 3rd dimension is critically important, but clinically 2D-radiographs are used due to high CT radiation. A new low-dose radiation machine (EOS) was clinically evaluated for intra/interobserver variability, but data are limited for EOS reconstruction accuracy compared to CT. Our study evaluated the shape, position and orientation accuracy, and how they differ based on the subject's positioning within EOS.

Introduction: Scoliosis evaluation based on 2D radiographs is a simplification of the true 3D deformity. The objective of this study was to assess the accuracy of 3D reconstructions from the new low-dose radiation EOS device compared to CT.

Methods: A synthetic scoliotic phantom (T1-L5; 42deg Cobb) was scanned in the upright position using EOS in 0, ±5, ±10deg axial rotation and in the supine position using CT. 3D EOS reconstructions, 2000 points per vertebra body (VB) were superimposed on corresponding CTs. For each VB, shape accuracy was reported as mean and root-mean-square (RMS) error from point-to-surface distances. Global spinal position precision was determined by optimizing the mean vertebral centroid distances for all levels between CT and EOS and reporting resulting RMS. VB orientation accuracy was defined as the max deviation of Lateral-Sagittal-Axial angles based on the VB local reference frames.

Results: Mean EOS shape accuracy was 1.04mm with 95%CI less than 2.75mm. VB, pedicles and posterior arch were modeled equally well. Spinal position and VB orientation accuracy were very high: max RMS was in the AP direction (0.89mm) and max mean (RMS) in lateral rotation was 1.03deg (0.97deg). The only parameter that changed with varying phantom's positioning was AP offset (0.35mm, p=0.016). Accuracy was equally good for all levels (T1-L5) with no systematic error.

Conclusion: EOS provides for accurate 3D representations of the scoliotic spine and can present a low radiation alternative for obtaining accurate spinal measurements for clinical and research purposes.

Significance: The study results will provide orthopedic surgeons with validity evidence pertaining to this new technology for routine clinical diagnosis and patient care.

E-POSTER #232

Surgical Outcome of Adult Idiopathic Scoliosis: Comparison with Adolescent Idiopathic Scoliosis

Se-Il Suk, MD; Jin-Hyok Kim; Sung-Soo Kim, MD; Dong-Ju Lim; Jae-Min Jeon; Seung-Hyun Choi

Republic of Korea

Summary: Adult idiopathic scoliosis patients who underwent deformity correction were compared to adolescent idiopathic patients with similar correction. The radiologic and clinical outcomes were analyzed. Coronal and sagittal correction were similar in two groups, but the adult group had poor clinical outcomes and more complications.

Introduction: Treatment of idiopathic scoliosis with pedicle screw instrumentation is safe and effective in adolescence. However, there have been few reports in adult idiopathic scoliotic patients. The purpose was to compare the surgical outcome of adult idiopathic scoliosis patients and adolescent patients.

Methods: Eighty five idiopathic scoliosis patients (41 adults and 44 adolescents) treated by segmental pedicle screw instrumentation were analyzed retrospectively with a minimum two year follow-up. In a radiologic study, flexion rate, correction rate, sagittal correction and coronal imbalance were analyzed. In the clinical study, blood loss, operative time, hospital stay, and complications were analyzed.

Results: Mean ages were 28.3 years (18~34) in adult and 13.4 years (12~16) in adolescents. The coronal curves were 55.2±9.9° in adults and 51.6±10.3° in adolescents, and corrected to 28.4±11.2° and 21.6±9.1° respectively in passive bending X-rays. As for correction rates, the average coronal curve was corrected to 16.9±7° in adults and 13.6±7.8° in adolescents. The curve correction in passive bending X-ray was higher in adolescents (p=0.05). The surgical curve correction was not different in the two groups (p=0.174).

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ELECTRONIC POSTER ABSTRACTS

There was moderate negative correlation between age and curve correctability in a passive bending X-ray (p=0.006, r=-0.345). There was no significant correlation between age and correction rate (p=0.793). Thoracic hypokyphosis was improved in both groups. Coronal imbalance was improved more significantly in adolescents (p=0.013). Operative time and hospital stay were shorter and blood loss was less in adolescents. As for complications, hemothorax occurred in 14 cases in adults, and 3 cases in adolescent (p=0.126).

Conclusion: Idiopathic scoliosis of adults was corrected effectively with pedicle screws. There was more blood loss, more hemothoraces, longer operative times and hospitalization in the adult group. We conclude that early surgical intervention in idiopathic Scoliosis is important to prevent the need for surgery in adult scoliosis patients.

E-POSTER #233

Trunk Motion Improves over Time after Spinal Fusion for Adolescent Idiopathic Scoliosis

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USA

Summary: Pre- and post-operative measurements in 474 adolescent idiopathic scoliosis patients revealed that post-op flexibility loss ranges from 3-37% at the 1 year time-point; longer fusions exhibited greater flexibility loss and less restoration of motion. Motion improved between 1 & 2 yrs post-operatively: forward flexion improved when the lumbar spine was spared, and lateral bending improved when the thoracic spine was spared. Although functional loss is difficult to quantify, this study documents the trunk flexibility initially lost and subsequently regained.

Introduction: Trunk and spinal motion is lost after spinal fusion. The purpose of this study was to evaluate post-operative changes in trunk flexibility that occur once patients return to unrestricted activity.

Methods: Trunk flexibility measurements were obtained pre-operatively and 1 & 2 years post-operatively on adolescent idiopathic scoliosis patients. Forward flexion (FWD FLX) was assessed via modified Schober's method (the distance between C7 and S1 in upright standing versus maximum flexion). Lateral Flexion (LAT FLX) motion was assessed via fingertip to floor measurement in upright standing versus maximum lateral bending. These techniques exhibit good convergent validity of postoperative motion and lowest instrumented vertebrae. Post-operative motion (expressed as a % of pre-operative motion) was compared across fusion groups of various lengths using an ANOVA (p=0.05).

Results: 474 patients comprised fusion groups: Short Thoracic (STH) fusions (LIV T9-T12), Long Thoracic (LTH) fusions (LIV L1, L2), Thoracolumbar/Lumbar (ThL/L) fusions, Thoracic and Lumbar (TH&L) fusions. Post-op flexibility loss ranged from 3-37%, with longer fusions (TH&L) exhibiting greater initial loss and less motion restoration over time. Flexibility gains exhibit 2 distinct patterns: Increased FWD FLX motion was seen following selective TH fusion, compared to ThL/L fusion ($p<0.05$). Increased LAT FLX motion was seen following ThL/L fusion compared to selective TH fusions ($p<0.05$) (Table 1).

Conclusion: After the first post-operative year, a modest return of spinal motion (0-12%) was seen at the 2 year time-point. The type of motion gained was related to the region of fusion: Lumbar facets lie in the sagittal plane (favoring FWD FLX motion) and when spared (TH fused), FWD FLX improved. Thoracic facets lie in the frontal plane (favoring LAT FLX motion) and when spared (ThL/L fused), LAT FLX improved.

Significance: Post-operative trunk flexibility restoration does occur following spinal fusion and motion type is related to spinal fusion region. Modest gains in trunk motion can be expected between the 1 & 2 yr post-operative time points as patients are allowed to return to unrestricted activity.

E-POSTER #234

Foraminal Dimensions in Adult Patients with Scoliosis and Radiculopathy

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USA

Summary: Sciatic and femoral nerve pain in scoliosis patients is associated with decreased disc space height, foraminal height and foraminal area.

Introduction: Patients with adult degenerative scoliosis frequently present femoral or sciatic nerve pain. Key for surgical planning is correct identification of the origin of this pain. The purpose of this study is to compare the foraminal spaces between scoliosis patients with and without radiculopathy.

Methods: 48 patients divided into 3 groups: B (back pain), S (sciatic pain) and F (femoral pain); Global and regional alignment were measured from standardized radiographs; CT scans were used to measure: Disc space height, foraminal height and foraminal area (Vitrea 3.0 workstation) (figure 1). Lateral olisthesis (Ploumis - Spine 2006). Data is presented as mean±SD. Chi-square, T-test and Pearson's coefficients were calculated; Inter-, intra-observer reproducibility (Cohen's kappa). A $p<0.007$ was considered significant (Bonferroni).

Results: Groups B, S and F were comparable in age, sex, BMI. The SF-36, ODI and VAS were comparable between B and both S and F. Lumbar and fractional curves were comparable. Group F had significantly smaller L2-L3 and L3-L4 disc space height than group B ($p<0.0025$) and group S ($p<0.0005$). Group S had significantly smaller L4-L5 and L5-S1 posterior disc space height than group B or F ($p<0.0001$). Group F had significantly smaller foraminal height and area at L2-L3 and L3-L4 then groups B (p=0.0004) and S (p=0.0051); group S had a significantly smaller foraminal height and area at L4-L5 and L5-S1 than group

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B ($p<0.0001$) and F ($p<0.0001$). Posterior disc space height correlated with foraminal height ($r=0.59$-0.72; $p<0.0001$); Foraminal height correlated with foraminal area ($r=0.68$-0.85; $p<0.0001$).

Conclusion: Patients with Sciatic pain have smaller foraminal height and area at the L4-L5 and L5-S1 levels than patients with back or femoral pain. Patients with Femoral nerve pain have a smaller foraminal height and area at L2-L3 and L3-L4 than patients with back or sciatic pain. Foraminal height and area correlated strongly with posterior disc space height.

Significance: Sciatic and femoral nerve pain in scoliosis patients is associated with decreased disc space height, foraminal height and area. Increasing foraminal height should be a goal of reconstructive surgery in these patients.

Figure 1: Para-sagittal CT-scan with measurements for (1) posterior disc space height; (2) foraminal height; and (3) foraminal area.

E-POSTER #235

The Predictive Value of the Fulcrum Bending Radiograph in Spontaneous Apical Vertebral De-Rotation in Adolescent Idiopathic Scoliosis

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China

Summary: Apical vertebral rotation (AVR) and Cobb angles (CA) were measured in patients suffered from thoracic adolescent idiopathic scoliosis before and after posterior spinal fusion and instrumentation without direct apical de-rotation maneuver. Spontaneous apical vertebral de-rotation occurred with correction of scoliosis deformity. The difference in AVR between fulcrum bending radiograph (FBR) and postoperative assessment was statistically insignificant. This amount of spontaneous apical de-rotation can be predicted with FBR and should be considered when assessing the de-rotational effects with different surgical strategies.

Introduction: Adolescent idiopathic scoliosis (AIS) is a three-dimensional coupling deformity. Various studies have reported vertebral rotational effects with different implant constructs and surgical techniques for AIS. However, none of them have considered the spontaneous coupling effect on vertebral de-rotation produced by correction of coronal deformity, in particular utilizing the predictive capacity of the preoperative fulcrum bending radiograph (FBR).

Methods: Twenty-five Lenke type 1 AIS patients with Cobb angles greater than 45° who underwent posterior spinal fusion with instrumentation, without direct apical de-rotation were prospectively assessed. Cobb angles (CA) and apical vertebral rotations (AVR) in standing, supine and FBR preoperatively, and in supine position postoperatively, were assessed on x-rays and CT scans.

Results: The study entailed 80% females and 20% males (mean age, 15.5 years). The mean CT-based AVR values on preoperative supine, FBR, and postoperative supine were 17.7, 9.8, and 8.1 degrees. The mean AVR degree difference on CT between preoperative FBR and postoperative supine assessment was 1.7 degrees ($p=0.056$). The preoperative FBR approximated a mean 82.7% of postoperative apical vertebral de-rotation. Preoperative supine CT-based AVR was positively correlated with FBR ($r=0.55$; $p=0.011$). The postoperative supine AVR was significantly positively correlated with postoperative CA ($r=0.82$), and negatively correlated with change in curve magnitude ($r=-0.49$), correction rate ($r=-0.83$) and fulcrum bending correction index ($r=-0.45$) ($p<0.05$).

Conclusion: The amount of spontaneous apical vertebral derotation in AIS patients can be predicted with FBR. Such spontaneous de-rotation should be considered when assessing the effects with different implants and surgical strategies.

Significance: Most of the apical vertebral rotation in AIS can be corrected spontaneously with correction of scoliosis deformity. The amount of spontaneous apical de-rotation can be predicted with fulcrum bending radiograph and should be considered when assessing de-rotational effects with different surgical techniques.

E-POSTER #236

Abnormalities Associated with Congenital Scoliosis

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China

Summary: The incidence of intraspinal and extraspinal abnormalities varied based on the investigating methods. Hospital medical records including: physical examination, plain radiograph, whole spine MRI screening , echocardiography, and abdominal ultrasound were reviewed. We found the intraspinal anomalies were present in 39% and extraspinal in 56% of 108 patients with congenital scoliosis. The most common anomalies were diastematomyelia and syringomyelia.

Introduction: The embryonic development of vertebrae is closely related with that of the spinal cord and the organs of the mesoderm. As a result, CS is often associated with intraspinal abnormalities and extraspinal abnormalities. The aim of this study was to assess the overall incidence of intraspinal anomaly and associated extraspinal abnormalities, and to study the associations between the different types of CS and the associated abnormalities

Methods: Between Jan 2005 and Dec 2009, 108 patients with (CS)ongenital scoliosis underwent a fully clinical assessment, plain radiograph, MRI screening of the spine, echocardiography, and abdominal ultrasound. MRIs were read by neuroradiologists. Diagnoses specifically looked for were Chiari malformation, syringomyelia, diastematomyelia, lipoma, intraspinal masses, arachnoid cyst, and tethered cord. All of our 108 patients have undergone surgical correction of the spinal deformity. The average age of these patients at surgery was 14.2 years (range, 8-40 years). The CS was classified as failure of formation, failure of segmentation, and mixed deformity. Pearson 2 test and Fisher test were used to evaluate the incidence of intraspinal anomalies and extraspinal abnormalities

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ELECTRONIC POSTER ABSTRACTS

Results: Intraspinal abnormalities were found in 42 patients (39%). These abnormalities were significantly more common in patients with scoliosis resulting from segmentation defects. Scoliosis patients with lumbar hemivertebrae had more intraspinal abnormalities than those with cervical and thoracic hemivertebrae. Patients with intraspinal abnormality had a higher incidence of positive clinical findings than those with a normal MRI (P=0.402). Other organic defects were found in 60 (56%) patients. Cardiac defects were detected in 20% and urogenital anomalies in 16% of the patients.

Conclusion: The abnormal findings on physical examination are unreliable indicators of intraspinal abnormality. Magnetic resonance imaging and echocardiography are suggested to be an essential part in the preoperative evaluation of patients with CS

Significance: Our study further demonstrated the preoperative invastigation like whole spine MRI screening , echocardiography, and abdominal ultrasound is essential for CS surgery

E-POSTER #237

Failure of Pelvic Fixation after Long Construct Fusions in Adult Deformity Patients; Clinical and Radiographic Risk Factors

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USA

Summary: This study of long construct for adult deformity identified the incidence of pelvic fixation failures and its risk factors. Major failures required revision surgery (rod breakage between L4-S1, failure of S1 screws, and prominence of iliac screws requiring removal). Minor failures included rod breakage between S1-iliac screws and failure of iliac screws. Overall failure occurred 34.3%. The major failure occurred 11.9%, and risk factors were revision surgery, greater pelvic incidence, and failure to adequately restore lumbar lordosis and sagittal balance.

Introduction: Pelvic fixation provides biomechanical support to the base of the long constructs used for adult deformity. However, the failure rate of the pelvic fixation and its risk factors are not well known.

Methods: The retrospective review included 190 adult deformity Pts who had long construct instrumentation (> 6 levels) with iliac screws. Pts' clinical and radiographic data were analyzed. Pts were divided into 2 groups: Failure (F) and Non-Failure (N-F). A minimum 2 year follow up was required for inclusion in N-F. In F, regardless of the failure occurred before or after 2 years, all Pts were included. In both groups, the Pts who needed revisions due to causes other than pelvic fixation failure before 2 yrs were also excluded (e.g. PJK). Failures were defined as Major(M) and minor(m). Major F(M-F) included rod breakage between L4-S1, failure of S1 screws (breakage, halo formation, or pullout), and prominent iliac screws requiring removal. Minor F(m-F) included rod breakage between S1-iliac screws and failure of iliac screws. Minor failures did not require revision surgery. Multiple clinical and radiographic values were compared between M-F and N-F.

Results: Out of 190 Pts, 67 Pts met inclusion criteria and were enrolled. Overall failure rate was 34.3%: 8 Pts in M-F (11.9%) and 15 Pts in m-F (22.4%). M-F occurred at a statistically significant greater rate in those Pts who had revision surgery, greater pelvic incidence (PI), and poor restoration of lumbar lordosis and/or sagittal balance. Pts with a higher number of co-morbidities and preop coronal imbalance showed trends toward an increase in M-F although these trends did not reach statistical significance. Age, sex, body mass index, smoking history, number of fusion segments, fusion grade, and several other radiographic values were not shown to be associated with increased risk of M-F. 87.5% of Pts in M-F and 84.1% of N-F had ant column support (ALIF or TLIF).

Conclusion: The incidence of overall failure was 34.3%, but the clinically significant major failure after pelvic fixation in adult deformity surgery was 11.9%. Risk factors for Major failures are a larger PI, revision surgery, and failure to restore lumbar lordosis and sagittal balance.

E-POSTER #238

Cervical Spinal Cord Dimensions and Clinical Outcomes in Adults with Klippel-Feil Syndrome: A Comparison with Matched Controls

Woojin Cho, MD, PhD; Dong-Ho Lee, MD, PhD; Joshua D. Auerbach, MD; Jennifer K. Sehn, BS; Colin E. Nabb, BS; K. Daniel Riew, MD

USA

Summary: We performed an independent 1: 2 case:control retrospective radiographic and chart review of a consecutive series of adult KFS patients. Contrary to the finding in previous reports on pediatric patients, there were no differences between KFS and well-matched control group in terms of age of onset, presentation, revision rate, complication rates, surgical outcomes, and cross sectional spinal cord and canal dimensions at the operative level. This either suggests that previous reports may have erred or that KFS patients undergo a relative enlargement of the spinal cord as they grow.

Introduction: It has been recently shown that KFS children, compared with age-matched controls, have a significantly smaller cross-sectional spinal cord area. If a similar finding occurs in adults, it may predispose the KFS patient to a lower threshold for neurologic deficit.

Methods: We performed an independent 1: 2 case: control retrospective radiographic and chart review of a consecutive series of adult KFS patients (> 18 years old) who underwent surgical intervention. The control group consisted of a consecutive group of non-KFS surgical patients. Patients were matched in 1:2 case: control manner according to gender and BMI. Their charts were reviewed and the clinical characteristics were compared. Axial T2-weighted MRI was used

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to measure the AP and med-latl axial spinal cord and spinal canal of the operative levels. Spinal cord and canal area were then calculated using the equation of an ellipse: Area (ellipse) = pi x (AP dimension) x (med-lat dimension), a previously validated technique. If there were multiple levels in a patient, the average area of the levels was used for comparison.

Results: A total of 22 KFS and 44 control patients were identified. The most common congenital fusion level was C2-3 followed by C3-4. 27% patients had >1 congenital fusion level. In the KFS population, the surgical level was as follows: 1-level cephalad to the congenital fusion (17%), 1-level caudal to the congenital fusion (66%), in between 2 congenitally-fused areas (17%). The KFS group had a tendency of more myeloradiculopathy, and the control group had a tendency towards more radiculopathy. However, both tendencies were not significantly different. MRIs of 10 KFS and 22 control group were available. There was no difference in the area of both spinal cord and canal at the operative levels.

Conclusion: Contrary to the finding in previous reports on pediatric patients, there were no differences between KFS and well-matched control group in terms of age of onset, presentation, revision rate, complication rates, surgical outcomes, and cross sectional spinal cord and canal dimensions at the operative level.

Significance: This either suggests that previous reports may have erred or that KFS patients undergo a relative enlargement of the spinal cord as they grow.

E-POSTER #239

Does Pedicle Screw Fixation Under Age Five Disrupt Vertebral Growth? A Computerized Tomography Study

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Turkey

Summary: Pedicle screw instrumentation before age 5 does not cause spinal canal narrowing.

Introduction: The influence of pedicle crew fixation below age 5 on canal diameter is controversial. Animal studies consistently demonstrated development of canal stenosis after pedicle screw fixation. However 2 clinical studies from the same center reported normal canal development after pedicle screw fixation in small kids. In both clinical studies analysis were done by indirect x-ray findings or MRI studies which were not the optimum methods to determine the canal area. The aim of this retrospective study was to evaluate the growth of several anatomic landmarks of vertebrae in patients who had pedicle screw instrumentation under age 5 by using Computerized Tomography.

Methods: Thirteen patients (8 female, 5 male) who had been operated due to spinal deformity under age 5 and had preoperative and more than 2 years follow-up CT of operated and adjacent vertebral segments, were included. All patients had congenital scoliosis and underwent hemivertebrectomy and transpedicular fixation one above and one below at an average age of 3 (range; 2 to 4). Measurements were done on CT scans at the instrumented upper (UIV) and lower (LIV) vertebrae as well as the uninstrumented upper (UAV) and lower (LAV) vertebrae. Measurements included; anterior vertebral body height (AVBH), posterior vertebral body height (PVBH), cranial end plate length (CrEPL), caudal end plate length (CaEPL), spinal canal area (SCA), anteroposterior diameter of vertebral body (APD) and lateral diameter of vertebral body (LD). Growth ratio for each parameter was calculated as percentage of change between the preoperative and final follow-up measurements. Statistical analysis was done by using repeated measures of ANOVA to compare the growth ratios in each parameter for each level. A p value of less than 0.05 was set for significance.

Results: The average follow-up was 3.6 (range; 2 to 8) years. Eleven of the patients were over age 5 during the final CT examination while 2 were at age 4. Female to male ratio was 8 to 5. There was no significant differences in growth ratios of all parameters (Table).

Conclusion: This CT study showed that pedicle screw instrumentation before age 5 does not cause spinal canal narrowing.

Significance: -

E-POSTER #240‡

Preoperative Vitamin D Status in Adults Undergoing Spinal Fusion Surgery

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USA

Summary: Serum 25-hydroxyvitamin D levels were measured in 262 consecutive adults undergoing spinal fusion. The prevalence of inadequacy (<32 ng/mL) was 65%. Deficiency (<20) was documented in 27%.

Introduction: Vitamin D plays a pivotal role in mineral homeostasis and bone health. Deficiency in the hormone predisposes to fracture and pseudarthrosis. It can also lead to bone pain and muscle weakness, which may translate into higher VAS, NDI, and ODI scores. To our knowledge, the prevalence of preoperative vitamin D deficiency has yet to be investigated in a dedicated adult spine surgery population.

Methods: Serum 25-hydroxyvitamin D levels were measured prospectively in 262 consecutive adults undergoing spinal fusion at a single institution. There were no initial exclusion criteria.

Results: The mean age and BMI of the population were 55.2±12.9 years and 28.7±5.8 kg/m2, respectively. Of the 262 patients, 55% were female, 94% were white, and 4.6% were black. There were 44% cervical, 38% thoracic, and 53% lumbar fusions. The mean vitamin D level was 28.6±13.0 ng/mL. The overall rates of vitamin D inadequacy (<32) and deficiency (<20) were 65%

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ELECTRONIC POSTER ABSTRACTS

and 27%, respectively. As expected, there were significantly higher rates of obesity (BMI≥30; p=0.025), black race (p=0.005), and smoking (p=0.023) in the vitamin D-inadequate subset. The mean VAS pain score was higher (p=0.024) and neurologic deficits were more prevalent (p=0.094) in this group as well. We generated a composite disability measure by pooling NDI and ODI scores of cervical and thoracolumbar patients, respectively. Upon excluding 57 patients with previous vitamin D or multivitamin supplementation, the mean pooled NDI and ODI score was significantly higher in the inadequate cohort (p=0.003).

Conclusion: Our investigation revealed an alarming high rate of vitamin D abnormality in the analyzed population. While certain previously identified risk factors were confirmed, validated indices of spine-related disability were higher in the presence of hypovitaminosis D.

Significance: Since augmenting serum vitamin D is easy and inexpensive and vitamin D deficiency may predispose to fracture and pseudarthrosis, we advocate vitamin D supplementation in patients with hypovitaminosis D.

Characteristics of Patients with Adequate and Inadequate Vitamin D Levels

E-POSTER #241

Are Oblique Views Valuable in the Diagnosis of Spondylolysis in Children?

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USA

Summary: We compared test characteristics, radiation, and cost between 4-view and 2-view plain film studies in the diagnosis of spondylolysis in children. 4-view studies had no benefit while increasing radiation and cost to patients.

Introduction: The diagnosis of spondylolysis in children is challenging and a subject of continuous debate. Physicians are making efforts to limit radiation exposure. No consensus on the use of plain films has been reached.

Methods: Radiographs of 49 patients with L5 spondylolysis w/out -listhesis and 51 controls were retrospectively reviewed. Our power analysis showed that our study was powered to detect effect sizes of 0.5 of a standard deviation at a type one error rate of 0.05. Controls were confirmed with gold standard (GS) of a negative CT or bone scan. Anteroposterior (AP), lateral, and right and left oblique radiographs of the lumbar spine were randomly presented for diagnosis to 4 pediatric spine surgeons; first with 4 views, then with only AP and lateral. 34 random cases were later repeated for intra-rater agreement calculations. Inter- and intra-rater agreement was assessed with percent overall agreement and intraclass correlation coefficients (ICC). PCXMC software generated effective radiation doses. Study charges are from radiology billing data.

Results: There was no significant difference in test characteristics between 4-view and 2-view plain films in the diagnosis of spondylolysis (See table). Sensitivity, specificity, inter- and intra-rater ICC, and agreement with GS ICC had no statistical difference. Overall agreement for inter- and intra-rater reliability was moderate for both. Percent overall agreement was 79.8% for 4-view and 79.7% for 2-view. Radiation effective dose was 1.26 mSv for 4-view studies and 0.72 mSv for 2-view (=0.54 mSv). 4-view studies charge $147 more than 2-view.

Conclusion: There is no difference in test characteristics between 4-view and 2-view studies. Although oblique views have long been standard practice, our data could not identify a diagnostic benefit that might outweigh the radiation and cost concerns.

Significance: This study supports 2-view plain film use over 4-view for diagnosis of spondylolysis in children.

E-POSTER #242

Pulmonary Function Changes following Posterior Vertebral Column Resection in Pediatric and Adult Spinal Deformity Patients

David Bumpass, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Jeremy J. Stallbaumer, MD; Yongjung J. Kim, MD; Michael J. Wallendorf, PhD; Woo-Kie Min, MD, PhD; Brenda A. Sides, MA

USA

Summary: Pediatric patients undergoing a posterior vertebral column resection for severe deformity demonstrated improvement in postoperative pulmonary function testing, while adult VCR patients did not demonstrate any significant change in PFTs. Pediatric PFT improvement was correlated with both deformity diagnosis as well as previous spinal surgery.

Introduction: Posterior vertebral column resection (PVCR) enables surgical correction of severe spinal deformity via a posterior-only approach, eliminating the need for a combined anterior/posterior (A/P) approach, which is known to have deleterious effects on pulmonary function. To our knowledge, no reports of pulmonary function test (PFT) changes after PVCR surgery are available.

Methods: PFTs in 20 pediatric/18 adult pts who underwent a PVCR at 1 institution were reviewed retrospectively with min 2yr followup (f/u). Mean age at surgery was 29.2yrs (range 8-72), and mean f/u was 2+6yrs (range 2-6). There were 24 females/14 males. Preop diagnoses were severe scoliosis (n=3), kyphoscoliosis (n=19), global kyphosis (n=9) and angular kyphosis (n=7). Thoracic PVCRs (T5-11) were performed in 25pts and thoracoabdominal PVCRs (T12-L5) in 13pts. Immediate preop and postop PFTs were obtained at regular f/u intervals. Comparison was made to PFTs from control groups of pediatric and adult pts who underwent combined A/P fusions for similar deformities.

Results: In pediatric pts, PVCR resulted in an increase of FVC from 2.12 to 2.42L (p=0.008) and FEV1 from 1.72 to 1.96L (p=0.01). However, there were no

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significant differences in % predicted values for FVC (71% to 69%, p=0.68) or FEV1 (66% to 64%, p=0.81). In adult pts, there were no significant changes in FVC (2.47 to 2.45L, p=0.87) or FEV1 (1.99 to 1.94L, p=0.61) after PVCR; also, changes in adult % predicted values for FVC (75% to 74%, p=0.96) and FEV1 (73% to 72%, p=0.86) were not significant. Comparison of changes in PFTs between the PVCR pts and control groups of pediatric and adult pts who underwent combined A/P approach did not reveal significant differences. In the pediatric PVCR pts, improved PFTs correlated with diagnosis (angular kyphosis showed most improvement, p=0.001 for FVC, p=0.0001 for FEV1), as well as with no history of previous surgery (p=0.002 for FEV1).

Conclusion: In pediatric pts, PVCR resulted in a small but significant increase in postop FVC and FEV1. In adult pts, no significant change in PFTs was found. No significant differences in PFTs were seen when comparing PVCR pts to combined A/P pts. Improvement in pediatric PFTs correlated with diagnosis as well as absence of prior spine surgery.

E-POSTER #243

The Reliability of X-Ray Based Evaluation of Pedicle Screw Misplacement in Adolescent Spinal Deformity

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USA

Summary: X-ray-based evaluation of pedicle screw misplacement is severely limited in spine deformity patients and better evaluation methods need to be considered.

Introduction: Post-operative x-rays are routinely used to detect misplaced pedicle screws. Kim, et al. have defined radiographic criteria for evaluation of screw placement in spinal deformity. This study evaluates pedicle screw misplacement on x-ray using these criteria as well as anterior placement on lateral x-ray, and compared them to screw misplacements seen on post-operative CT scan.

Methods: Post-op x-rays and low dose CT scans of 104 adolescent spinal deformity patients who underwent PSF were reviewed. A blinded review of screw placement on x-ray was carried out using Kim et al.'s criteria: 1)violation of the harmonious change; 2)no crossing of medial pedicle wall by screw tip; 3)violation of imaginary midline of the vertebral body. On lateral x-ray, a screw was considered misplaced if: 1) an anterior breach was seen or 2) the length of the screw inside the vertebral body was ≥ 80% of the width of the vertebral body. Kappa analysis was used for overall agreement as well as agreement within specific regions of the curve.

Results: 2087 screws were evaluated on x-ray and CT. CT classified 1820 screws as acceptable, 143 lateral, 30 medial, and 94 anterior. X-ray had 908 acceptable, 304 lateral, 241 medial, and 634 anterior. X-ray correlated with CT Scan in 50% of acceptable screws, 213% of laterally placed screws, 803% of medially placed screws, and in 674% of anteriorly placed screws. X-ray overestimated the number of misplaced screws and had poor reliability for detecting properly placed screws. Overall agreement was 0.08, indicating poor correlation. 53 screws were identified by CT scan as concerning - either breeching the canal or lying adjacent to the aorta. Of these, only 35% were correctly classified on x-ray. Further review of these screws on x-ray was unable to identify any relationship to structures of concern.

Conclusion: X-ray evaluation of screw placement showed poor correlation with CT data. X-rays were found to be inadequate to evaluate screw misplacement or relationship to structures of concern.

Significance: Routine postoperative x-rays have significantly high false positive rates for screw misplacement. The practice of evaluating accuracy on x-ray needs to be examined. Low dose CT scan or intra-op image guidance should be considered.

E-POSTER #244

Night-Time Detorsion Brace for the Treatment of Idiopathic Scoliosis in Children under Six Years Old

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France

Summary: The goal of this radiological study was to determine the efficiency of night-time detorsion brace in children < 6 years old. 30 patients were included, with a mean follow-up of 82 months. Main curve Cobb's angle averaged 33° before treatment, and was reduced to 24°. The overall success rate was 76.5%. In addition, thoracic kyphosis was maintained within normal range in 80% of the cases. Night-time detorsion brace is an effective conservative treatment for progressive scoliosis in young children.

Introduction: Satisfactory results have been recently reported with night-time braces in adolescent idiopathic scoliosis. However, conservative treatment remain challenging in young children. The goal of this study was to determine the efficiency of night-time detorsion brace in the treatment of scoliosis in children younger than 6 years old.

Methods: All patients treated for progressive infantile or juvenile I idiopathic scoliosis, and meeting the following SRS criteria, were included: curves > 25° or > 20° but with a progression > 5° in 6 months, Risser 0 at brace initiation, and brace worn more than 24 months. The brace was worn 8 hours per night and no restriction was given regarding sports activities. Radiological analysis was performed every 6 months using biplanar radiographs (EOS). Three groups were defined at latest follow-up: (1) success (progression < 5°), (2) progression >

ELECTRONIC POSTER ABSTRACTS

5° but not requiring surgery, and (3) failure (surgery or curve progressing to > 45° or interruption of treatment).

Results: Thirty patients were included, with a mean age at referral and brace initiation of 45 months (+/- 20). Mean follow-up was 82 months. The main curve Cobb's angle averaged 33° (+/-13) before treatment, and was reduced to 24° (+/-16) at latest follow-up. The overall success rate was 76.5%. Two patients were in group 2 and 5 were in the failure group. Thoracic kyphosis was maintained within normal range in 80% of the cases.

Conclusion: Night-time detorsion brace is an effective conservative treatment for progressive scoliosis in children under 6 years old. Given the lounger course of treatment compared to adolescent idiopathic scoliosis, it offers potential psychosocial and compliance benefits.

Significance: This is the first study reporting the results of night-time bracing in young children. The success rate is slightly lower than the one reported in adolescents, but is equivalent to previous studies published with full-time brace or casts. In addition, results of conservative treatment on the spinal sagittal balance had never been investigated previously.

E-POSTER #245

Cartilage Biomarkers in Degenerative Lumbar Scoliosis

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Japan

Summary: Serum levels of keratan sulfate, cartilage oligomeric matrix protein (COMP) and procollagen type II C-propeptide (CPII) were significantly higher in degenerative lumbar scoliosis (DLS) patients. There was a significant positive correlation between Cobb angle and CPII in DLS group. This study suggests that synthesis and degradation of type II collagen are promoted in DLS patients which may be related to development and progression of DLS.

Introduction: Degenerative lumbar scoliosis (DLS) develops following degeneration of intervertebral discs and facet joints. Several biomarkers have been used for the evaluation of osteoarthritis of limb joints.

In this study, we assessed the serum cartilage metabolites to evaluate whether they can serve as biomarkers for DLS.

Methods: Thirty DLS patients over 40 years of age (mean 66.0 yrs) with Cobb angle > 10° were included in this study. Mean Cobb angle was 26.5° (11.7 to 62.3°). Fifteen patients with spinal diseases other than deformity (Cobb angle <10°, mean 63.4 yrs) served as controls. Blood samples were collected after obtaining their informed consent.

Serum level of hyaluronic acid (HA) was measured by enzyme-linked binding protein assay, keratan sulfate (KS) by HPLC and cartilage oligomeric matrix protein (COMP), collagen type II cleavage (C2C) and procollagen type II C-propeptide (CPII) with ELISA.

The degree of osteoarthritis change of the lumbar spine was assessed using Kellgren Lawrence grade. The statistical analysis was conducted using unpaired-T test and Mann-Whitney test.

Results: Serum levels of KS (DLS 1.24 ± 0.39 vs. control 0.85 ± 0.35 μg/ml), COMP (DLS 715.2 ± 321.2 vs. control 435.5 ± 158.7 ng/ml) and CPII (DLS 2215.2 ± 822.9 vs. control 1662.3 ± 703.2 ng/ml) were significantly higher in DLS group than the control group. There were no significant differences in serum levels of HA (DLS 59.5 ± 30.2 vs. control 50.5 ± 26.3 ng/ml) or C2C (DLS 223.6 ± 40.8 vs. control 216.0 ± 54.8 ng/ml). There was a significant positive correlation between Cobb angle and CPII in DLS group (R=0.62). Kellgren Lawrence grade of the lumbar spine was significantly higher in DLS group than the control group (DLS 3.5 ± 0.6 vs. control 1.9 ± 0.8), and had significant positive correlation between CPII (R=0.40) and COMP (R=0.32).

Conclusion: This is the first study that evaluated the cartilage biomarkers in DLS patients. This study suggests that synthesis and degradation of type II collagen are promoted in DLS patients as indicated by the increase in serum CPII and COMP, respectively. As type II collagen is a major component of collagens in nucleus polposus and facet joint cartilages, its enhanced turnover may be related to development and progression of DLS.

E-POSTER #246

Readmission Rates after Decompression Surgery for Lumbar Spinal Stenosis Among Medicare Beneficiaries

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USA

Summary: The purpose of this study to calculate readmission and re-operation rates following spine stenosis decompression surgery.

Introduction: Operative management of lumbar spinal stenosis has significant and measurable benefits compared with non-operative care. Revision rates for lumbar decompression have been reported with significant variability.

Methods: This retrospective study of medicare claims data was performed on a 5% randomly selected sample of medicare beneficiaries. A total of 4902 patients had a decompression procedure (ICD-9 procedure code 03.09), and stenosis diagnosis (724.02) with or without fusion from 2005 to 2007 and were followed through 2008. Readmission rates for decompression with fusion, decompression without fusion and spine injections were calculated using Kaplan-Meier censoring for death and de-enrollment.

Results: The overall rate of readmission was 7.7%, 13.9%, 18.8% at 1,2 and 3 years after index operation. Rates of readmission for patients who underwent

fusion with spine decompression were slightly higher after one year than patients who underwent decompression alone [7.4% for without fusion vs. 8.8% with fusion]. However, the difference was not significant-P=0.293. Patients receiving decompression with fusion were more likely female [58% vs. 42%, P<0.0001] and slightly younger. Procedures performed during readmission were similar for the fusion and no fusion cohorts: fusion was performed in 58%, decompression without fusion in 21% and injection in 21%. Of readmitted patients, 16% had multiple readmissions.

Conclusion: Re-operation rates for spinal stenosis decompression were approximately 6-7% per year. Fusion at the index procedure did not protect against subsequent readmission. Revision surgeries included revision decompression, revision decompression with fusion, and injection procedures.

Significance: Large databases can inform choice of surgical options by focusing examination on indications for surgery and reasons for readmission.

E-POSTER #247

Is Pre-Operative PFT Assessment Worthwhile in SK?

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Summary: Assessment of pulmonary function in pre-operative Scheuermann's Kyphosis patients has not been routine. No study has prospectively assessed the impact of SK on pulmonary function in an operative cohort. Decline in %FVC was noted for greatest Cobb kyphosis ≧ 90 degrees. Pulmonary function testing should be performed selectively in these patients.

Introduction: There is a paucity of data on pulmonary function associated with severe Scheuermann's kyphosis. One study performed decades ago has shown diminished vital capacity for the most severe cases in a retrospective natural history analysis of SK patients. Assessment of pulmonary function, pre-operatively in Scheuermann's kyphosis (SK) has not been the standard of care. The purpose of this study is to define the impact of SK on pulmonary function in pre-operative patients.

Methods: Pulmonary function testing including absolute and percent predicted forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1) and total lung capacity (TLC), were assessed in 56 patients enrolled in a prospective longitudinal study on operative Scheuermann's kyphosis patients up to age 25. Analysis included impact of kyphosis apex (T vs TL) and magnitude on pulmonary function. ANOVA and Pearson's correlations were utilized to compare the groups.

Results: Mean age was 16.29 years and 35.7% were female. FEV, % FVC and TLC predicted were significantly higher in males ($p<0.05$). There was no difference in pulmonary function based on apex location. Percent predicted FVC and absolute value TLC, negatively correlated with Greatest Cobb Angle. Decline of % FVC to ≦ 80% of predicted occurs as greatest Cobb kyphosis reaches 89° or greater. (Figure 1)

Conclusion: Pulmonary function in operative Scheuermann's Kyphosis has been studied for the first time in a prospective fashion. Significant decline in vital capacity is found for kyphosis magnitude over 90°. Pulmonary function testing should be performed selectively in this patient population.

Significance: Pulmonary function has been analyzed and defined prospectively in the SK population for the first time.

E-POSTER #248

Pulmonary Function Comparison following Adult Spinal Deformity Surgery: Minimum Two-Year Follow-Up

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USA

Summary: Pulmonary function tests were evaluated in 120 consecutive adult spinal deformity surgery patients with 2 year-minimum follow-up. Age, smoking history and surgical approach did not affect results. Revision patients declined more than primary, FEV1% (-10.4 vs. -1.95, P=0.003) FVC% (-9.97 vs. 2.28, P=0.009). Age associated declines in PFTs were exacerbated by revision surgery.

Introduction: The purpose of this study was to prospectively analyze pulmonary function tests (PFTs) in adult spinal deformity surgery pts to identify variables (approach, diagnosis, operative, demographic) that influence PFTs in this population.

Methods: PFTs were evaluated in 120 consecutive adult spinal deformity (ASD) pts, ≥age 18, at one institution with minimum 2yr F/U (ave 2.35, range 2.0-4.7yrs). Preop (PRE) and F/U forced expiratory volume in one second (FEV1), % predicted FEV1 (FEV%), forced vital capacity (FVC), % predicted FVC (FVC%) and thoracic Cobb angles (47.3° PRE) were recorded. Age (avg. 47.0, range 18-73), sex (93% female), smoking history (12%), primary (71 pts/59%) vs revision (rev) (49/41%) procedures, surgical approach and diagnoses were documented PRE. Surgical approach was divided into posterior (94 pts), anterior/posterior (23 pts) (1 thoracotomy, 7 thoracoabdominal, 16 retroperitoneal/paramedian) and anterior alone (3 pts) (2 thoracoabdominal and 1 thoracotomy). Diagnoses: adult idiopathic scoliosis (AdIS) (61 pts, 15% rev); fixed sagittal imbalance (FSI) (30 pts, 93% rev); thoracic hyperkyphosis (THK) (19 pts, 47% rev); degenerative scoliosis (DS) (10 pts, 30% rev).

Results: PRE: Younger age positively affected FEV1 (P<0.001) and FVC (P=0.001). PRE to F/U: FEV% (-5.39±14.5, P<0.001) and FVC% (-5.42±14.8, P<0.001) decreased across entire group. Revision pts declined

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ELECTRONIC POSTER ABSTRACTS

more than primary, FEV% (-10.4 vs -1.95, P=0.003), FVC% (-9.97 vs -2.28, P=0.009). FEV% and FVC% were not affected by age (P=0.795, 0.916), sex (P=0.387, 0.601), smoking history (P=0.978, 0.677) approach (P=0.917, 0.972) or thoracic levels fused (P=0.577, 0.762). AdIS decreased less (FEV% -1.62 vs -9.28, P=0.001) (FVC%-1.93 vs -9.02, P=0.032) and FSI decreased more (FEV% -10.5 vs -3.68, P=0.015). In primary pts, increasing AP thoracic Cobb correction positively affected FEV% (P=0.0130) and FVC % (P=0.0062).

Conclusion: Contrary to the AIS population, pulmonary function decreased following operative intervention for ASD. Age, smoking history and surgical approach did not affect the results. However, in primary patients, increased thoracic coronal Cobb correction did improve all PFT parameters. The general age decline in PFTs was exacerbated by revision surgery.

E-POSTER #249

Comparison Between Posterior-Only Correction and Combined Anterior/ Posterior Fusion for Severe Scheuermann's Kyphosis

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Japan

Summary: In a comparison of 35 patients treated with posterior-only segmental pedicle screw constructs and posterior osteotomies vs 27 patients treated with anterior/posterior approach for severe (>75° kyphosis) and stiff (>50° max residual kyphosis on hyperextension) Scheuermann's kyphosis patients, we found similar radiographic correction but less blood loss, OR time and complications in the posterior-only group.

Introduction: The purpose of this study was to compare the surgical results of posterior-only treatment with segmental thoracic pedicle screw constructs (Group 1) versus combined anterior/posterior fusion (Group 2) in the treatment of severe Scheuermann's kyphosis.

Methods: We investigated 62 patients (Group 1 n=35, Group 2 n=27) who were followed for a minimum of 2 years. Patients were selected based on preoperative kyphosis >75° and >50° of maximal hyperextension residual kyphosis using a bolster. The mean age was 18.1 years and 20.0 years, respectively. The deformity was measured by Cobb angles preoperatively, postoperatively and at final follow-up, preoperative maximal hyperextension, and percent correction loss at final follow-up. Operative time, blood loss and complications were also recorded.

Results: The average preoperative kyphosis was 88.8° (Group 1) vs 91.0° (Group 2) (p>0.05), and the preoperative hyperextension residual Cobb angle was 57.6° vs 65.0° (p<0.01). Initial postoperative kyphosis was 52.4° vs 54.3° (p>0.05) and final postoperative kyphosis was 52.7° vs 55.1° (p>0.05) respectively. The average correction loss at final follow-up was 1.3% in Group 1, 2.7% in Group 2 (p>0.05). The average operative time was 410 min vs 623 min (p<0.01), and the average blood loss was 1056cc vs 1515cc (p<0.01), respectively. Complications occurred in 8 (23%) vs 12 patients (44%), respectively (p<0.01). The most frequent complications were instrumentation failure and junctional kyphosis for each group.

Conclusion: A similar correction and maintenance of correction can be achieved by a posterior-only thoracic pedicle screw approach versus a combined anterior/ posterior approach with the added benefits of less operative time, blood loss, and complications for the treatment of severe and stiff Scheuermann's kyphosis.

E-POSTER #250

The Prevalence of Abnormal Preoperative Neurologic Exam in Scheuermann's Kyphosis: Correlation with X-Ray, MRI, and Surgical Outcome

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USA

Summary: The prevalence of abnormal neurologic exam was 9% in primary operative Scheuermann's kyphosis patients. No x-ray findings correlated with the abnormal preop neurologic exam. A normal MRI can be found with an abnormal neurologic exam, and a normal exam can also be seen with an abnormal MRI. Corrective surgery was beneficial in improving neurologic symptoms.

Introduction: There have been sporadic reports about abnormal neurologic findings in Scheuermann's kyphosis pts. The purpose of this study was to report the prevalence of abnormal neurologic findings detected by physical exam in Scheuermann's kyphosis, and to correlate it to x-rays, MRI findings and results of operative treatment.

Methods: Among 82 Scheuermann's kyphosis pts who underwent corrective surgery, 69 primary cases were selected. Patient charts were reviewed retrospectively in terms of pre and postop neurological exams. Sensory or motor change was defined as an abnormal neurologic exam. Their duration, associated problems, and various parameters on preop x-rays and MRI exams were also measured to search for any atypical findings associated with an abnormal neurologic exam.

Results: There were 6 cases (9%) (Group AbN) with an abnormal neurologic exam ranging from severe myelopathy to a subtle change (e.g. sensory paresthesias on trunk). 5 pts recovered to a normal neurologic exam after corrective surgery. The remaining 1 severe myelopathic pt also showed marked improvement and was ambulatory unassisted by 2yr follow-up. In pts with a normal neurologic exam (Group N, n=63), only 1 pt had neurologic sequelae due to ant spinal artery syndrome after combined A/P correction. No preop

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x-ray parameters were significantly different between groups. Ave age was 21.3 (AbN) and 18.6 (N) yrs (P=0.55). Ave preop T5-12 kyphosis was 69.0° (AbN) and 72.5° (N) (P=0.61). 42 MRIs were obtained, all showed typical findings of Scheuermann's kyphosis. In abN, 5 pts had MRI (1 had a CT/myelo) and in 37 in N.

Conclusion: The prevalence of abnormal neurology in Scheuermann's kyphosis was 9%, emphasizing the importance of detailed preop neurologic exam. If congenital stenosis or herniated thoracic disc is combined, myelopathy can occur. No x-ray findings correlated with the abnormal preop neurologic exam. A normal MRI can exist in the face of an abnormal neurologic exam, and conversely, a normal neurologic exam can be seen with an abnormal MRI as well. Surgery was successful in alleviating abnormal neurologic issues.

Significance: Deformity surgeons who correct Scheuermann's kyphosis should rule out neurologic issues preoperatively.

E-POSTER #251‡

The Effect of Spinal Fusion on Life Expectancy for Patients With Profound Cerebral Palsy

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USA

Summary: In this long term follow-up case controlled study, patients with scoliosis and cerebral palsy who underwent instrumented spinal fusion had improved life expectancy over those treated non-operatively.

Introduction: For decades spine surgeons and others who care for patients with cerebral palsy and scoliosis have been trying to obtain evidence that spine fusion helps these children. There is little agreement that we are able to improve spinal balance and reduce curve magnitudes but there is scant evidence that this improves the many other factors involved in the care of these patients, including life expectancy.

Methods: Thirty-seven subjects were identified from a homogeneous cohort of patients identified and reported on in 1994. Subjects had scoliosis, greater then 50° or previous spinal fusion and profound cerebral palsy, GMFCS Level V. Two groups were identified, those that underwent instrumented spinal fusion and those treated non-operatively. Medical records were reviewed. Statistical analysis included Chi square and relative risk assessment, and Cox Hazard ratio and Kaplan-Meier survival.

Results: 100% follow-up was obtained. Fifteen were currently residing at the same institution, l3 moved to local residences and 19 died. The overall mortality rate of this cohort was 51%. In the non-fused group maximal coronal curve measured 76°, in the fused group, pre-operative maximal coronal curve measured 69°, post-operative curve measured 34°(ns). In the non-fused group: 8 (40%) of subjects were living, mean age 23.4 years; 12 (60%) had died, mean age 35.9 years. In this group, 6 (50%) of the deaths were due to pulmonary complications.

In the fused group: 10 (59%) of the subjects were living, mean age 25.1 years; 4 (41%) had died, mean age 37.2 years. In this group, 3 (37%) of deaths were due to pulmonary complications.

Age weighted Chi square analysis of these two groups noted a significant difference with respect to death ($p<0.0001$). Risk difference assessment noted an 18.8% improvement in survival following spinal fusion, with and Odds ratio of 2.1. Kaplan-Meier and Cox Hazard analysis also demonstrated an improvement in survival in those who underwent fusion (Hazard ratio of 0.572) (figure 1).

Conclusion: In profoundly involved patients with CP and severe scoliosis, spinal fusion improves life expectancy.

Significance: This study provides further support for the surgical management of severe spinal deformity in this high-risk population.

E-POSTER #252

Spondylolisthesis, Sacro-Pelvic Morphology and Orientation in Young Gymnasts

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Canada

Summary: We assessed sacro-pelvic morphology and orientation in a population of 92 gymnasts, including 6 subjects presenting spondylolisthesis. Weekly training hours, as well as sacro-pelvic orientation and morphology were different between gymnasts with and without spondylolisthesis.

Introduction: Sacro-pelvic morphology and orientation in gymnasts and their relationship with spondylolisthesis have never been analyzed. The purpose of this study was therefore to evaluate the prevalence of spondylolisthesis in a cohort of gymnasts, from all age groups (under 21), with similar environmental risk factors, regardless of symptoms of low back pain, as well as the associated demographic characteristics and sacro-pelvic morphology and orientation.

Methods: Radiological evaluation of 92 gymnasts was performed to identify spondylolisthesis, and to measure pelvic incidence, pelvic tilt, sacral slope and sacral table angle. Different demographic and training characteristics were evaluated. Radiographic parameters were compared with reference values published for asymptomatic children and adolescents, and for subjects with spondylolisthesis. The level of significance was set to 0.05.

Results: A 6.5 % prevalence of spondylolisthesis was found in our cohort. The weekly training schedule was the only statistically significant different demographic characteristic between subjects with and without spondylolisthesis. Pelvic incidence, pelvic tilt, sacral slope and sacral table angle were respectively

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69±20°, 15±13°, 54±11° and 88±7° in gymnasts with spondylolisthesis, and 53±11°, 10±6°, 43±9° and 94±6° in gymnasts without spondylolisthesis. When compared to asymptomatic individuals, pelvic incidence and pelvic tilt were slightly increased in gymnasts without spondylolisthesis. Pelvic incidence, sacral slope and sacral table angle were significantly different between gymnasts with and without spondylolisthesis.

Conclusion: The prevalence of spondylolisthesis in young gymnasts was similar to that observed in the general population. This prevalence is lower than that reported in previous studies, presumably due to modified training methods related to the awareness of potential risks for spondylolisthesis in the two centers involved in this study. Sagittal sacropelvic morphology and orientation was abnormal in gymnasts with spondylolisthesis. Sagittal sacropelvic morphology and orientation was also slightly different in gymnasts without spondylolisthesis when compared to the normal population.

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TRADITIONAL POSTER ABSTRACTS

POSTER #301‡

The Lonstein-Carlson Progression Factor Does Not Predict Scoliosis Curve Progression in a Replication Study

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USA

Summary: The Lonstein-Carlson Progression Factor does not predict scoliosis curve progression in an independent replication study>

Introduction: A risk of progression model for adolescent idiopathic scoliosis (AIS) was created in pivotal research by Lonstein and Carlson (L-C) in 1984. This study suggested a formula and nomogram for risk of progression in AIS curves 20-29o in those who were skeletally immature using Risser sign, chronologic age and Cobb angle as inputs. To our knowledge, the formula and nomogram have not been formally evaluated in a second cohort of AIS patients. Our objective was to test the performance of the L-C model in an independent population.

Methods: Using the same methods as the original study, we compared the L-C study of 268 patients with 315 similar AIS patients drawn from a wide distribution in North America. We calculated the progression factor versus the incidence of progression as defined in the original L-C study.

Results: The demographic and clinical features of the L-C cohort and the present study cohort were not statistically different. As shown in the plot below, there was little correlation between the progression score and the observed risk of progression (R=0.24).

Conclusion: This replication study shows that the L-C Progression Factor model is not generalizable. Furthermore, any algorithm that relies so heavily on the Cobb angle is not truly predicting the risk of progression, rather it is an observation of how much progression has already occurred.

Significance: The L-C study used rigorous and state-of-the-art methods, but widespread use (and some misuse) of the data have occurred prior to any validation and replication studies. It is clear that biomarkers other than Risser sign, age and Cobb angle are necessary to provide more accurate parameters for calculating a risk of progression.

POSTER #302

Pulmonary Function after Costoplasty in Adolescent Idiopathic Scoliosis - A Multi-Center Study

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USA

Summary: Costoplasty has been considered effective in improving rib-cage deformity in scoliosis patients. Based on limited data, there are concerns regarding its adverse effects on pulmonary functions. Our multicenter study reaffirms these concerns. We found statistically significant reduction of percent predicted values of various lung function parameters at one and two years post-surgery. Furthermore, the percentage of patients having clinically significant reduction in various lung function parameters is significantly greater in costoplasty group.

Introduction: Costoplasty is a very effective tool to improve rib-cage asymmetry in patients with Adolescent Idiopathic Scoliosis (AIS). Limited data suggest that it adversely affects pulmonary function. The goal of the current multicenter study is to evaluate the effects of costoplasty on pulmonary function tests (PFTs) in AIS at 1 and 2 years post-surgery.

Methods: In this retrospective study, patients with a diagnosis of AIS who underwent posterior spinal fusion (PSF) with costoplasty between 1996 and 2008 from 6 centers were included as study group. The patients having PSF without costoplasty were controls. Patients with anterior procedures were excluded. The groups were matched for the pre-operative (Pre0) curve-measure, rib-hump and baseline lung function. Percentage of predicted value for Forced Expiratory Volume in the first second (%FEV1), Forced Vital Capacity (%FVC) and Total Lung Capacity (%TLC) at Pre0, 1 year post-operative (P01) and 2 years post-operative (P02) visits were studied. Reduction >10% from baseline of any parameters is considered clinically significant. P<0.05 was considered statistically significant.

Results: 27 patients were included in study group, 136 in the control. Values of PFT parameters are reported in figure. Mixed ANOVA test was used to analyze results. At P01, statistically significant reduction in %FEV1 (p=0.006) and %FVC (p=0.03) were seen. At P02, statistically significant reduction in % FEV1, %FVC and %TLC (p=0.004, 0.009, 0.009 respectively) were noticed.

Greater percentage of patients in costoplasty group compared to control showed clinically significant (>10% decrease) in %FEV(47% vs 25% p=0.04) and %FVC(58% vs 30% p=0.025) at P01 (Fischers exact test). At P02, clinically significant reduction persisted only in %FEV1(47% vs 20% p=0.016) but not %FVC(47% vs 30% p=0.09). Reduction of %TLC was found to be significant at P02 (53% vs 20% p=0.01).

Conclusion: Reduction in %FEV1 and %TLC in lung function following costoplasty are statistically and clinically significant even at 2 years post-surgery. %FVC reduction is clinically and statistically significant at first year but loses clinical significance at second year.

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TRADITIONAL POSTER ABSTRACTS

POSTER #303

Treatment of Lenke 1 AIS Curves: Where to Stop Proximally and How does it Affect Shoulder Balance? Comparison of Selective vs. Non-Selective Thoracic Fusions

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USA

Summary: A retrospective radiographic evaluation of Lenke 1 Adolescent Idiopathic Scoliosis (AIS) pts treated with fusion and pedicle screw fixation demonstrated no differences in proximal thoracic (PT) curve correction or shoulder symmetry when the fusion did not include the flexible non-structural proximal thoracic curve. Instrumentation of proximal thoracic curves in the treatment of Lenke 1 AIS pts may not be indicated.

Introduction: Shoulder symmetry is an important factor to consider in surgery for AIS. Many surgeons currently fuse flexible PT curves in an effort to obtain improve shoulder balance. This study investigated the need to include or exclude the PT curve in Lenke 1 pts with the hypothesis that no difference would be present with respect to shoulder symmetry.

Methods: A retrospective review of 148 consecutive AIS pts treated with fusion was performed. 22 pts met inclusion criteria of Lenke 1 curve type, posterior pedicle screw fixation, and 2-yr f/u. The 22 pts were divided into 2 groups: Group 1 (n=9) included those who were fused to the upper end vertebra or one level higher. Group 2 (n=13) included those fused 2 or 3 levels proximal to the upper end vertebra. Radiographic measurements including PT, main thoracic (MT), T1 tilt, clavicle angle (CA) and shoulder height difference (SHD) were performed for each patient at preop, 6 wk and final f/u.

Results: The avg age in both groups was 14 yrs (10-17yrs). The avg f/u in Group 1 was 28 mos (24-36mos) and 30 mos (24-47mos) in Group 2. There was no difference between the 2 groups in preop angles for MT (p=0.77), T1 tilt (p=0.25), CA (p=0.54), and SHD (p=0.22). Preop PT curves averaged 19.6 deg (12-28deg) in Group 1 and 28.3 deg (14-41deg) in Group 2 (p=0.02). Preop PT curve flexibility averaged 35% (range 21-61) in Group 1 and 50% (range 14-73) in Group 2 (p=0.04). Postop, no significant differences were seen in PT (p=0.21) or MT (p=0.06) curve correction or changes in T1 tilt (p=0.44) or SHD (p=0.19). Changes in CA averaged 4.1 deg in Group 1 and 2.1 deg in Group 2 (p=0.02).

Conclusion: While Group 2 had larger preop PT curves, these curves were also much more flexible. No significant differences were seen in either group with respect to postop measures of T1 tilt or SHD. Increased changes in CA were seen in Group 1.

Significance: This study indicates that there is no benefit to incorporating the PT curve in the surgical Lenke 1 AIS pts. This can potentially avoid the increased implant cost, neurologic risk, and operative time required to extend instrumentation proximally.

POSTER #304

Using the Adolescent Idiopathic Scoliosis Prognostic Test (AIS-PT) to Predict Progression to Moderate Curves in Patients with a Mild Curve

James W. Ogilvie, MD; Lesa M. Nelson, BS; Kenneth Ward, MD

USA

Summary: In mild AIS with a low risk AIS-PT score the risk progression to a Cobb >30 degrees correlates with the score.

Introduction: We recently validated a panel of DNA markers to predict a low risk of progression to severe (surgical) Cobb angles in adolescent idiopathic scoliosis (AIS). Roughly 75% of patients with mild AIS are identified as "low risk" by the AIS prognostic test (AIS-PT). As a group, low risk patients have a less than 1% probability of progressing to a severe curve. The purpose of this study was to determine whether the same AIS-PT can also predict the risk of progression to a significant moderate curve (>30o) in low risk patients (score <50 on a scale of 1-200).

Methods: We combined data from four recent AIS-PT validation trials and examined Cobb angles at skeletal maturity in patients with an AIS-PT score of 1 to 50. Skeletal maturity was defined as being 16 years of age or being two years post menarche and Risser 4-5. AIS-PT scores are based on genotypes for 53 genetic markers and the patient's presenting Cobb angle.

Results: Data for 628 Caucasian subjects are expressed in the Table below by score quintiles. 20% of patients had risk scores of 1-6. None of these patients progressed to a severe curve, while 1.5% did progress to a Cobb angle greater than 30 degrees. The risk of progressing to a curve over 30 degree increased with increasing AIS-PT scores.

Conclusion: Although the current algorithm was not designed for this purpose, a clear gradation of risk is seen with increasing scores.

Significance: The need for surgical fusion is only one of several important outcomes in scoliosis management; most patients are concerned about the cosmetic and potential functional implication of moderate curves. Future enhancements to the AIS-PT predictive makers and algorithms might allow more precise predictions and further improve the clinical usefulness of the genetic testing.

‡ Goldstein Award Nominee for Best Clinical Poster or E-Poster Ω Moe Award Nominee for Best Basic Science Poster or E-Poster

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TRADITIONAL POSTER ABSTRACTS

POSTER #305

Establishing Parameters for T12 as the Lowest Instrumented Vertebra (LIV) in Selective Thoracic Fusions

Jahangir Asghar, MD; Harry L. Shufflebarger, MD; Dianna C. Morales, BA; Tracey Bastrom, MA

USA

Summary: This study reviews parameters for choosing T12 as LIV, and compares a single surgeon's outcomes where T12 was LIV versus a matched cohort. In selective thoracic fusion of Lenke 1 and 2 curves with segmental pedicle screw constructs, T12 is an excellent choice for LIV. Contrary to classical teaching, T12 is an acceptable LIV in the absence of pre-operative thoraco-lumbar kyphosis and when T12 is touched by the CSVL.

Introduction: Classical teaching holds that T12 as LIV has a higher risk of balance complications than more distal levels. Conversely, T12 is often the stable vertebrate and appropriate distal level of instrumentation for selective thoracic fusions. This study reviews parameters for choosing T12 as LIV, and compares a single surgeon's outcomes where T12 was LIV versus a matched cohort.

Methods: Using a prospective multi-center database, 20 patients with AIS surgically treated by the senior author, T12 as LIV, and minimum 2 years follow-up were reviewed. A 1:1 matched cohort was created based on Lenke curve type, lumbar modifier, stable vertebrate, and a curve magnitude within 7°. However, the LIV for the matched cohort was a level other than T12. Segmental pedicle screws were employed in both groups.

Results: 75% of the matched cohort was fused to lumbar spine, and the median LIV was L1 at 35% (See Graph). No statistically different differences were noted between the two groups in thoracic and lumbar curve correction, thoracic kyphosis, or lumbar lordosis. Furthermore, There was no significant difference in the change of distal junctional kyphosis measurements. The incidence of distal junctional kyphosis (>10°) was, also, similar. No statistical differences in C7-CSVL, LIV translation, or disc angulation below LIV were noted. There was a statistically significant difference ($p>0.05$) in LIV angulation with the matched cohort at 3.05° and the T12 group at 7.85°. However, the pre-operative LIV angulation and change in LIV angulation was significantly larger in the T12 group ($p>0.05$).

Conclusion: In selective thoracic fusion of Lenke 1 and 2 curves with segmental pedicle screw constructs, Thoracic 12 is an excellent choice for LIV. The thoracolumbar junction (T10-L2) should have no kyphosis. Thoracic 12 should be touched by the CSVL. Excellent correction of both curves and coronal and sagittal balance is predictable.

Significance: Contrary to classical teaching, T12 is an acceptable LIV in the absence of pre-operative thoraco-lumbar kyphosis and when T12 is touched by the CSVL

POSTER #306

Lateral Approach for Interbody Fusion (LIF) is a Safe and Effective Technique to Reconstruct the Anterior Spinal Column in Complex Adult Spinal Deformity: A Minimum Two-Year Follow-Up Study

Behrooz A. Akbarnia, MD; Gregory M. Mundis, MD; Ramin Bagheri, MD; Nima Kabirian, MD; Pooria Salari, MD; Jeff Pawelek

USA

Summary: Sixteen adult patients with an average scoliosis of 47° were treated with anterior interbody release and spinal fusion via a less invasive lateral approach (LIF). While there were predictable perioperative sequelae, there was significant (64%) improvement of curve magnitude ($p<0.05$) and various improved clinical outcome measures were observed (VAS 62%, ODI 60% and SRS-22, 46%) at latest follow-up ($p<0.05$). Average segmental coronal and sagittal Cobb also showed significant improvements ($p<0.05$).

Introduction: Anterior reconstruction of the spine is a widely accepted approach in adult deformity to improve fusion rate and achieve coronal and sagittal correction. We present our experience using less invasive far lateral retroperitoneal/transpsoas approach (LIF) to achieve these goals.

Methods: Adult patients who underwent LIF as part of their primary treatment of scoliosis (Cobb ≥30°) and had minimum 2-year follow up were retrospectively reviewed. Of 62 patients, 16 met the inclusion criteria. Clinical, radiographic and outcome instrument data were analyzed.

Results: There were 15 females and 1 male. Mean age was 56 yrs (23-84), 7 had idiopathic and 9 had degenerative scoliosis. Mean co-morbidities were 2.6 per patient. Scoliosis improved from 47° to 17° (64%), the coronal L4 tilt corrected from 23° to 9.6° ($p<0.05$). Segmental coronal and sagittal deformities (Table) were also significantly improved ($p<0.05$) and segmental sagittal deformity improved to historic norms ($p>0.05$). Coronal segmental correction was greatest at T12-L1. Changes in global sagittal and coronal balances and lordosis (L1-S1) were not significant. Five of 16 (31%) developed a total of 8 complications associated with LIF: 3 had abdominal wall weakness, 3 with post-op quadriceps weakness, 1 anterior cage dislodgment requiring revision, and 1 pleural effusion requiring a chest tube. All patients regained quadriceps function within 6 months. Nine of 16 (56%) experienced anterior thigh numbness (2 still present at latest FU) and 8/16 (50%) had anterior thigh pain for at least 4 weeks post-op. All outcome measurements improved from pre-op to final follow-up ($p<0.05$): VAS (6.5 to2.5), ODI (60 to 24) and SRS-22 (2.6 to 3.8).

Conclusion: Conclusion: LIF is a safe, effective and less invasive alternative to open anterior approach for adult scoliosis. Patients with advanced spinal deformities should be made aware of the high likelihood of post-op thigh numbness, pain and/or transient weakness as sequelae of this approach.

‡ Goldstein Award Nominee for Best Clinical Poster or E-Poster Ω Moe Award Nominee for Best Basic Science Poster or E-Poster

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TRADITIONAL POSTER ABSTRACTS

POSTER #307

Posterior Decompression and Instrumented Fusion for Management of Degenerative Lumbar Scoliosis

Jun Young Yang, MD, PhD; Yong Bum Joo; Soo Min Cha; June Kyu Lee

Republic of Korea

Summary: To analyze the clinical results of posterior decompression and instrumented fusion of degenerative lumbar scoliosis and to inspect the causes and the consequences of failed treatment.

Introduction: Authors studied the revised surgery cases and compared the just one operation cases, the the difference of findings of radiology, the clinical outcomes in degenerative lumbar scoliosis.

Methods: 123 cases that underwent posterior decompression and instrumented fusion for degenerative lumbar scoliosis from March 1998 to July 2007 were selected for the study. The cases were divided into group A, 90 cases that did not underwent re-operation, and group B, 33 cases that underwent re-operation, and for the inspection of postoperative clinical results, leg and back pain score, VAS score, Oswestry disability index(ODI), and SF-36 were used, and clinical satisfaction was evaluated using Korkaldy-Willis criteria.

Results: Leg pain score decreased 92% in group A and 71% in group B(p=0.032), back pain score decreased 79% in group A and 70% in group B(p=0.064), and postoperative VAS score decreased 5 points in group A and 4.1 points in group B on average(p=0.045). The duration of the use of analgesics was 3 months after operation in group A and 8 months after operation in group B on average. Patients were satisfied in 78% of group A and 54% in group B(p=0.028), postoperative ODI was 7.8 in group A and 13.3 in group B on average, and postoperative SF-36 was 44 in group A and 37 in group B(=0.043). The causes of re-operation include progressive junctional kyphosis in 9 cases, failure in distal portion in 15 cases, metal damage in 3 cases, infection in 3cases and neurologic defect in 3 cases. Among these cases, the 9 cases that had progressive junctional kyphosis all underwent proximal fixation confined on L1-2.

Conclusion: The posterior decompression and instrumented fixation for degenerative lumbar scoliosis showed good results in terms of leg and back pain and clinical satisfaction overall, and group that underwent re-operation showed poorer clinical results compared to the group that did not underwent re-operation. The causes of the re-operation were various, and among them, the progressive junctional kyphosis was thought to be related to the extent of fusion of proximal portion, thus, could be lessened by fixing the thoracolumbar region.

POSTER #308

Correction of Neglected Congenital Spinal Deformities Associated With Intraspinal Anomalies. Is it Safe?

Yasser ElMiligui, MD, FRCS; Wael Koptan, MD; Mohammad M. El-Sharkawi, MD; AbdElMohsen Arafa; Mohamed O. Ramadan, MD, MSc

Egypt

Summary: Twenty patients with congenital spine deformities associated with intraspinal anomalies had concomitant surgical treatment of both pathologies. Correction was done through a posterior approach, up to total hemivertebrectomy if needed, using hybrid instrumentation. Patients were followed up for an average of 4.5 y (range 2 - 6 y) and achieved satisfactory clinical and radiographic outcome in both sagittal and coronal planes.

Introduction: The incidence of intraspinal anomalies associated with congenital spinal deformities is almost 30%. These anomalies were usually surgically managed first followed on an average of 3 months latter by correction of the congenital spinal deformity. As very few reports focused on managing patients with such challenging problems, we aimed to evaluate the outcome of concurrent surgical management for both pathologies.

Methods: This is a prospective study performed between 2002 and 2008. It included 20 patients, 13 females and 7 males, with an average age of 14.5y (range 10 - 19y). Fifteen patients had a hemivertebra, 3 had a block vertebra and 2 had mixed anomalies. All patients had a posterior correction +/- total hemivertebrectomy and hybrid instrumented fusion. The first six patients had an isolated tethered cord that was separately untethered while the following 14 patients had a diastematomyelia and tethered cord that were both managed in concomitantly.

Results: All patients were followed up for an average of 4.5 y (range 2 - 6 y). The total operative time had an average of 8.45 h (range 6 - 14 h) and the average blood loss was 1230 cc (range 800 - 1850 cc). All patients had a positive wake up test. The average scoliosis was 45° corrected to an average of 11° and the loss of correction had an average of 1.5°; the average kyphotic deformity was 83° corrected to an average of 35° and the loss of correction had an average of 2.2°. There were no neurological insults, CSF leaks or metal failures. The SRS-30 questionnaire ranged from 92 to 134 with an average of 112.

Conclusion: Concomitant surgical management of neglected congenital spinal deformities associated with intraspinal anomalies can be performed safely; meticulous untethering allows adequate correction with satisfactory clinical and radiographic outcome.

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TRADITIONAL POSTER ABSTRACTS

POSTER #309

Single Stage Posterior Vertebral Column Resection of Lumbar Hemivertebrae in Children under the Age of Ten Years

Yasser ElMiligui, MD, FRCS; Wael Koptan, MD; Mohammad M. El-Sharkawi, MD; AbdElMohsen Arafa

Egypt

Summary: Twenty nine patients with a hemivertebra of the lumbar spine had total resection of the hemivertebra and short segment posterior instrumentation. Patients were followed-up for an average of 4.5y (range 2 - 8y) and achieved adequate correction with satisfactory clinical and radiographic outcome without the need for anterior surgery.

Introduction: A single lumbar hemivertebra can result in a progressive spinal deformity. Total resection of these hemivertebrae is ideal for correcting these deformities and several alternatives were suggested including anterior and/or posterior approaches. The aim of this study is to evaluate the clinical and radiographic outcome of single stage total hemivertebrectomy in children less than 10 years old.

Methods: he study was performed between 2000 and 2008 and included twenty nine patients with a lumbar hemivertebra. The average age was 8.5 y (range 6 - 9.5y). The technique involved laminectomy, excision of the pedicle and hemivertebra, and curettage of both end plates; the gap created was filled with morselized cancellous bone. Short segment posterior instrumentation was performed; the gap was gently closed by compression over the pedicle screws and the remaining autograft bone was placed in the posterolateral gutter. A wake up test was done.

Results: Patients were followed-up for an average of 4.5y (range 2 - 8y). The operative time had an average of 2.5 h (range 2 - 4 h) and the average blood loss was 410 cc (range 230 - 650 cc). The scoliotic deformity corrected from an average of 41° to an average of 5° postoperatively and an average of 6° at final follow up; kyphosis corrected from an average of 32° to an average of 4° postoperatively and an average of 5° at final follow up. There were no vascular injuries, neurologic insult, implant failure or crank shafting.

Conclusion: Single stage posterior excision of hemivertebrae with short segment pedicle screw instrumentation is a safe, efficient alternative that offers excellent correction in both sagittal and coronal planes without the need for anterior surgery.

POSTER #310

Outcomes of Growing Rod Techniques in Early Onset Scoliosis: Multicenter Study in Japan

Kota Watanabe; Morio Matsumoto, MD; Koki Uno, MD, PhD; Noriaki Kawakami, MD; Taichi Tsuji, MD; Haruhisa Yanagida, MD; Manabu Ito, MD, PhD; Toru Hirano; Ken Yamazaki, MD; Shohei Minami; Hiroshi Taneichi, MD; Shiro Imagama, MD; Katsushi Takeshita; Takuya Yamamoto

Japan

Summary: Multicenter study in Japan was performed to evaluate the outcomes of surgical treatments for early onset scoliosis using growing rod technique (GR). 88 patients from twelve spine institutes were included. All patients had undergone GR under the age of 10 years and had been followed up for more than two years. The correction rate of 42±22% at the final follow-up was a comparable with previous reports. The complications occurred in 57% of the patients and in 22% for each procedure.

Introduction: Currently, growing rod technique (GR) has been widely used for treatments of early onset scoliosis (EOS). The purpose of this study was to evaluate the outcomes of surgical treatment for EOS using GR by multicenter study in Japan.

Methods: 88 patients who were treated using GR for EOS from twelve spine institutes in Japan were included in this study. All patients had undergone GR under the age of 10 years and had been followed up for more than two years. The mean age at the time of surgery was 6.5±2.2 years and the mean follow-up period was 3.9±2.6 years. The etiology of these patients were syndromic in 44 patients, idiopathic in 14, neurofibromatosis in 9, neuromuscular in9, congenital in 8, osteochondrodystrophy in 3, and iatrogenic in 1. Preoperative and final radiographical data and clinical data throughout the treatment period were analyzed.

Results: Of the 88 patients, 20 (23%) underwent final fusion, 65 were under the treatment of GRs, and 3 had implant removal without final fusion. The preoperative mean Cobb angle of the main curve was 83±20° and was corrected to 45±15° with the mean correction rate of 45±15% after rod placements. At the final follow-up, the mean Cobb angle was 48±20° with the mean correction rate of 42±22%. 119 complications were recognized during the treatment period in 538 procedures (22% of procedures) for 50 patients (57% of the patients). The complications included 86 implant- related failures (72%), 19 infections (16%), 3 neurological impairments (3%), and 11 others. The implant-related failures included 61 dislodgements of the anchor (71%), and 17 rod breakages (20%). The most of the anchor dislodgements occurred at proximal anchor sites (95%). Kaplan-Meier survival analysis indicated that 50% of the patients who had rod lengthening 5 times and more suffered from one and more complications.

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Conclusion: In the present study, the correction rate of 42±22% at the final follow-up was a comparable with previous reports. The complications occurred in 57% of the patients and in 22% for each procedure. Since the majority of implant-related complications were predominantly found at the proximal anchor sites, techniques for proximal anchoring need improvement to reduce complications.

POSTER #311

Radiation Exposure in Growing Rod Surgery for Early Onset Scoliosis

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USA

Summary: Growing rod (GR) surgery for early onset scoliosis (EOS) requires repetitive surgeries and serial radiographic imaging. This type of imaging emits ionizing radiation (IR), a well-known known health hazard in high doses. IR exposure in four GR patients with idiopathic EOS was quantified. The average IR exposure per year of spine treatment and per spine surgery was 4.5 times and 4.6 times the average annual exposure to background radiation, respectively.

Introduction: Health hazards related to ionizing radiation (IR) exposure have been well studied; however, no longitudinal studies have monitored IR exposure in growing rod surgery (GR) for treatment of early onset scoliosis (EOS). GR surgery with subsequent periodic surgical spinal distractions require multiple radiographic studies during the course of treatment. The purpose of this study was to quantify IR exposure in this group of patients.

Methods: Idiopathic EOS patients under age 11 who underwent GR surgery at a single center between 1997 and 2010 were retrospectively reviewed. Out of 5 patients who met the inclusion criteria, 4 pts had complete surgical and radiographic history available for analysis. All imaging studies using IR were recorded for each patient. Estimated IR was measured in millisieverts (mSv). IR was calculated based on historic controls: spine x-ray (1.5 mSv); extremity x-ray (0.001 mSv); chest x-ray (0.1 mSv); CT c-spine (2 mSv); CT T-spine (2 mSv); CT L-spine (2 mSv); CT chest (7 mSv); yearly background radiation (BR) (2.4 mSv).

Results: There were a total of 254.8 mSv of IR and 23 surgeries recorded among all 4 patients. Average follow-up from initial spine evaluation was 5.9 years (range 2.2 to 14.8 years). Avg IR exposure per surgical event was 11.08 mSv, 4.6 times the average annual IR from BR. Average IR exposure per year of treatment was 10.7mSv, 4.5 times the average annual IR from BR (Table 1).

Conclusion: This small series of EOS patients received at least 4 times the average annual IR from BR for each year of treatment. IR is grossly underestimated as the average mSv values used for this study were based on the "average sized" adult, multiple x-rays are often taken to obtain one satisfactory film, and patients frequently have other co-morbidities requiring additional IR studies unrelated to the spinal deformity. This study demonstrates the need for a large prospective study to address this understudied risk to patients.

Significance: This study is the first to quantify IR in EOS. Stronger conclusions can then be made with prospectively collected data in regards to lifetime risk of exposure for these patients and possible ways to decrease exposure needed for treatment.

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).

POSTER #312

Preliminary Experience with Clinical Use of a DNA Prognostic Test for Adolescent Idiopathic Scoliosis in 196 Patients

Suken A. Shah, MD; Petya Yorgova; Geraldine I. Neiss, PhD; E. Patrick Curry, MD; Brain S. Winters, MD; Peter G. Gabos, MD; J. Richard Bowen, MD

USA

Summary: A prospective series of patients who underwent prognostic AIS genetic testing is described. 48% of patients tested low risk and had smaller curve magnitudes on the test date, a longer period between follow up visits and X-rays, and a lower incidence of bracing.

Introduction: A commercially available saliva-based prognostic DNA test has been developed which utilizes a panel of 53 SNPs to predict the risk of progression in pts with mild adolescent idiopathic scoliosis (AIS) to a severe curve (>40°).

Methods: 196 pts with mild AIS who were skeletally immature underwent this test in a prospective, consecutive fashion. Scores were reported in a range of 1 to 200, stratified as follows: Low risk (LR)(1-50), Intermediate risk (IR)(51-179) and High risk (HR)(180-200).

Results: 95 pts (48%) tested LR; 92 pts (47%) tested IR; and 9 pts (5%) tested HR. Mean age was 11.8 yrs (range 9-14 yrs). The mean Cobb angle(CA) at testing was 16.6° (range 10-25°) and did differ significantly between groups: the mean CA at testing was 13.3° in LR, 19.2° in IR, and 24.1° in HR ($p<0.001$). Pts presenting with curves of less than 20° tested LR 63% of the time. Thus far, 101 pts have had at one follow-up (f/u) visit at a mean interval of 7.0 months and had a mean CA of 19.2°. The length of first f/u is significantly different: 3.4 months for HR, 6.7 months for IR, and 8.5 months for LR ($p<0.001$). 43 pts have had a second f/u visit at a mean interval of 6.5 months after the first f/u with a mean CA of 21.2°. There was no difference among groups in the change in CA between visits. One pt in the HR group has progressed to 44° at the latest f/u. 36 pts overall (23%) are being treated with a brace: 60% pts in HR, 33% in IR, and only 7% in LR ($p<0.001$).

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TRADITIONAL POSTER ABSTRACTS

Conclusion: A prospective series of pts who underwent prognostic AIS genetic testing is described. 48% of pts tested low risk and had smaller curves on the test date, a longer period between follow up visits and X-rays, and a lower incidence of bracing. Follow up to at least skeletal maturity is required to make any statements about validation of the test for risk of children with mild AIS progressing to a severe curve.

Significance: Proportions of AIS prognostic test results in our practice are different than those described by the developers of the test; it may be that our high acuity practice does not reflect a school screening population. This is important for clinicians in similar situations since it affects recommendations for anticipatory guidance.

POSTER #313

Preoperative Halo-Gravity Traction for Severe Pediatric Spinal Deformity: Complications, Radiographic Correction and Changes in Pulmonary Function

Ljiljana Bogunovic; Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Scott J. Luhmann, MD

USA

Summary: Preoperative halo-gravity traction for severe pediatric spinal deformity achieved a 35% radiographic correction and 21% improvement in PFTs from baseline values. There was a 27% transient minor complication rate and no long-term neurologic complications.

Introduction: The purpose of this study was to determine the safety and efficacy of preoperative HGT for severe pediatric spinal deformity.

Methods: An analysis was completed of pediatric spinal deformity patients from one tertiary-care pediatric hospital from 1998-2007 treated with preoperative HGT. Complete records were available on 33 patients whose mean age was 12.8 yrs (4.1 to 20.2). Diagnoses included: idiopathic (15), neuromuscular (4), congenital (3), and syndromic (11).

Results: Average time in traction was 70.1 days (26 to 161) at an average of 38.5% total body weight (%TBW) (19.7-66.9). Average time to the maximal traction weight was 30.5 days (0-73). Pre-traction coronal Cobb was 96.4d (10 to 170) and sagittal Cobb was 83.3d (22 to 168). The major pre-traction Cobb was 114.5d (68 to 170). The post-traction coronal Cobb was 62.4d (0 to 130; 35.7%) and sagittal Cobb was 52.2d (12 to 102; 34.5%). Total curve correction averaged 63.1d. Traction weight (%TBW) at the time of maximal Cobb correction was 36.9% coronal and 35.5% sagittal. Ten temporary minor complications (9 halo-related) occurred in 9 patients (27%). Complications included transient nystagmus (3), upper extremity numbness (1), pin site erythema (1), pin site infection/pin removal (2), unilateral miotic pupil (1) and progression of myelopathy (1). There were no long-term neurologic complications. PFTs were obtained in 22 patients; 19 patients PFTs improved with traction. Pre-traction FVC was 45.4% and FEV1 was 43.7% predicted. Post-traction FVC was 53.1% and FEV1 was 52.7% predicted. After HGT FVC % predicted improved 9.4% (20.7% improvement); FEV1 % predicted improved 9.0% (20.6% improvement).

Conclusion: HGT is a well-tolerated method to safely achieve an average of 35% correction in the coronal and sagittal planes. There was a 27% minor complication rate and no long-term neurologic complications. An added benefit of HGT was the overall 9% increase in PFTs (21% improvement).

Significance: Preoperative halo-gravity traction for severe pediatric spinal deformity achieved a 35% radiographic correction and 21% improvement in PFTs from baseline values. There was a 27% transient minor complication rate and no long-term neurologic complications.

POSTER #314

Influence of Level of Evidence on Acceptance of Scientific Papers for Presentation in SRS Annual Meeting, and Agreement between the Authors vs. Independent Reviewers

Dilip K. Sengupta, MD; James O. Sanders, MD; Douglas C. Burton, MD; Reginald Q. Knight, MD, MHA; Richard E. Bowen, MD; Kevin F. Spratt, PhD; V. James Raso, MASc

USA

Summary: This study evaluated the influence of Level of Evidence (LOE) on acceptance of abstracts in SRS annual meeting. The agreement between the authors vs. five independent reviewers in determination of LOE was also evaluated

Introduction: Emphasis on the Level of Evidence (LOE) in scientific papers and abstracts is increasing. However, very little evidence is available concerning how LOE influences abstract acceptance, or the level of agreement amongst those evaluating the submitted abstracts.

The purpose of this study was to evaluate (i) the relationship between acceptance status and author reported study type and LOE, and (ii) the agreement in study type and LOE classifications of the author with independent reviewers.

Methods: The relationship of disposition (podium, poster, rejected) of abstracts submitted for SRS annual meeting, and Study Type (basic science, therapeutic, diagnostic, prognosis, and economic/decision analysis) and LOE (I-IV) was evaluated using $\chi 2$. The relationship between study type and LOE across raters (five independent reviewers) was restricted to those abstracts that were accepted for podium presentation (N=103). Inter-rater agreement for Study Type and LOE classification of authors (R0) with independent rater (R1-R5) classifications were evaluated using Kappa statistics.

Results: Overall there were 785 abstracts, of which 142 were classified as basic science and, therefore, had no LOE classifications. The association of disposition and LOE, summarized in the table below, indicates that podium acceptance was

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related to LOE=I positively and to LOE=IV inversely; otherwise, LOE and disposition were not strongly related.

Study Type Kappas for R0 with R1-R5 were: .40, .30, .45, .40 and .38, respectively; and LOE Kappas were: .24, .22, .21, .35 and .48, respectively. In general, authors were more likely to classify LOE higher than independent raters.

Conclusion: Acceptance was significantly related to author provided LOE. Kappas comparing author vs. independent rater's evaluation of study type were moderate, but author and independent rater agreement for LOE classification were low.

Significance: There is a need for better understanding and agreement of LOE.

POSTER #315

The Natural History of Major Neurological Deficits in Surgical Correction of Spinal Deformity

Yong Qiu, MD; Xiang Shao; Zhen Liu; Weiwei Ma, MD; Zezhang Zhu, MD; Bangping Qian; Feng Zhu; Bin Wang, MD

China

Summary: Neurologic deficit is one of the risks of surgical correction of scoliosis. Seventeen patients with major neural complications in spinal surgery were reviewed and the majority of them achieved great degree of recovery within three months.

Introduction: Major neurological deficit was defined as lesions involving the spinal cord, which was one of the risks of surgical correction of spinal deformity. In the current study, the prognosis of major neurological complications was reviewed by a long-term follow-up.

Methods: A retrospective study was conducted with 2348 consecutive patients who had undergone correction surgery between Jan. 2000 and Jan. 2008. There were 17 major neurological deficits: 3 complete paraplegia, 7 incomplete paraplegia in both lower extremities and 7 incomplete paraplegia in one lower extremity. There were 8 males and 9 females, and the mean follow-up period was 3.8 years (2.5-9years). There were 9 congenital scoliosis, 4 neuromuscular scoliosis, 1 Marfan syndrome, 1 neurofibromatosis 1, 1 arthrogryposis multiplex and 1 idiopathic scoliosis. All 17 patients received spinal fusion and instrumentation, and 10 out of them underwent vertebral column resection. The neurological status was evaluated at immediate post-operation, 3-6 months post-operation and the latest follow-up.

Results: Immediately after surgery, according to the Frankle grading, 3 patients were Grade A, 2 patients were Grade B and 12 patients were Grade C. In 4 of the 17 cases, the instrumentations were removed, in 9 cases the instrumentations were released or partially removed combined with laminectomy. At the latest follow-up, 13 cases achieved normal or near normal recovery (Grade E) and the other 4 cases had partially residual dysfunction (Grade D). In addition, the main neurological recovery was achieved in the first three months and the improvement progressed very slowly thereafter.

Conclusion: In surgical correction of scoliosis, vertebral column resection is a pronounced risk factor. The majority of patients with major neurological deficit would achieve recovery in the first three month. With major neurological deficits, the removal or releasing of instrumentation and laminectomy is a recommended option of choice.

POSTER #316‡

The Incidence of Lumbar Adjacent Segment Disease: A Comparison of Single-Level Lumbar Fusion Procedures

Brian Neuman, MD; David T. Anderson, MD; Kristen E. Radcliff, MD; Todd J. Albert, MD; Alexander R. Vaccaro, MD, PhD; D. Greg Anderson, MD; Alan Hilibrand, MD

USA

Summary: There appears to be no correlation between the development of ASD or the re-operation rate for ASD with the type of single-level lumbar arthrodesis.

Introduction: A primary concern after a lumbar spine arthrodesis is the development of adjacent segment disease (ASD). Determining risk factors for ASD has been extensively examined through clinical studies. However, any correlation with the development of ASD with a particular type of single-level lumbar arthodesis remains unclear. The purpose of this study was to compare the rates of ASD among patients undergoing posterior lumbar fusion (PLF), transforaminal interbody fusion (TLIF) with PLF, and anterior lumbar interbody fusion (ALIF).

Methods: A retrospective review of 369 consecutive patients who underwent a single-level lumbar arthrodesis was performed. 239 patients had at least two year follow-up, averaging 4 years. 142 patients had a PLF, 77 patients underwent a TLIF/PLF, and 20 patients an ALIF. For each group with the consensus of the authors, ASD and reoperation rates were determined . Subgroups were compared using Fisher's exact test. ASD was defined as new radiculopathy or recurrent claudication referable to a motion segment adjacent to a previous lumbar arthrodesis with symptoms greater than 6 weeks.

Results: 17.6% (N=25/142) of patients in the PLF group developed ASD and 6.3% underwent re-operation. Among the TLIF / PLF group, 18.2% (N=14/77) developed ASD and 9% underwent re-operation. The incidence of ASD among ALIF patients was 20% (N=4/20) with no re-operations. There was no significant difference between subgroups in ASD incidence or reoperation rate.

Conclusion: Lumbar ASD occurred at a high rate although only a minority of patients required surgery. The likelihood of developing ASD after a lumbar fusion did not appear to correlate with the type of fusion, suggesting that ASD may reflect the natural history of degenerative disease.

‡ Goldstein Award Nominee for Best Clinical Poster or E-Poster Ω Moe Award Nominee for Best Basic Science Poster or E-Poster

The Moe Award is given to the best Basic Science Poster or E-Poster at the SRS Annual Meeting and the Louis A. Goldstein Award is given to the best Clinical Poster or E-Poster at the SRS Annual Meeting.

TRADITIONAL POSTER ABSTRACTS

POSTER #317

Does Iliac Crest Autograft Affect the Outcome of Fusion in the Setting of Degenerative Spondylolisthesis? A Subgroup Analysis of the SPORT Study

Kristen E. Radcliff, MD; Raymond W. Hwang, MD, MEng, MBA; Alan Hilibrand, MD; Harvey E. Smith, MD; Jordan Gruskay, BA; Jon D. Lurie, MD; Wenyan Zhao, MS; Todd J. Albert, MD; James N. Weinstein, DO, MS

USA

Summary: There is considerable controversy about the long-term morbidity of autologous local iliac crest bone graft versus bone graft substitutes. This study showed that there is no long term difference in outcome in patients who underwent posterior lumbar fusion with iliac crest bone graft compared to non-iliac crest bone graft.

Introduction: The SPORT trial is a prospective, multicenter study of surgical treatment versus nonoperative treatment for lumbar degenerative conditions. There is considerable controversy about the long-term morbidity of autologous local iliac crest bone graft versus bone graft substitutes. The hypothesis of this study is that there is no long term difference in outcome in patients who underwent posterior lumbar fusion with iliac crest bone graft compared to non-iliac crest bone graft.

Methods: Subgroup Analysis of Prospective Randomized Controlled Study. The study population includes patients enrolled in the degenerative spondylolisthesis (DS) cohort of SPORT who underwent fusion. Patients were divided according to whether or not they underwent autologous iliac crest autograft.

Results: There were 108 patients who had fusion with iliac crest autograft (ICBG) and 246 non-iliac crest autograft (No-ICBG). There were no baseline demographic differences between groups. There was an increased percentage in the ICBG group of neurological deficit (ICBG 65% vs No-ICBG 50%, p=0.011), asymmetric depressed reflexes (35% vs 22%, p=0.017), and neuroforaminal stenosis (51% vs 39%, p=0.041). There was an increased percentage of multilevel fusions in the ICBG (32% vs 21%, p=0.033), L5-S1 decompression (38% vs 26%, p=0.031). Operative time was increased in the ICBG group (233.4 vs 200.9 minutes, p<0.001), and there was a trend toward increased blood loss (686.0 vs 582.3, p=0.057). There were no differences in postoperative complications including infection or revision rate between groups.

There were no significant differences in SF36 score, ODI, stenosis bothersomeness index, low back pain bothersomeness index, or percent satisfaction with symptoms between ICBG and No-ICBG groups at 4 years or averaged over the study period.

Conclusion: ICBG was not shown to be associated with an improvement in outcome or reduction in revision rate in degenerative spondylolisthesis. However, the complications of ICBG were not significantly different from No-ICBG surgery, suggesting that its use is not associated with long term reduction in outcome.

POSTER #318

Predictors of Reoperation in Lumbar Stenosis and Degenerative Spondylolisthesis Surgery: A Subgroup Analysis of the SPORT Study

Kristen E. Radcliff, MD; E. Patrick Curry, MD; Alan Hilibrand, MD; Wenyan Zhao, MS; Jon D. Lurie, MD; Tor D. Tosteson, ScD; Jeffrey A. Rihn, MD; Alexander R. Vaccaro, MD, PhD; Todd J. Albert, MD; James N. Weinstein, DO, MS

USA

Summary: There are baseline differences between patients who underwent reoperation and those who did not undergo reoperation for lumbar stenosis and degenerative spondylolisthesis.

Introduction: The SPORT trial is a prospective, multicenter study of surgical treatment versus nonoperative treatment for lumbar stenosis (SS) and degenerative spondylolisthesis (DS). This subgroup analysis searched for significant baseline differences between patients who underwent reoperation and those who did not.

Methods: Subgroup analysis of prospective, randomized study. Change in primary and secondary outcome measures and treatment effect of surgery were assessed at baseline and every year for four years for patients enrolled in SPORT for treatment of spinal stenosis and degenerative spondylolisthesis.

Results: There were 54 reoperation and 359 non-reoperation patients in the SS cohort. There was an increased percentage of patients with duration of symptoms greater than 12 months in the reoperation group (56% Reop vs 36% No-Reop, p<0.008). There was significantly less improvement in the reoperation patients in SF36 BP, SF36 PF, ODI and Sciatica Bothersomeness Index averaged over the four year study period. Reoperations were equally distributed between the index 49% (range 67-31%) and adjacent levels 51% (range 68-33%).

There were 58 reoperation and 333 non-reoperation DS patients. There was decreased incidence of pseudoclaudication (74% vs 88%, p=0.007) and asymmetric depressed reflexes (12% vs 28%, p=0.015) in the reoperation patients. There was significantly less improvement in SF36 BP, SF36 PF, and ODI in the DS Reoperation patients averaged over the study period.

Conclusion: Duration of symptoms > 12 month was a risk factor for reoperation of spinal stenosis. Pseudoclaudication and asymmetric depressed reflexes were associated with reduced risk of reoperation for degenerative spondylolisthesis. There was significantly less improvement in the outcome of patients who underwent reoperation for both spinal stenosis and degenerative spondylolisthesis. The aggregate 4 year rate of reoperations was 13% for spinal stenosis and 15% for degenerative spondylolisthesis, consistent with previous values. Reoperations were equally distributed between index and adjacent lumbar levels. Fusion, number of levels addressed, and instrumentation were not associated with increased risk of reoperation in either cohort.

‡ Goldstein Award Nominee for Best Clinical Poster or E-Poster Ω Moe Award Nominee for Best Basic Science Poster or E-Poster

The Moe Award is given to the best Basic Science Poster or E-Poster at the SRS Annual Meeting and the Louis A. Goldstein Award is given to the best Clinical Poster or E-Poster at the SRS Annual Meeting.

REFERENCES

The Scoliosis Research Society gratefully acknowledges K2M for their support of the E-Poster and Internet Kiosks and Instructional Course Lectures.

GLOSSARY OF SPINAL DEFORMITY BIOMECHANICAL TERMS

(Selected and adapted from White and Panjabi: Clinical Biomechanics of the Spine. Philadelphia: J. B. Lippincott, 1978).
Proposed by SRS Terminology Committee, 1999

AXES SYSTEMS, ETC. (SEE DIAGRAM)

Local, regional (spinal) and global axis systems (See Figure 1)

Vector - A quantity that possesses both a magnitude and a direction (e.g. force; velocity; displacement).

LOADING

Force - An action that causes a body to displace or deform. (SI Unit of measure = Newton, i.e., N)

Tension Force - A force that tends to elongate a structure of material.

Compression Force - A force that tends to shorten a structure or material.

Moment or Torque - The sum of the forces applied to a structure multiplied by their perpendicular distance from a reference point or axis. (SI Unit of measure = Newton- metre, i.e., Nm)

Bending Moment at a point within a structure. (See Figure 2). The moment that tends to bend a structure. It is usually the sum of the moments due to several forces.

Couple - Two equal non-collinear forces producing a torque.

3-Point Bending (See Figure 3) - A structure is loaded in 3-point bending when a single force is applied on one side and two forces are applied on the other side acting in opposite directions.

4-Point Bending - (See Figure 3) - A long structure is loaded in 4-point bending when two transverse forces are applied on one side and two on the other.

Stress - The force per unit area of a structure and a measurement of the intensity of force (SI Units are Newtons/m2=Pascals. Hence 1 N/m2 = 106 N/mm2 = 1 MPa).

Normal Stress - The intensity of force perpendicular to the surface on which it acts.

Shear Stress - The intensity of force parallel to the surface on which it acts.

Compressive Stress - A normal stress that tends to shorten a material.

Tensile Stress - A normal stress that tends to elongate a material.

Principal Stresses - The stresses normal to the principal planes of a material are called principal stresses.

Stress Concentration - A site of stress that is high compared to that of nearby sites in a structure or material. It is often caused by a sharp change in shape.

Center of Gravity - The point in a body in which the body mass is centered.

DISPLACEMENT/DEFORMATION

Absolute Motion - Motion of a rigid body relative to the global axis system.

Relative Motion - Motion of a rigid body relative to the local axis system of an adjacent body.

Rotation (Figure 4) - Motion of a rigid body in which a certain straight line within or adjacent to the body remains motionless. (That straight line is the axis of rotation)

Translation (Figure 4) - Motion of a rigid body in which a straight line in the body always remains parallel to itself.

Plane Motion - A motion of a rigid body in which the body moves in a single plane.

Degrees of Freedom (Figure 5) - The number of independent displacements that can occur in a mechanism (e.g. the spine and instrumentation) - total of possible displacements and rotations at all of the joints.

Instantaneous Axis of Rotation (Figure 5) - When a rigid body moves at every instant there is a line in the body or some hypothetical extension of it that does not move. For plane motion the axis of rotation becomes the center of rotation. Note: This applies to absolute motion of a single body, also to the relative motion of two bodies such as two vertebrae.

Bending - Deformation of a structure in response to a bending moment.

Neutral Axis - Line or axis within a beam or other structure about which bending occurs.

Strain - (Figure 6) Deformation divided by original length or thickness.

Normal Strain is defined as the change in length divided by the original length. Normal strain can be tensile or compressive.

Shear Strain - Shear deformation divided by the thickness perpendicular to the shear.

Plastic Deformation (Figure 7) - Deformation that remains after the deforming load is removed.

LOAD-DISPLACEMENT, STRESS-STRAIN RELATIONSHIPS ELASTIC BEHAVIOR:

Stiffness - Relationship between load and deformation – the force applied divided by the deformation it produces.

Modulus of Elasticity - Relationship between stress and strain. (e.g., Young's modulus = normal stress divided by normal strain)

Torsional Rigidity - The applied moment or torque divided by the rotational deformation (torsion) that it produces.

GLOSSARY OF SPINAL DEFORMITY BIOMECHANICAL TERMS

TIME DEPENDENT BEHAVIOR:

Creep - Time dependent deformation of a material resulting from the application of a constant load.

Viscoelasticity - Material behavior in which the resistance to deformation depends on the amount of deformation (elastic) and the rate of deformation (viscous).

FAILURE

Yield Stress - (Figure 7) Magnitude of stress on the stress-strain curve at which appreciable deformation takes place without any appreciable increase in the stress.

Ductility - Property of a material in which there is a large amount of deformation possible after the yield point. This implies that a large amount of deformation energy is absorbed by the material before failure. (opposite of brittle)

Fatigue - Eventual failure after repeated cycles of sub-failure loading. This usually occurs as a result of the process of the growth of cracks in structures subjected to repetitive load cycles.

Equilibrium - State of a system in which all forces and moments are balanced, hence it does not displace.

Free Body Analysis (Figure 8) - Equilibrium analysis in which a system is split into real or imagined components (free bodies), in order to check that each part is in equilibrium. It is also used for determining the internal stresses in a structure subjected to external loads.

Statics - The branch of mechanics that deals with the equilibrium of bodies at rest or in motion with zero acceleration.

Dynamics - The branch of mechanics that deals with motion of systems in which the accelerations of masses have significant effect.

Kinematics - The branch of mechanics that deals with motion.

Stability - Behavior of a system whereby it returns to its equilibrium position after being disturbed.

Buckling - A kind of instability in which a structure suddenly bends and collapses when a certain critical load is applied. The stable equilibrium position is a position of minimum potential energy – any displacement of the structure requires a net input of energy. Although stiffness or rigidity of a structure can contribute to its stability, stiffness and stability are not the same thing. When referring to the rigidity of, for example an instrumentation construct, use the term stiffness or rigidity, not stability.

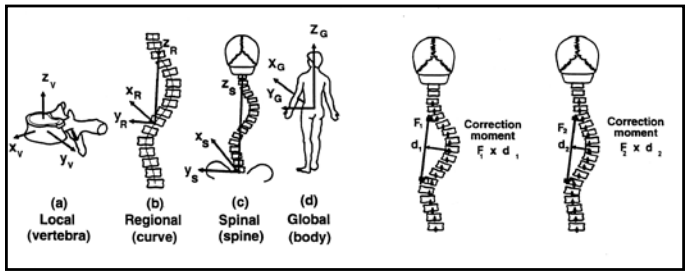


Figure 1. Local, regional (spinal) and global axis systems. Note: these are Cartesian systems, defined by three mutually perpendicular lines (axes).

Figure 2. Bending moment (produced here by the force in a Harrington rod) is the force multiplied by its perpendicular distance from a point in the structure (spine).

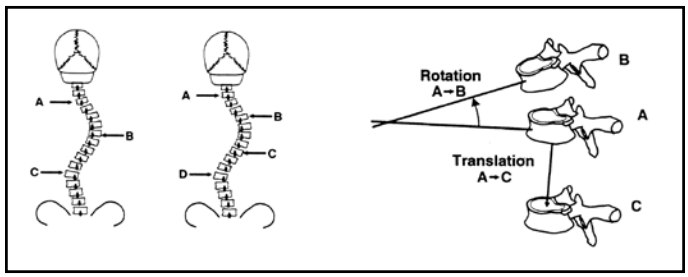


Figure 3. 3 and 4 point bending. For 3 point bending, the maximum bending moment is at point 'B'. For 4 point bending with four equal forces, the bending moment between forces 'B' and 'C' is uniform (constant).

Figure 4. Rotation and translation motion. The motion form A to B is a pure rotation, with an axis of rotation lying outside the vertebra. The motion from A to C is a pure translation.

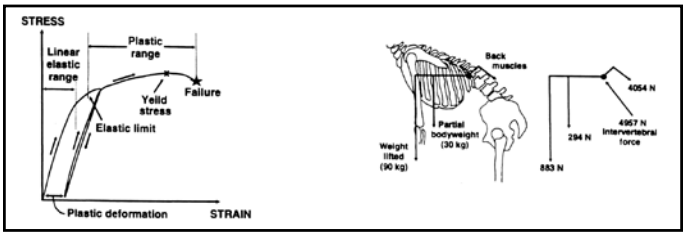


Figure 5. A motion segment has six degrees of freedom (i.e., six possible relative displacements of one vertebrae relative to its neighbor). The motion at any instant can be described as a translation along and a rotation about an instantaneous axis rotation.

Figure 6. Stress is the standardized measure of loading (force/unit area) and strain is the standardized measure of deformation (deformation divided by original length). (a) Normal stress and strain. (b) Shear stress and strain.

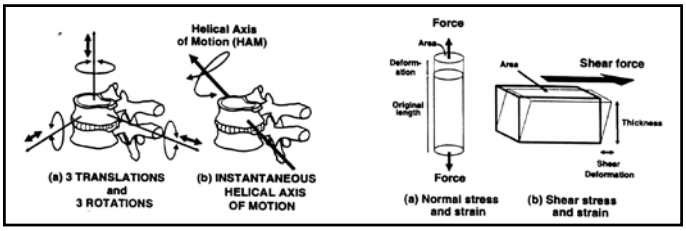


Figure 7. Stress-strain graph of a typical material. A sample was loaded past its elastic limit, unloaded to demonstrate plastic deformation, then loaded again to failure.

Figure 8. Simple static analysis (no motion occurring) of lifting mechanics to determine forces at the thoracolumbar junction. Here a free-body analysis is used. All forces acting on the upper part of the body must be in equilibrium (i.e., no net force or moment acting on the upper body) – otherwise it would be forced to accelerate.

ABOUT SRS

GOALS AND MISSION STATEMENT

Scoliosis Research Society Mission Statement

The purpose of Scoliosis Research Society is to foster the optimal care of all patients with spinal deformities

Goals and Aspirations of the Scoliosis Research Society

The Scoliosis Research Society is composed of physicians and scientists, who, prior to becoming members, have concentrated on the problems of spinal deformities and who, as members, make a continuing commitment to solve the problems of spinal deformity, to participate in research and to contribute to the Society's educational and service efforts. The business of the Scoliosis Research Society is knowledge. The Society is concerned with the development of new knowledge, the continuing education of its members, and the communication of knowledge to others. Because knowledge brings responsibility, members are committed to the highest standards of ethical practice and professional service to the Society and the research community. Education and care of patients are the central activities through which members channel their expertise. It is expected that members will be active to some extent in each of these areas, but with different emphasis based on individual interests and talents.

Research

It is not by accident that the word "research" occupies a central place in the name of our Society. The members of the Society are committed to research in spinal deformities.

All members participate in some research activity which leads to increased knowledge. The one Society-sponsored research project in which every member can participate is the Morbidity and Mortality report. This project has produced more useful information for the Society than any other single research program. Other means of participation in research include individual basic scientific or clinical studies, interinstitutional studies or Society-sponsored projects. In all forms of research, members strive for objectivity and meticulous honesty.

Education of Members

New data and new techniques evolve rapidly in the medical and surgicalcare of spinal disorders. The members of the Scoliosis Research Society take responsibility for their own continuing medical education. In addition, the Society provides structured educational experiences through printed material, IMAST, Worldwide Conferences and the Annual Meeting. These educational efforts are focused on the members of the Society, who already possess a high degree of expertise, and their value depends on the member's willingness to participate. Members contribute to the education of others by reporting on cases from their own practices in the open forums of the Annual Meeting and IMAST.

Education of Residents and Fellows

We believe that the possession of specialized knowledge and expertise carries with it the responsibility to transmit this to others. The members of the Society, collectively and individually, will participate in the design and structuring of residency and fellowship programs. We expect Society members to be active in AAOS, AANS, and comparable educational programs in spinal deformity for their respective national Orthopaedic and/or Neurosurgical organizations throughout the world.

Public Education

The scoliosis research society recognizes a responsibility to public education and the need for effective liaison with lay organizations dedicated to some aspect of the prevention and treatment of spinal deformities. We believe that we have a responsibility to be the leading resource for information and encouragement to these groups.

The society has dedicated time and resources to the development of educational programs for the public. We expect members to support and participate locally in those programs with which the society cooperates.

Ethical Practice

The members of the scoliosis research society are dedicated to the highest standards of ethical practice.

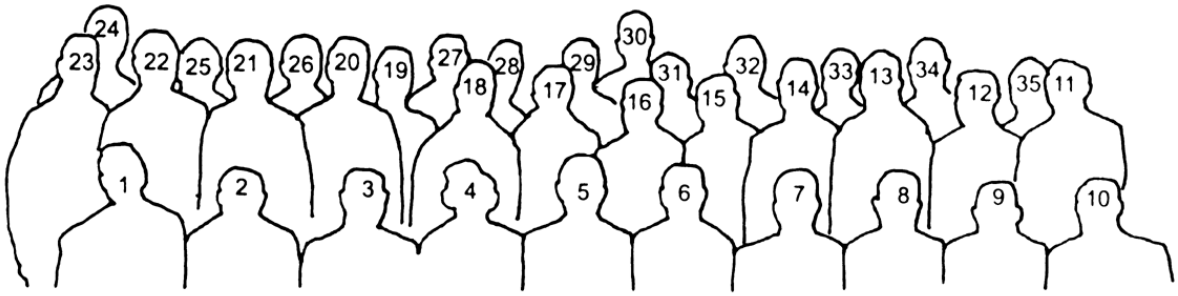
Members strive to:

1. Develop thoughtful diagnoses and treatment plans based on common sense, scientific principles and data.
2. Recognize personal, technical and cognitive limitations.
3. Charge fair and appropriate fees for the services performed and assist in providing health care to all members of the community.
4. Distinguish appropriate alternative treatment plans from ill conceived ones when giving opinions and not disparage physicians who recommend other acceptable treatments.
5. Recognize that the assessment of evolving technology is difficult and therefore maintain a degree of caution about new techniques, using these to improve patient care rather than to gain a competitive advantage.

Acknowledging Support

The society as a whole and individual members have benefited from the generous support of private and corporate sponsors. We will give full acknowledgment for this support without concern that such recognition of assistance may be misinterpreted.

FOUNDING FELLOWS



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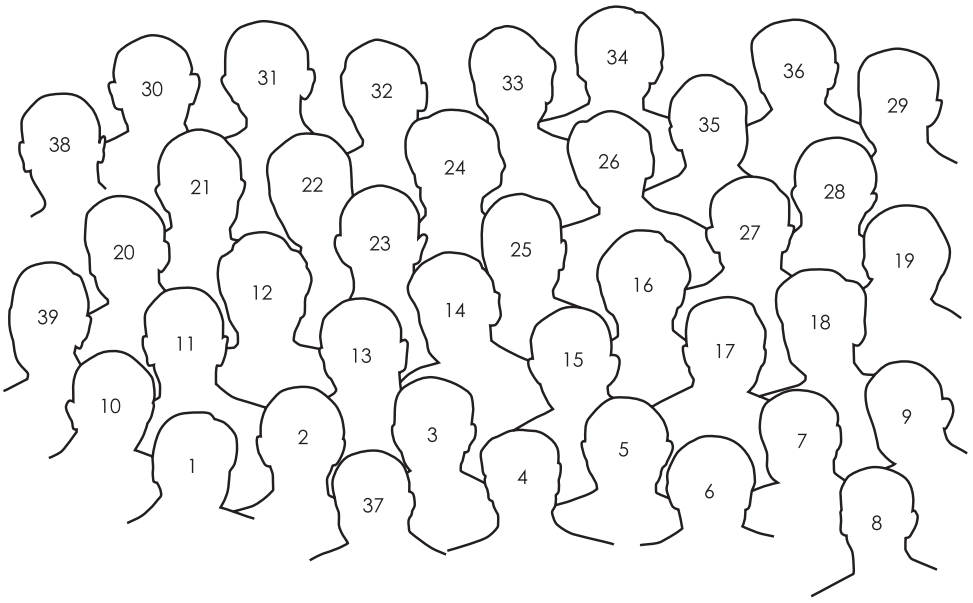

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1	R. Kirklin Ashley	1971-72
2	Harry L. Shufflebarger	2000
3	Vernon T. Tolo	1996
4	John E. Lonstein	1991
5	Theodore R. Waugh	1982
6	Robert N. Hensiger	1989
7	James W. Ogilvie	2004
8	Randal R. Betz	2005
9	Paul R. Harrington	1973
10	Behrooz A. Akbarnia	2006
11	Gordon L. Engler	1994
12	Wilton H. Bunch	1986
13	Clyde Lester Nash, Jr.	1983
14	John P. Kostuik	1987
15	John H. Moe	1966-68
16	Daniel R. Benson	1992
17	Allen S. Edmonson	1985
18	David S. Bradford	1984
19	Kenton D. Leatherman	1975
20	Denis S. Drummond	2002
21	Ronald L. DeWald	1988
22	Robert B. Winter	1974
23	Marc A. Asher	1997
24	Keith H. Bridwell	2003
25	Edward H. Simmons	1976
26	William J.Kane	1980
27	Gordon W.D. Armstrong	1981
28	Alvin H. Crawford	2001
29	Edgar G. Dawson	1995
30	Jessie H. Dickson	1990
31	John Carlisle Brown	1993
32	John E. Hall	1960-70
33	G. Dean MacEwen	1977-78
34	Donald P.K. Chan	1998
35	Courtney W. Brown	1999
36	David B. Levine	1979
37	George H. Thompson	2007-08
38	Oheneba Boachie-Adjei	2009
39	Richard E. McCarthy	2010

PAST MEETINGS AND OFFICERS

1ST ANNUAL MEETING

October 2-4, 1966 – Minneapolis, MN, USA

President	John H. Moe
Secretary-Treasurer	William J. Kane
Directors	William F. Donaldson
	Louis A. Goldstein
	John E. Hall
	Paul R. Harrington
	David B. Levine
	Jacquelin Perry

2ND ANNUAL MEETING

1967 – Minneapolis, MN, USA

President	John H. Moe
President-Elect	John E. Hall
Secretary-Treasurer	William J. Kane
Directors	William F. Donaldson
	Louis A. Goldstein
	Paul R. Harrington
	David B. Levine
	Jacquelin Perry

3RD ANNUAL MEETING

1968 – Houston, TX, USA

President	John H. Moe
President-Elect	John E. Hall
Secretary-Treasurer	William J. Kane
Directors	William F. Donaldson
	Louis A. Goldstein
	Paul R. Harrington
	David B. Levine
	Jacquelin Perry

4TH ANNUAL MEETING

Sept. 4-6, 1969 – Anaheim, CA, USA

President	John E. Hall
President-Elect	G. Dean MacEwen
Secretary-Treasurer	William J. Kane
Past President	John H. Moe
Directors	Allen S. Edmonson
	Richard M. Kilfoyle
	Jacquelin Perry
	James W. Tupper

5TH ANNUAL MEETING

Sept. 10-12, 1970 – Toronto, ON, CANADA

President	John E. Hall
President-Elect	G. Dean MacEwen
Secretary-Treasurer	William J. Kane
Sec.-Treas.-Elect	David B. Levine
Past President	John H. Moe
Directors	Robert P. Keiser
	Theodore R. Waugh, Jr.
	Robert C. Zuege

6TH ANNUAL MEETING

Sept. 8-10, 1971 – Hartford, CT, USA

President	G. Dean MacEwen
President-Elect	Paul R. Harrington
Secretary-Treasurer	David B. Levine
Past President	John E. Hall
Directors	Charles H. Herndon
	John C. Kennedy
	John H. Moe
	Frank C. Wilson, Jr.

7TH ANNUAL MEETING

1972 – Wilmington, DE, USA

President	G. Dean MacEwen
President-Elect	Paul R. Harrington
Secretary-Treasurer	David B. Levine
Treasurer-Elect	James H. Hardy
Past President	John E. Hall
Directors	Kenton D. Leatherman
	Lawrence Noall
	Albert C. Schmidt

8TH ANNUAL MEETING

1973 – Gothenburg, SWEDEN

President	Paul R. Harrington
President-Elect	Robert B. Winter
Secretary	David B. Levine
Treasurer	James H. Hardy
Past President	G. Dean MacEwen
Directors	Gordon W.D. Armstrong
	Kenton D. Leatherman
	Lawrence Noall

9TH ANNUAL MEETING

Sept. 11-13, 1974 – San Francisco, CA, USA

President	Robert B. Winter
President-Elect	Kenton D. Leatherman
Secretary	David B. Levine
Secretary-Elect	Theodore R. Waugh, Jr.
Treasurer	James H. Hardy
Past President	Paul R. Harrington
Directors	Gordon W.D. Armstrong
	R. Kirklin Ashley
	Wilton H. Bunch

10TH ANNUAL MEETING

Sept 10-12, 1975 – Louisville, KY, USA

President	Kenton D. Leatherman
President-Elect	Edward H. Simmons
Secretary	Theodore R. Waugh, Jr.
Treasurer	James H. Hardy
Past President	Robert B. Winter
Directors	R. Kirklin Ashley
	Wilton H. Bunch
	Ronald L. DeWald

11TH ANNUAL MEETING

Sept. 4-6, 1976 – Ottawa, ON, CANADA

President	Edward H. Simmons
President-Elect	Louis A. Goldstein
Secretary	Theodore R. Waugh, Jr.
Treasurer	James H. Hardy
Treasurer-Elect	Wilton H. Bunch
Past President	Kenton D. Leatherman
Directors	Ronald L. DeWald
	Robert B. Winter

12TH ANNUAL MEETING

Oct. 24-27, 1977 – HONG KONG

President	R. Kirklin Ashley
President (9/76-10/76)	Louis A. Goldstein
Secretary	Theodore R. Waugh, Jr.
Treasurer	Wilton H. Bunch
Past President	Edward H. Simmons
Directors	Jesse H. Dickson
	Kenton D. Leatherman
	Marr P. Mullen

PAST MEETINGS AND OFFICERS (continued...)

13TH ANNUAL MEETING

Sept. 13-15, 1978 – Boston, MA, USA

President	R. Kirklin Ashley
President-Elect	David B. Levine
Secretary	Theodore R. Waugh, Jr.
Secretary-Elect	Allen S. Edmonson
Treasurer	Wilton H. Bunch
Past President	Edward H. Simmons
Directors	Marr P. Mullen
	Clyde L. Nash, Jr.

14TH ANNUAL MEETING

Sept. 11-14, 1979 – Seattle, WA, USA

President	David B. Levine
President-Elect	William J. Kane
Secretary	Allen S. Edmonson
Treasurer	Wilton H. Bunch
Past President	R. Kirklin Ashley
Directors	James E. Holmblad
	Donald A. Jones
	S. Henry LaRocca
	Clyde L. Nash, Jr.

15TH ANNUAL MEETING

Sept. 17-19, 1980 – Chicago, IL, USA

President	William J. Kane
President-Elect	Gordon W.D. Armstrong
Secretary	Allen S. Edmonson
Treasurer	Wilton H. Bunch
Treasurer-Elect	John C. Brown
Past President	David B. Levine
Directors	James E. Holmblad
	Donald A. Jones

16TH ANNUAL MEETING

Sept. 16-18, 1981 – Montreal, QC, CANADA

President	Gordon W.D. Armstrong
President-Elect	Theodore R. Waugh, Jr.
Secretary	Allen S. Edmonson
Treasurer	John C. Brown
Past President	William J. Kane
Directors	James E. Holmblad
	Gordon L. Engler
	David S. Bradford

17TH ANNUAL MEETING

Sept. 22-25, 1982 – Denver, CO, USA

President	Theodore R. Waugh, Jr.
President-Elect	Clyde L. Nash, Jr.
Secretary	Allen S. Edmonson
Secretary-Elect	Robert N. Hensinger
Treasurer	John C. Brown
Past President	Gordon W.D. Armstrong
Directors	Gordon L. Engler
	David S. Bradford
	Morris A. Duhaime
	Harold K. Dunn

18TH ANNUAL MEETING

Sept. 28-Oct. 1, 1983 – New Orleans, LA, USA

President	Clyde L. Nash, Jr.
President-Elect	David S. Bradford
Secretary	Robert N. Hensinger
Treasurer	John C. Brown
Past President	Theodore R. Waugh, Jr.
Directors	Morris A. Duhaime
	Harold K. Dunn
	Edgar G. Dawson
	John P. Kostuik

19TH ANNUAL MEETING

Sept. 19-22, 1984 – Orlando, FL, USA

President	David S. Bradford
President-Elect	Allen S. Edmonson
Secretary	Robert N. Hensinger
Treasurer	John C. Brown
Treasurer-Elect	Gordon L. Engler
Past President	Clyde L. Nash, Jr.
Directors	Edgar G. Dawson
	John P. Kostuik
	Thomas I. Lowry

20TH ANNUAL MEETING

Sept. 17-20, 1985 – San Diego, CA, USA

President	Allen S. Edmonson
President-Elect	Wilton H. Bunch
Secretary	Robert N. Hensinger
Treasurer	Gordon L. Engler
Past President	David S. Bradford
Directors	Thomas I. Lowry
	Marc A. Asher
	L. Ray Lawson
	Albert B. Schultz

21ST ANNUAL MEETING

Sept. 21-25, 1986 – Hamilton, BERMUDA

President	Wilton H. Bunch
President-Elect	John P. Kostuik
Secretary	Robert N. Hensinger
Secretary-Elect	William P. Bunnell
Treasurer	Gordon L. Engler
Past President	Allen S. Edmonson
Directors	Marc A. Asher
	L. Ray Lawson
	Robert Gillespie
	John E. Lonstein

22ND ANNUAL MEETING

Sept. 15-19, 1987 – Vancouver, BC, CANADA

President	John P. Kostuik
President-Elect	Ronald L. DeWald
Secretary	William P. Bunnell
Treasurer	Gordon L. Engler
Past President	Wilton H. Bunch
Directors	Robert Gillespie
	Rae R. Jacobs
	John E. Lonstein
	Stuart L. Weinstein

23RD ANNUAL MEETING

Sept. 21-25, 1988 – Baltimore, MD, USA

President	Ronald L. DeWald
President-Elect	Robert N. Hensinger
Secretary	William P. Bunnell
Treasurer	Gordon L. Engler
Treasurer-Elect	Edgar G. Dawson
Past President	John P. Kostuik
Directors	Ralph W. Coonrad
	Denis S. Drummond
	Rae R. Jacobs
	Stuart L. Weinstein

24TH ANNUAL MEETING

Sept. 17-22, 1989 – Amsterdam, NETHERLANDS

President	Robert N. Hensinger
President-Elect	Jesse H. Dickson
First Vice President	John E. Lonstein
Secretary	William P. Bunnell
Treasurer	Edgar G. Dawson
Past President	Ronald L. DeWald
Directors	Daniel R. Benson
	Ralph W. Coonrad
	Denis S. Drummond
	Thomas S. Renshaw

PAST MEETINGS AND OFFICERS (continued...)

25TH ANNUAL MEETING

Sept. 23-27, 1990 – Honolulu, HI, USA

President	Jesse H. Dickson
President-Elect	John E. Lonstein
First Vice President	Daniel R. Benson
Secretary	William P. Bunnell
Secretary-Elect	Vernon T. Tolo
Treasurer	Edgar G. Dawson
Past President	Robert N. Hensinger
Directors	Robert W. Gaines, Jr.
	Thomas S. Renshaw
	Susan M. Swank
	Stephen J. Tredwell

26TH ANNUAL MEETING

Sept. 24-27, 1991 – Minneapolis, MN, USA

President	John E. Lonstein
President-Elect	Daniel R. Benson
First Vice President	John C. Brown
Secretary	Vernon T. Tolo
Treasurer	Edgar G. Dawson
Past President	Jesse H. Dickson
Directors	Alvin H. Crawford
	Robert W. Gaines, Jr.
	Stanley D. Gertzbein
	Stephen J. Tredwell

27TH ANNUAL MEETING

Sept. 23-26, 1992 – Kansas City, MO, USA

President	Daniel R. Benson
President-Elect	John C. Brown
First Vice President	Gordon L. Engler
Secretary	Vernon T. Tolo
Treasurer	Edgar G. Dawson
Treasurer-Elect	Courtney W. Brown
Past President	John E. Lonstein
Directors	Alvin H. Crawford
	Stanley D. Gertzbein
	Donald P.K. Chan
	Susan W. Swank

28TH ANNUAL MEETING

Sept. 18-23, 1993 – Dublin, IRELAND

President	John C. Brown
President-Elect	Gordon L. Engler
First Vice President	Edgar G. Dawson
Past President	Daniel R. Benson
Secretary	Vernon T. Tolo
Treasurer	Courtney W. Brown
Directors	Donald P.K. Chan
	Susan W. Swank
	Behrooz A. Akbarnia
	John A. Herring

29TH ANNUAL MEETING

Sept. 21-24, 1994 – Portland, OR, USA

President	Gordon L. Engler
President-Elect	Edgar G. Dawson
First Vice President	Vernon T. Tolo
Past President	John C. Brown
Secretary	Harry L. Shufflebarger
Treasurer	Courtney W. Brown
Directors	Behrooz A. Akbarnia
	John A. Herring
	William A. Carr
	Dennis R. Wenger

30TH ANNUAL MEETING

Sept. 13-16, 1995 – Asheville, NC, USA

President	Edgar G. Dawson
President-Elect	Vernon T. Tolo
First Vice President	Marc A. Asher
Past President	Gordon L. Engler
Secretary	Harry L. Shufflebarger
Treasurer	Courtney W. Brown
Directors	William A. Carr
	Dennis R. Wenger
	Thomas F. Kling, Jr.
	Jack K. Mayfield

31ST ANNUAL MEETING

Sept. 25-28, 1996 – Ottawa, ON, CANADA

President	Vernon T. Tolo
President-Elect	Marc A. Asher
First Vice President	Donald P.K. Chan
Past President	Edgar G. Dawson
Secretary	Harry L. Shufflebarger
Treasurer	Courtney W. Brown
Treasurer-Elect	William A. Carr
Directors	Thomas F. Kling, Jr.
	Jack K. Mayfield
	Keith H. Bridwell
	Thomas R. Haher

32ND ANNUAL MEETING

Sept. 25-27, 1997 – St. Louis, MO, USA

President	Marc A. Asher
President-Elect	Donald P.K. Chan
First Vice President	Courtney W. Brown
Past President	Vernon T. Tolo
Secretary	Harry L. Shufflebarger
Secretary-Elect	Denis S. Drummond
Treasurer	William A. Carr
Directors	Keith H. Bridwell
	Thomas R. Haher
	R. Mervyn Letts
	Michael G. Neuwirth

33RD ANNUAL MEETING

Sept. 16-20, 1998 – New York, NY, USA

President	Donald P.K. Chan
President-Elect	Courtney W. Brown
First Vice President	Harry L. Shufflebarger
Past President	Marc A. Asher
Secretary	Denis S. Drummond
Treasurer	William A. Carr
Directors	R. Mervyn Letts
	Michael G. Neuwirth
	John B. Emans
	James W. Ogilvie

PAST MEETINGS AND OFFICERS (continued...)

34TH ANNUAL MEETING

Sept. 23-25, 1999 – San Diego, CA, USA

President	Courtney W. Brown
President-Elect	Harry L. Shufflebarger
First Vice President	Alvin H. Crawford
Past President	Donald P.K. Chan
Secretary	Denis S. Drummond
Treasurer	William A. Carr
Directors	John B. Emans
	James W. Ogilvie
	John V. Banta
	Thomas G. Lowe

35TH ANNUAL MEETING

Oct. 18-21, 2000 – Cairns, AUSTRALIA

President	Harry L. Shufflebarger
President-Elect	Alvin H. Crawford
First Vice President	Denis S. Drummond
Past President	Courtney W. Brown
Secretary	John B. Emans
Treasurer	William A. Carr
Treasurer-Elect	Behrooz A. Akbarnia
Directors	John V. Banta
	Thomas G. Lowe
	John P. Lubicky
	George H. Thompson

36TH ANNUAL MEETING

Sept. 19-22, 2001 – Cleveland, OH, USA

President	Alvin H. Crawford
President-Elect	Denis S. Drummond
First Vice President	Keith H. Bridwell
Past President	Harry L. Shufflebarger
Secretary	John B. Emans
Treasurer	Behrooz A. Akbarnia
Directors	John P. Lubicky
	George H. Thompson
	Stewart I. Bailey
	Thomas S. Whitecloud, III

37TH ANNUAL MEETING

Sept. 18-21, 2002 – Seattle, WA, USA

President	Denis S. Drummond
President-Elect	Keith H. Bridwell
First Vice President	James W. Ogilvie
Past President	Alvin H. Crawford
Secretary	John B. Emans
Treasurer	Behrooz A. Akbarnia
Directors	Stewart I. Bailey
	Thomas S. Whitecloud, III
	Randal R. Betz
	Howard A. King

38TH ANNUAL MEETING

Sept. 10-13, 2003 – Quebec City, CANADA

President	Keith H. Bridwell
President-Elect	James W. Ogilvie
First Vice President	Randal R. Betz
Past President	Denis S. Drummond
Secretary	John B. Emans
Secretary-Elect	Thomas R. Haher
Treasurer	Behrooz A. Akbarnia
Treasurer-Elect	Richard E. McCarthy
Directors	Howard A. King
	Hubert H.L. Labelle
	John P. Dormans
	David W. Polly, Jr.

39TH ANNUAL MEETING

Sept. 6-9, 2004 – Buenos Aires, ARGENTINA

President	James W. Ogilvie
President-Elect	Randal R. Betz
First Vice President	Behrooz A. Akbarnia
Past President	Keith H. Bridwell
Secretary	Thomas R. Haher
Treasurer	Richard E. McCarthy
Directors	John P. Dormans
	David W. Polly
	Oheneba Boachie-Adjei
	Michael A. Edgar

40TH ANNUAL MEETING

Oct. 27-30, 2005 – Miami, FL, USA

President	Randal R. Betz
President-Elect	Behrooz A. Akbarnia
Vice President	George H. Thompson
Past President	James W. Ogilvie
Secretary	Thomas R. Haher
Treasurer	Richard E. McCarthy
Directors	Oheneba Boachie-Adjei
	Michael A. Edgar
	Steven M. Mardjetko
	Mark Weidenbaum

41ST ANNUAL MEETING

Sept. 13-16, 2006 – Monterey, CA, USA

President	Behrooz A. Akbarnia
President-Elect	George H. Thompson
Vice President	Thomas G. Lowe
Secretary	Thomas R. Haher
Treasurer	Richard E. McCarthy
Past President	Randal R. Betz
Past President	James W. Ogilvie
Past President	Keith H. Bridwell
Directors	Steven M. Mardjetko
	Mark Weidenbaum
	Paul D. Sponseller
	Nobumasa Suzuki

42ND ANNUAL MEETING

Sept. 5-8, 2007 – Edinburgh, SCOTLAND

President	George H. Thompson
President-Elect	Oheneba Boachie-Adjei
Vice President	Richard E. McCarthy
Secretary	Thomas R. Haher
Treasurer	Steven M. Mardjetko
Secretary-Elect	David W. Polly, Jr.
Past President	Behrooz A. Akbarnia
Past President	Randal R. Betz
Past President	James W. Ogilvie
Directors	Paul D. Sponseller
	Nobumasa Suzuki
	Lawrence G. Lenke
	B. Stephens Richards

PAST MEETINGS AND OFFICERS (continued...)

43RD ANNUAL MEETING

Sept. 10-13, 2008 – Salt Lake City, UT, USA

President	George H. Thompson
President-Elect	Oheneba Boachie-Adjei
Vice President	Richard E. McCarthy
Secretary	David W. Polly, Jr.
Treasurer	Steven M. Mardjetko
Past President	Behrooz A. Akbarnia
Past President	Randal R. Betz
Past President	James W. Ogilvie
Directors	Azim Hamzaogiu
	Lawrence G. Lenke
	B. Stephens Richards
	James W. Roach

44TH ANNUAL MEETING

Sept. 23 – 26, 2009 – San Antonio, TX, USA

President	Oheneba Boachie-Adjei
President-Elect	Richard E. McCarthy
Vice President	Lawrence G. Lenke
Secretary	David W. Polly, Jr
Treasurer	Steven M. Mardjetko
Past President	George H. Thompson
Past President	Behrooz A. Akbarnia
Past President	Randal R. Betz
Directors	Azmi hamzaoglu
	James W. Roach
	Kamal Ibrahim
	Kenneth MC Cheung

45TH ANNUAL MEETING

Sept. 21-24, 2010 – Kyoto, JAPAN

President	Richard E. McCarthy
President-Elect	Lawrence G. Lenke
Vice President	B. Stephens Richards, III
Secretary	David W. Polly, Jr.
Secretary-Elect	Hubert Labelle
Treasurer	Steven M. Mardjetko
Past President	Oheneba Boachie-Adjei
Past President	George H. Thompson
Past President	Behrooz A. Akbarnia
Directors	Kamal N. Ibrahim
	Kenneth MC Cheung
	J. Abbott Byrd, III
	Serena S. Hu

PREVIOUS AWARD & RESEARCH GRANT RECIPIENTS

POSTER AWARDS

1982	Ronald L. DeWald, Mary Faut Rodts, James S. Fister *The Management of Unstable Burst Fractures of the Thoracic and Lumbar Spine*
1984 (Blount)	R. Mervyn Letts and G.J.Gouw *Scoliosis in the Head Injured Child*
1985 (Blount)	Kiyoshi Kaneda, Tomoyuki Hashimoto, Shigenobu Satoh, Kuniyoshi Abumi *Late Progressive Neurologic Deficit Following Thoracolumbar Spine Fractures*
1986 (Blount)	Greg Houghton, Anne McInerny, Tony Tew *Compliance Monitoring System for Spinal Braces*
1987	Jeffrey H. Owen, Keith H. Bridwell *Motor (MEPs) and Somatosensory Evoked Potentials (SEPs) in Animals and Humans: Sensitivity and Specificity*
1991	Ian A.F. Stokes, Mack Gardner-Morse, Jeffrey P. Laible *The Biomechanics of Surgical Derotation*
1992	Tali Siegal, Tzony Siegal *Neoplastic Spinal Cord Compression: Manipulation of Vasogenic Edema by Ketanserin, a 5-HT2 Receptor Blocker*
1993	Kristian Høy, S.M. Jespersen, E.S. Hansen, K.Ø. Christensen, B.E. Lindblad, S.Z. He, C. Bunger *Hemodynamics of the Spinal Cord, Cauda Equina, Nerve Roots and the Dural Sac During Exercise - An Experimental Study*
1994 (Moe)	Kirkham B. Wood, Timothy A. Garvey, Cooper Gundry, Kenneth Heitoff *Thoracic MRI Evaluation of Asymptomatic Individuals*
1995 (Moe)	Michael P. Chapman, Christopher L. Hamill, Keith H. Bridwell, Lawrence G. Lenke, Kathy Blanke, Christy Baldus *Can We Lordose the Spine with Zielke Instrumentation Anteriorly?*
1996 (Moe)	Sakae Sato, Marc A. Asher *Comparison of Lamina Hook to Pedicle Screw Anchors for Correction of Double Structural Adolescent Idiopathic Scoliosis*
1997 (Moe)	Tatsuto Takeuchi, Kuniyoshi Abumi, Itaru Oda, Yasuhiro Shono, Kiyoshi Kaneda *Biomechanical Evaluation of Thoracic Spinal Stability: A Significance of Costovertebral Joints in Providing Stability*
1998 (Moe)	Itaru Oda, Bryan W. Cunningham, Charles J. Haggerty, Kiyoshi Kaneda, Paul C. McAfee *An In-Vitro Study Investigating the Stability of Reconstruction Methods Following Total Spondylectomy*
1999 Moe - Basic Science	Edward P. Southern, Howard S. An, Charles E. Edmiston, Jr., Larry Newman, Michael Goheen, Dawn Zuelke, Sharon Sinski, Gary Seabrook *A Microbiology and Lint Study in the Orthopaedic Surgery Operating Room*
1999 Goldstein Clinical	Christian Fras, Twee Do, Stephen Burke, Bernard Rawlins, Roger Widmann, Oheneba Boachie-Adjei *Routine Preoperative MRI in Adolescent Idiopathic Scoliosis: A Prospective Study of 327 Patients*
2000 Moe – Basic Science	R.K. Wilcox, T.O. Boerger, R.M. Hall, D.C. Barton, D.L. Limb, R.A. Dickson *Canal Pressure Measurements and Video Recording of Thoracolumbar Burst Fractures*
2000 Goldstein Clinical	Makoto Tokunaga, Shohei Minami, Hiroshi Kitahara, Yoshinori Nakata, Hideshige Moriya *Neurologic Complications in Scoliotic Patients with Syringomyelia*
2001 Moe – Basic Science	P.C. McAfee, B.W. Cunningham, A.E. Dmitriev, N. Shimamato, J.C. Sefter, I.L. Fedder *General Principles of Porous Ingrowth Total Disk Replacement Arthroplasty Compared to Diarthrodial Total Joint Arthroplasty. A Non-Human Primate Model – Part 1*
2001 Goldstein Clinical	Mohammed J. Al-Sayyad, Charles T. Mehlman, Alvin H. Crawford *Effectiveness of Spinal Release and Halo-Femoral Traction in the Management of Severe Spinal Deformity*

PREVIOUS AWARD & RESEARCH GRANT RECIPIENTS

2002 Moe – Basic Science	**Andrew A. Merola, Michael F. O'Brien, Amit Lamba, Gregorio Chejfec, Thomas R. Haher, Andrew Castro, Franco Givna, Sameer Mathur, Mario Brkavic, David A.B. Smith, James M. Eule, N. Joseph Espat, Thomas G. Lowe, Thomas F. Dwyer** *Attenuation of Cillary Neurotrophic Factor (CNTF) in Acute Spinal Cord Injury (ASCI) Treated with Intravenous Methylprednisolone (MP)*
2002 Goldstein Clinical	**Behrooz A. Akbarnia, David S. Marks, Oheneba Boachie-Adjei, Marc A. Asher, Alistair G. Thompson, Richard C. Rooney, Chatupon Chotigavanichaya** *Dual Rod Posterior Instrumentation Without Fusion for the Treatment of Progressive Early Onset Scoliosis: A Multicenter Study*
2003 Moe – Basic Science	**William W. Lu, Kenneth M.C. Cheung, Keith D.K. Luk, John C.Y. Leong** *A Novel Sr-HA Bioactive Bone Cement for Vertebroplasty*
2003 Goldstein Clinical	**Athanasios I. Tsirikos, Freeman Miller, Wei-Ning Chang, Kirk W. Dabney, Joseph Glutting** *Life Expectancy in Pediatric Patients with Cerebral Palsy and Neuromuscular Scoliosis who Underwent Spinal Fusion*
2004 Moe – Basic Science	**Vikas V. Patel, Li Zhao, Pamela Wong, Ben Bhupendra Pradhan, Linda Kanim, Hyun W. Bae, Rick B. Delamarter** *Controlling BMP-Simulated Bone Growth Using Fibrin Glue*
2004 Goldstein Clinical	**André van Ooij, F. Chumhur Oner, Ab J. Verbout** *Complications of Artificial Disc Replacement: A Report of 45 Patients with an Unconstrained Disc Prosthesis*
2005 Goldstein Clinical	**Gene Cheh, Lawrence G. Lenke, Keith H. Bridwell, Young-Jung J. Kim** *"Decompression Alone vs. Decompression and Limited Fusion for the Treatment of Degenerative Lumbar Scoliosis"*
2005 Moe – Basic Science	**Cathy Xiao Xi Guo, Kenneth McCheung, Danny Chan, Michael Irwin** *"Comparison of the Effect of Non-Selective NSAID and Cyclooxygenase-2 (COX-2) Selective NSAID on Bone Formation – Implications for Spinal Fusion"*
2006 Goldstein Clinical	**Clayton L. Dean, Josue P. Gabriel, Michael J. Bolesta, Ezequiel Cassinelli, Henry H. Bohlman** *Degenerative Spondylolisthesis of the Cervical Spine. A Long Term Follow-up Study*
2006 Moe – Basic Science	**Nancy Hadley Miller, Beth Marosy, Marie Helene Roy-Gagnon, Kimberly F. Doheny, Elizabeth W. Pugh, Alexander F. Wilson, Cristina M. Justice** *Familial Idiopathic Scoliosis: Defining Genomic Loci on Chromosomes 9 and 16 Utilizing Custom SNP Panels*
2007 Moe – Basic Science	**Jonathan G. Schoenecker, Nicholas Mignemi, Heidi Hamm, Herbert Schwartz, Ginger Holt, Gregory Mencio** *Aprotinin Inhibits Bone Formation In Vitro*
2007 Goldstein Clinical	**Mark J. Sokolowski, Timothy A. Garvey, John Perl, Amir A. Mehbod, Burak Akesen, Margaret S. Sokolowski, Ensor E. Transfeldt** *Prospective Study of Post-Operative Lumbar Epidural Hematoma: Does Size Really Matter?*
2008 Moe – Basic Science	**Chi Wai Gene Man; Hiu Yan Yeung, PhD; Wei Jun Wang, MPHIL; Kwong Man Lee, PhD; Bobby KW Ng, MD; Vivian W. Hung; Yong Qiu, MD; Jack Chun Yiu Cheng, MD** *A Study on the Effect of Melatonin Toward the Proliferation and Differentiation of Osteoblasts in Adolescent Idiopathic Scoliosis*
2008 Goldstein Clinical	**Daniel J. Sucato, MD, MS; Timothy R. Kuklo, MD, JD; Mohammad Diab, MD; B. Stephens Richards, III, MD; Charles E. Johnston, MD; Lawrence G. Lenke, MD; Spinal Deformity Study Group** *Risk Factors for Critical Intraoperative Neuromonitoring Changes During AIS Surgery*
2009 Moe – Basic Science	**Hong Zhang; Daniel J. Sucato, MD, MS** *Quantitative Histology of the Neurocentral Synchondrosis in a Growing Animal Scoliosis Model*
2009 Goldstein Clinical	**Jean-Marc Mac-Thiong; Stefan Parent; Benoit Poitras; Hubert Labelle** *Neurological Outcome Associated with Severely Misplaced Pedicle Screws: A Case Report*

PREVIOUS AWARD & RESEARCH GRANT RECIPIENTS

2010 Moe – Basic Science	Hong Zhang, MD and Daniel J. Sucato, MD, MS *Neurocentral Synchondrosis Screws to Create and Correct Experimental Deformity*
2010 Goldstein Clinical	J.C. Tassone, MD; Lynn M. Rusy, MD; Keri Hainsworth, PhD; Tom J. Nelson, PharMD; Michelle Czarnecki; John G. Thometz, MD; Roger Lyon, MD; Richard J. Berens, MD; and Steven Weisman, MD *A Randomized, Double Blind, Controlled Trial of Perioperative Gabapentin Use to Decrease Opiod Consumption in the Pediatric Idiopathic Spinal Fusion Patient*

PREVIOUS AWARD & RESEARCH GRANT RECIPIENTS

BEST DISCUSSOR

1984 Harold K. Dunn, MD
1985 Dennis R. Wenger, MD
1986 Vernon T. Tolo, MD
1988 Thomas F. Kling, Jr., MD
1989 J. Andy Sullivan, MD
1991 John E. Hall, MD
1992 Gordon L. Engler, MD

HIBBS AWARD FOR BEST BASIC SCIENCE PRESENTATION

1980 Kazuhiko Satomi, Jens Axelgaard
Effects of Selective Cord Transections on Spinal Evoked Potentials

1981 Ensor E. Transfeldt, Edward H. Simmons
Functional and Pathological Biomechanics of the Spinal Cord: An In Vivo Study

John A. Herring
Early Complications of Segmental Spinal Instrumentation

1982 R.G. Burwell, J.J. James, F. Johnson, J.K. Webb, Y.G. Wilson
Standardized Trunk Asymetry Scores: A New Method and a Study of Normality

Roger P. Jackson, E.J. Simmons, D. Stripinis
Structural Changes Correlating with Back Pain in Scoliosis

1983 Robert Barrack
Proprioception in Idiopathic Scoliosis

1984 Cohen, Solomons, Lowe
Altered Platelet Calmodulin Activity in Idiopathic Scoliosis

D. Hoppenfeld, Gross and Andrews
The Ankle Clonus Test

1985 Thomas F. Kling, Jr, P.M. Spargo, Robert N. Hensinger, P.R. Knight III
The Effect of Nitroglycerin Induced Hypotension With and Without Spine Distraction on Canine Spinal Cord Blood Flow

1986 William C. Schrader, Daniel Bethem, Vladimir Scerbin
The Chronic Local Effects of Sublaminar Wires - An Animal Model

1987 Jeffrey H. Owen, John Laschinger, Keith Bridwell, Shelle Shimon, Carl Nielsen, Janet Dunlap
Sensitivity and Specificity of Somatosensory and Neurogenic-Motor Evoked Potentials in Animals and Humans

1988 Steve K. Salzman, A.A. Mendez, A.S. Fonseca, E.B. Ingersol, G.M. Freeman, I.H. Choi
Effects of Anesthesia on Outcome After Experimental Spinal Trauma: Halothane has a Protective Effect

1989 Rick B. Delamarter, Henry H. Bohlman, D. Bodner, C. Biro
Urologic Function Following Experimental Cauda Equina Compression: Cystometrograms vs. Cortical Evoked Potentials

1990 Steven K. Salzman, Michael A. Puniak, Zhong-jun Liu, Richard P. Maitland-Heriot, Gina M. Freeman, Cynthia A. Agresta, Laura Van Newkirk
Pharmacological Treatment of Acute Spinal Trauma I: Mechanisms of Action of the Serotonin Antagonist Mianserin

1991 Dale Dalenberg, Marc A. Asher, Gopal Jayaraman, Ralph Robinson
The Effect of a Stiff Spinal Implant and Its Loosening on Bone Mineral Content in Canines

1992 Sanford E. Emery, Mark S. Brazinski, Anuradah Koka, Jay S. Bensusan, Sharon Stevenson
The Biological and Biomechanical Effects of Irradiation on Anterior Spinal Bone Grafts - A Canine Model

1993 Stephen D. Cook, Thomas S. Whitecloud, Jeannette E. Dalton, D.C. Rueger
In Vivo Evaluation of Recombinant Human Osteogenic Protein (rhOP-1) as a Bone Graft Substitute for Spine Fusions

1994 Jeffrey H. Schimandle, Scott D. Boden, W.C. Hutton
Experimental Spine Fusion with Recombinant Human Bone Morphogenetic Protein (rhBMP-2)

1995 Douglas M. Petraco, Jeffrey M. Spivak, Joseph G. Cappadona, Frederick J. Kummer, Michael G. Neuwirth
An Anatomic Evaluation of L5 Nerve Stretch in Spondylolisthesis Reduction

1996 S.B. Tan, J.T.H. Chew, R. Fortune, H.H. Tan, K.P. Tan, R.T.H. Ng, I.C. Song
Allograft Vertebral Disc Transplantation in a Porcine Model

1997 Keith M. Bagnall, Cian O'Kelly, Marc Moreau, James Raso, Xiaoping Wang
Scoliosis Development Following Pinealectomy in Young Chickens, Rats and Hamsters

1998 John R. Dimar II, Steven Glassman, George Raque, Y. Ping Zhang, Christopher Shields
The Influence of Canal Narrowing and Timing of Decompression on Neurological Recovery Following Spinal Cord Contusion in the Rat Model

1999 Jeffrey C. Wang, Stephen Yoo, Linda E.A. Kanim, Paula L. McAllister, Scott D. Nelson, Edgar G. Dawson, Jay R. Lieberman
Gene Therapy for Spinal Fusion: Transformation of Marrow Cells with an Adenoviral Vector to Produce BMP-2

PREVIOUS AWARD & RESEARCH GRANT RECIPIENTS

2000 **K.D. Riew, J. Lou, N.M. Wright, S.-L. Cheng, T. Bae, L.V. Avioli**
Thoracoscopic Intradiscal Spine Fusion Using Gene Therapy

2001 **M. Darryl Antonacci, Manu Nothias, Catherine Humphreys, Richard Frisch, Marion Murray**
Axonal Regeneration Using Transplants of Genetically Engineered Fibroblasts in Spinal Cord Injury

2002 **Kohei Goshi, Oheneba Boachie-Adjei, Bernard A. Rawlins, Ronald G. Crystal, Chisa Hidaka**
Genetically Modified Marrow Cells Enhance Spine Fusion

2003 **M. Darryl Antonacci, Jean Nothias, Tom Parks, Richard Fritsch, Chris Cawley, Marion Murray**
Human Marrow Stromal Cell Transplants in a Collagen Matrix Support Axonal Regeneration of Descending Pathways Across Complete Spinal Cord Transections

2004 **William C. Horton, Chaiwat Kraiwattanapong, Tomoyuki Akamaru, Akihito Minamide, Moon-Soo Park, William Hutton**
The Role of the Sternum, Costosternal Articulations, Intervertebral Disc, and Facets in Thoracic Sagittal Plane Biomechanics and Deformity Correction: A Comparison of Three Different Sequences of Surgery

2005 **Brian K. Kwon, Jie Liu, Clarrie Lam, Loren W. Oschipok, Armin Blesch, Wolfram Tetzlaff**
"Brain Derived Neurotrophic Factor Gene Transfer with Adeno-Associated Viral and Lentiviral Vectors Prevents Rubrospinal Neuronal Atrophy and Stimulates Regeneration Associated Gene Expression after Acute Cervical Spinal Cord Injury"

2006 **Howard S. An, Kei Miyamoto, Jesse G. Kim, Nozomu Inoue, Koji Akeda, Gunnar Andersson, Koichi Masuda**
An Intradiscal Injection of Osteogenic Protein-1 Restores the Viscoelastic Properties of Degenerated Intervertebral Discs in the Rabbit Anular Puncture Model

2007 **Kenneth J. Hunt, John T. Braun, Bryt A. Christensen**
The Effect Of Two Clinically Relevant Fusionless Scoliosis Implant Strategies On The Health of the Intervertebral Disc

2008 **Hemal Mehta, MSc; Brian D. Snyder, MD, PhD; Stephen R. Baldassarri, BA; Melissa J. Hayward, MD; Michael J. Giuffrida, MD; Supriya P. Bansal, BS; Vahid Entezari, MD; Nipun D. Patel, MS; Andrew C. Jackson, PhD**
VEPTR Improves Pulmonary Hypoplasia in a Postnatal Rabbit Model of Thoracic Insufficiency Syndrome

2009 **Francis Shen; Qing Zeng; Gary Balain**
Influence of GDF-5 on Osteogenic Differenciation of Adipose-Derived Stromal Cells in a Three-Dimensional Microsphere Matrix (Plaga)

2010 **Hitesh N. Modi, MS, PhD; Seung-Woo Suh, MD, PhD; Jae Hyuk Yang, MD; Jae-Young Hong, MD**
Effect of Spinal Shortening on Motor-Evoked Potentials and Spinal Cord Blood Flow

HIBBS AWARDS FOR BEST CLINICAL PRESENTATION

1981 **John A. Herring, Dennis R. Wenger**
Early Complications of Segmental Spinal Instrumentation

1982 **Roger P. Jackson, Edward H. Simmons, D. Stripinis**
Structural Changes Correlating with Back Pain in Scoliosis

1984 **Hoppenfeld, Gross and Andrews**
The Ankle Clonus Test

1985 **Bert Mandelbaum, Vernon Tolo, Paul McAfee, Peggy Buresh**
Nutritional Deficiencies After Staged Anterior and Posterior Spinal Surgery

1986 **Paul D. Sponseller, Mark S. Cohen, John E. Hall, Alf L. Nachemson**
Long-Term Follow-Up of Adult Scoliosis Treated Surgically

1987 **Christine S. O'Donnell, William P. Bunnell, Randal R. Betz, Cynthia R. Tipping**
Electrical Stimulation in the Treatment of Idiopathic Scoliosis

1988 **John E. Lonstein, Robert B. Winter**
Milwaukee Brace Treatment of Adolescent Idiopathic Scoliosis - Review of 939 Patients

1989 **J.P. Thompson, Ensor E. Transfeldt, David Bradford, Oheneba Boachi-Adjei**
Evaluation of Spinal Imbalance and Shoulder Elevation Following Cotrel-Dubousset Instrumentation with Special Reference to Uncoupling

1990 **David M. Apel, G. Marrero, W.D. Goldie, J. King, Vernon T. Tolo, George S. Bassett**
Avoiding Paraplegia During Anterior Spinal Surgery: The Role of SSEP Monitoring During Temporary Occlusion of Segmental Spinal Arteries

1991 **Lawrence G. Lenke, Keith H. Bridwell, Christy Baldus, Kathy Blanke**
Preventing Decompensationin King Type II and III Curves Treated with Cotrel-Dubousset Instrumentation (CDI): 24 to 64 Month Follow-Up

D. Holte, Robert Winter, John Lonstein, Francis Denis
Hemivertebra Excision and Wedge Resection in the Surgical Treatment of Patients with Congenital Scoliosis

PREVIOUS AWARD & RESEARCH GRANT RECIPIENTS

1992 **Shanti S. Upadhyay, P. Sell, B. Sell, M.J. Saji, E.K.W. Ho, J.Y.C. Leong**
Seventeen Year Prospective Study of Surgical Management of Tuberculosis of the Spine: A Controlled Trial Comparing Anterior Debridement with Hong Kong Radical Operation

1993 **Mark Goldberg, Nancy Mayo, Benoit Poitras, Susan Scott, James Hanley**
The Ste-Justine Adolescent Idiopathic Scoliosis (AIS) Cohort Study I & II: Description of the Cohort Health Outcomes and Back Pain

1994 **Thomas Haher, R. Zipnick, D. Manor, Andrew Merola, John Gorup, J. Dryer, R. Nucci, J. Orchowski, C. Kaufmann**
Meta-Analysis of Surgical Outcome in Scoliosis: A Thirty One Year Review of Eleven Thousand Patients

1995 **Howard H. Ginsburg, L. Goldstein, P. William Haake, Shannon Perkins, K. Gilbert**
Longitudinal Study of Back Pain in Postoperative Idiopathic Scoliosis: Long-Term Follow-Up, Phase IV

1996 **James O. Sanders, David G. Little, B. Stephens Richards**
Prediction of the Crankshaft Phenomenon by the Peak Growth Age

1997 **John P. Kostuik**
The Development of a Preoperative Scoring Assessment System of Metastatic Spine Disease

1998 **Stuart L. Weinstein, Lori Dolan, Kevin Spratt, Kirk Peterson, Mark Spoonamore**
Natural History of Adolescent Idiopathic Scoliosis: Back Pain at 50-Year Follow-Up

1999 **Marc A. Asher, Sue Min Lai, Douglas C. Burton**
Further Development and Validation of the SRS Outcomes Instrument

Hiroshi Taneichi, Kiyoshi Kaneda, Kuniyoshi Abumi, Manabu Ito
Radiological Differentiation Between Benign and Malignant Vertebral Body Collapse

2000 **R. Jhanjee, K. Wood, G. Buttermann, T. Garvey, R. Kane, V. Sechreist, A. Mehbod**
Operative Vs. Nonoperative Treatment of Thoracolumbar Burst Fractures without Neurological Deficit: A Randomized, Prospective Study

2001-TIE **Aina J. Danielsson, I. Wiklund, K. Pehrsson, Alf L. Nachemson**
Health-Related Quality of Life in Patients with Adolescent Idiopathic Scoliosis – A Matched Follow-Up at Least Twenty Years After Treatment with Brace or Surgery

Harry L. Shufflebarger, Cynthia Clark
The Posterior Approach for Lumbar and Thoracolumbar Adolescent Idiopathic Curves: Posterior Shortening and Pedicle Screws

2002 **C. Barrios, C. Pérez-Encinas, J.I. Maruenda, P. Renovell, N. de Bernardo, L. García del Moral, J.A. Martín-Benlloch, M. Laguía**
Significant Ventilatory Functional Restriction in Adolescents with Mild or Moderate Scoliosis During Maximal Exercise Tolerance Test

2003 **Eric J. Wall, Donita Bylski-Austrow, Ronald Kolata, Alvin H. Crawford**
Endoscopic Mechanical Spinal Hemiepiphysiodesis Modifies Spine Growth

2004 **Christopher Hulen, H. Temple, Allaaddin Mollobashy, Frank Eismont**
Oncological and Functional Outcome Following Sacrectomy for Sacral Tumors

2005 **Ilkka Helenius, Tommi Lamberg, Kalevi Österman, Dietrich Schlenzka, Timo Yrjönen, Seppo Seitsalo, Mikko Poussa, Ville Remes**
"Posterolateral, Anterior or Circumferential Fusion In-Situ for High-Grade Spondylolisthesis in Young Patients: A Long-Term Evaluation using SRS Questionnaire"

2006 **Joshua D. Auerbach, Daniel M. Schwartz, Denis S. Drummond, Kristofer J. Jones, John M. Flynn, Yaser El-Gazzar, Thomas McPartland, J. Andrew Bowe, Samuel Laufer, Peter D. Pizzutillo, J. Richard Bowen, John P. Dormans**
Detection Of Impending Neurologic Injury During Surgery For Adolescent Idiopathic Scoliosis: A Comparison Of Transcranial Motor And Somatosensory Evoked Potential Monitoring In 1121 Consecutive Cases

2007 **Lawrence G. Lenke; Brenda A. Sides; Linda Koester; Marsha Hensley; Kathy Blanke**
Posterior Vertebral Column Resection (VCR) for Severe Pediatric and Adult Spinal Deformity: Indications, Results, and Complications of 43 Consecutive Cases

2008 **Michael D. Daubs, MD; Alpesh Patel, MD; Darrel S. Brodke, MD**
Clinical Instinct vs. Standardized Questionnaire: The Spinal Surgeon's Ability to Detect Psychological Distress

2009 **Justin Smith; Christopher I. Shaffrey; Steven D. Glassman; Sigurd Berven; Christopher Hamill; William C. Horton; Stephen L. Ondra; Frank Schwab; Charles A. Sansur; Keith H. Bridwell**
Risk-Benefit Assesment of Surgery for Adult Scoliosis: An Analysis Based on Patient Age

2010 **Kushagra Verma, MS; Thomas Errico, MD; Neil Bharucha; Christopher Diefenbach, BS; Laura E. Dean, BA; Shaun Xavier, MD; Joseph Dryer; Tessa Huncke, MD; Kirsten Boenigk, MD, PhD; Baron S. Lonner, MD**
Do Intra-Operative Antifibrinolytics Reduce Blood Loss in Adolescent Idiopathic Scoliosis? A Prospective Randomized Comparison

PREVIOUS AWARD & RESEARCH GRANT RECIPIENTS

WALTER P. BLOUNT HUMANITARIAN AWARD

1987 Marc A. Asher, MD
1989 Howard and Barbara Schulman
1992 Laura Gowen
1996 David B. Levine, MD
1997 Albert E. Sanders, MD
1998 L. Ray Lawson, MD
2001 Charles F. Heinig, MD
2002 James E. Holmblad, MD
2006 Oheneba Boachie-Adjei, MD
2007 Professor John CY Leong
2008 Behrooz A. Akbarnia, MD
2009 Robert M. Campbell, MD
2010 Jean Dubousset, MD
2011 James W. Ogilvie, MD

LIFETIME ACHIEVEMENT AWARDS

2008 John E. Hall, MD
Jacqueline Perry, MD, DSc

2009 Marc A. Asher, MD
David B. Levine, MD

2010 Clyde "Les" Nash, Jr., MD, MS MedEd
John P. Kostuik, MD

2011 Denis S. Drummond, MD
Ronald L. DeWald, MD

SRS TRAVELLING FELLOWS

1970 John D. King, California
Jen Fang Wang, Taiwan

1971 Donald P.K. Chan, Vermont
Gourish R. Palekaar, India

1993 **Medtronic Sofamor Danek Traveling Fellows**
Robert B. Winter, MD, Senior Fellow
George S. Bassett, MD, Junior Fellow
J. Kenneth Burkus, MD, Junior Fellow
Ensor E. Transfeldt, MD, Junior Fellow

1995 **Medtronic Sofamor Danek Traveling Fellows**
John E. Hall, MD, Senior Fellow
Howard S. An, MD, Junior Fellow
Hubert H.L. Labelle, MD, Junior Fellow
Lawrence G. Lenke, MD, Junior Fellow

1997 **Medtronic Sofamor Danek Traveling Fellows**
Ronald L. DeWald, MD, Senior Fellow
Vincent Arlet, MD, Junior Fellow
Allen L. Carl, MD, Junior Fellow
Michael F. O'Brien, MD, Junior Fellow

1999 **Medtronic Sofamor Danek Traveling Fellows**
Clyde L. Nash, MD, Senior Fellow
Serena S. Hu, MD, Junior Fellow
Joseph Y. Margulies, MD, PhD, Junior Fellow
Rolando M. Puno, MD, Junior Fellow
Kirkham B. Wood, MD, Junior Fellow

2000 **DePuy AcroMed International Traveling Fellows**
Ufuk Aydinli, MD, Turkey
Henry F.H. Halm, MD, Germany
Yutaka Hiraizumi, MD, PhD, Japan

2001 **Medtronic Sofamor Danek Traveling Fellows**
John P. Kostuik, MD, Senior Fellow
Peter O. Newton, MD, Junior Fellow
Richard M. Schwend, MD, Junior Fellow
Edward P. Southern, MD, Junior Fellow

2002 **DePuy AcroMed International Traveling Fellows**
Bruce F. Hodgson, FRACS, New Zealand
Jin-Hyok Kim, MD, Korea
Muharrem Yazici, MD, Turkey
(Note: Tamás Illés, MD, Hungary, was originally selected but unable to participate)

2003 **Medtronic Sofamor Danek Traveling Fellows**
Courtney W. Brown, MD, Senior Fellow
Timothy R. Kuklo, MD, Junior Fellow
Daniel J. Sucato, MD, Junior Fellow
Alexander R. Vaccaro, MD, Junior Fellow

2004 **DePuy Spine International Traveling Fellows**
Ahmet Alanay, MD, Turkey
Kenneth M.C. Cheung, MD, Hong Kong
Ulf R. Liljenqvist, MD, Germany

2005 **Medtonic Somamor Danek Traveling Fellows**
Donald P.K. Chan, MD, Senior Fellow
Matthew B. Dobbs, MD, Junior Fellow
Charles T. Mehlman, MD, Junior Fellow
Suken Shah, MD, Junior Fellow

2006 **DePuy Spine International Traveling Fellows**
Theodoros B. Grivas, MD, Greece
Ashok Johari, MD, India
Reinhard D. Zeller, MD, France

PREVIOUS AWARD & RESEARCH GRANT RECIPIENTS

2007 **Medtronic Traveling Fellows**
James Ogilvie, MD, Senior Fellow
Youngjung Kim, MD, Junior Fellow
Praveen Mummaneni, MD, Junior Fellow
Jean Ouellet, MD, Junior Fellow

2008 **DePuy Spine International Traveling Fellows**
Kyu-Jung Cho, MD, South Korea
Kan Min, MD, Switzerland
Avraam Ploumis, MD, Greece

2009 **Medtronic Spine International Traveling Fellows**
Alvin H. Crawford, MD - Senior Traveling Fellow
Jacob Buchowski, MD, MS
Frank LaMarca, MD
Francis Shen, MD

2010 **DePuy Spine International Traveling Fellows**
S. Rajasekaran, MD, PhD
Katsushi Takeshita, MD
Jun Young Yang, MD, PhD

2011 **Medtronic Traveling Fellows**
Harry L. Shufflebarger, MD – Senior Travelling Fellow
Khaled Kebaish, MD
Ronald Lehman, MD
Jean Marc Mac-Thiong, MD

RESEARCH GRANT RECIPIENTS

In the last ten years, SRS, in conjunction with OREF and the Cotrel Foundation have provided more than $1.8 million for spinal deformity research projects. The following are previous SRS Research Grant recipients:

1998

Nancy Hadley Miller, MD
Genetic Anaylsis of Etiologic Factors of AIS
$50,000 – 2 years

John A. Szivek, PhD
Monitoring Spinal Fusion in Scoliosis Patients: A Biomechanical & In Vivo Study
$54,000 – 2 years

Jack Engsberg, PhD
Comparison of Outcome Measures in Adult Scoliosis Patients Undergoing an Extended Spinal Fusion to L5 or Sacrum or Revision of Previous Long Spinal Deformity Fusion
$80,308 – 3 years

William A. Vannah
Longitudinal Study of Balance & Other Factors in AIS
$10,887.50 – 2 years

1999

Jack C.Y. Cheng, MD
The Loss of Synchronous Coupling of Endochrondral and Membranous Ossification in AIS: The Morphological and Biological Evidences
$35,400 – 1 year

James O. Sanders, MD
A Determination of Maturity in Girls with Idiopathic Scoliosis: A Pilot Study
$48,252 - 2 years

2000

Keith Bagnall, PhD
The Relationship Between Serum Melatonin & Growth Hormone in Pinealectomy Model
$14,250 – 2 years

Oheneba Boachie-Adjei, MD w/ Dr. Raymond Clarke
Developmental Basis of the Klippel-Feil Syndrome
$60,000 – 3 years

Frances Farley, MD
Prediction of Curve Progression in Congenital Scoliosis Using a Mouse Model
$44,926 – 2 years

Carol A. Wise, PhD
Localization of a Gene for Susceptibility To Idiopathic Scoliosis
$36,066.50 – 2 years

Nancy Hadley Miller, MD
Genetic Linkage of Familial Idiopathic Scoliosis – A Complex Orthopaedic Disorder
$50,000 – 2 years

Thomas Lowe, MD
Platelet Calmodulin Levels in AIS: A Predictor of Curve Progression and Severity
$42,070 – 2 years

2001

Jack C.Y. Cheng, MD
Relationship between Postural Balance, Somatosensory Evoked Potential and the Progression of Scoliotic Deformity in the AIS
$70,800 – 2 years

2002

Carol Wise, PhD
Localization & Analysis of Candidate Genes of Idiopathic Scoliosis
$36,666.50 – 2 years

PREVIOUS AWARD & RESEARCH GRANT RECIPIENTS

2003

Jack. C.Y. Cheng, MD
Are VDR, Era and PTHR1 Genes Associated With The Occurrence as well As Abnormality In Bone Growth And Sexual Maturation In Adolescent Idiopathic Scoliosis
$70,800 – 2 years

John Kostuik, MD
Adult Onset of Scoliosis: Relationship between Osteoporosis and Deformity
$30,000 – 2 years

Matthew Dobbs, MD
Idiopathic Scoliosis: Gene Mapping Identification
$47,177 – 2 years

2004

Philip Giampietro, MD, PhD
Mutation Analysis is Human Congenital Scoliosis and Vertebral Malformations
$77,077 – 2 years

Carol Wise, PhD
Localization and Analysis of Candidate Genes for Idiopathic Scoliosis
$50,000 – 2 years

Ralph Marcucio, PhD
A Comparison of the Expressions of Malatonin, Calmodulin and 5-HT4 in Paravertebral Muscle and Platelets of Patients with our without Adolescent Idiopathic Scoliosis
$50,000 – 2 years

2005

Kenneth Cheung, MD
Surface Modification of Nitinol by Plama Immersion ION Implantation
$100,000 – 2 years

Robin Patel, MD
Biofilms and Spinal Instrumentation
$99,850 – 2 years

Alf Nachemson, MD, PhD
A Continuation of the "SRS Study for Brace Treatment of Adolescent Idiopathic Scoliosis" – Follow-up of the Swedish Patients at Least 10 Years After Maturity
$47,020 – 2 years

Brian Snyder, MD, PhD
How does VEPTR Affect Pulmonary Function: An In-vivo Assessment using the Rabbit Scoliosis Model
$34,408 – 1 year

Stefan Parent, MD, PhD
Analysis of Local 3-D Measurements of the Curve as Predictive Factors for Curve Progression in AIS
$25,000 – 1 year

Francis Shen, MD
Can We Eliminate the Need for Autologous Bone Graft Harvest? The Use of Multipotential Adipose-derived Stromal Cells in an Activated Matrix for Posterolateral Spinal Fusions
$25,000 – 1 year

Andrew Merola, MD
Association between an Aggrecan Gene Polymorphism and AIS
$10,000 – 1 year

Anthony Florschutz, MD
Experimental Scoliosis Using Vertebral Body Implanted Magnets in an Immature Goat Model
$10,000 – 1 year

Stefan Parent, MD, PhD
Growth Modulation of the Chest Case in a Pre-Natal Ovine Model: A Preliminary Study
$10,000 – 1 year

Andrew Mahar, MS
How Does Increasing Curve Magnitude in Scoliotic Deformity Affect the Biomechanics of the Spine with Implications Toward Curve Correction?
$10,000 – 1 year

Donita Bylski-Austrow, PhD
Mechanbiology of Growth: In-Vivo Growth Plate Pressures
$10,000 – 1 year

Felix Breden, BA, MSc, PhD
The Guppy 'Curveback' Mutant as a Model for Spinal Deformity
$10,000 – 1 year

Jack C.Y. Cheng, MD
Abnormal Differential Longitudinal Growth of Vertebral Column and Spinal Cord in AIS – A Morphological and Functional Study
$77,000

Brian K. Kwon, MD, PHD, FRCSC
Neuroprotection for Acute Spinal Cord Injury: The Preclinical Evaluation of Drugs That Are Currently Used in Human Non-Spinal Applications
$24,881.60 – 2 years

PREVIOUS AWARD & RESEARCH GRANT RECIPIENTS

2006

Carol Wise, PhD
Identification of Genetic Susceptibility in Idiopathic Scoliosis
$19,000 – 2 years

Shane Burch, MD FRCSC
The Role of Hypoxic Stress on the Vertebral Growthplates of the Developing Spine and its Potential Role in Pathogenesis of Scoliosis
$10,000 – 1 year

Vedat Deviren, MD
The Minimal Clinically Important Difference (MCID) for Spinal Disorders: Finding the Threshold of Clinically Significant Change
$24,996 – 1 year

2007

Jeffrey Shilt, MD; Peter Apel, MD
Temporary Unilateral Paraspinal Muscle Paralysis on the Prevention and Progression of Scoliosis: Investigation in a Chicken Model
$9,740 - 1 year

Mohammad Diab, MD
Comparison of Extended-Release Epidural Morphine, Patient-Controlled Epidural Analgesia and Patient-Controlled Intravenous Analgesia for Postoperative Pain after Posterior Spinal fusion in Adolescents
$24,245 – 2 years

Frank Schwab, MD
Adult Deformity: Development of an Effective Treatment Algorithm Based upon Outcomes Analysis
$50,000 – 2 years

John Lonstein, MD
Long-trem Function Outcomes of Early Fusions for Congenital Scoliosis
$75,450 – 2 years

Michael Vitale, MD
CT Analaysis of Pedicle Screw Placement in Pediatric Patients
$20,595 – 1 year

Vidyadhar Upasani, MD
The Effect of Increasing Construct Rigidity on Intervertebral Disc Health: A Pilot Study in a Porcine Anterior Spinal Growth Modulation Model
$10,000– 1 year

Xudong Li, MD
Nucleus Pulposus Regeneration with Genetically Engineered Fat-derived Stem Cells
$50,000 – 2 years

Josh Auerbach, MD
An in vivo Porcine Animal Model to Detect Spinal Cord Vascular Flow in Spinal Deformity Surgery using Transcranial Motor Evoked Potential Monitoring
$10,000 – 1 year

2008

David Aronsson, MD
The Contribution of Asymmetric Growth and Vertebral Remodeling to Apical Wedging
$41,829 – 2 years

Sigurd Berven, MD
Impact of Spinal Disorders on Health Related Quality of Life
$5,000 – 1 year

Andrew Briggs, MD
Measurement of Vertebral Subregional Bone Mineral Density using Lateral-Projection DXA: Establishing Concurrent and Predictive Validity
$10,000 – 1 year

Shane Burch, MD
Monitoring of Nerve Root Injury Using Transcranial Motor-Evoke Potentials in a Pig Model
$23,255 – 2 years

Qian Chen, PhD
The Potential Role of Fibronection in the Pathogenesis of Congenital Scoliosis
$25,000 – 1 year

Daniel Y.T. Fong, MD
Single-Blind Comprehensive Cohort Study Incorporating A Randomized Controlled Design on Bracing in AIS: A Feasibility Study
$25,000 – 2 years

Safdar Khan, MD
Utilizing a Novel MRI-based (Dense-FSE) Technique to Characterize Spatial Strain Distributions in an Estalbished Model of Intervertebral Disc Degeneration: Implications for Tissue Engineering
$10,000 – 1 year

Hubert Labelle, MD
Towards a 3D Classification of Adolescent Idiopathic Scoliosis
$49,600 – 2 years

Carol Wise, PhD
Identification of Genetic Susceptibility in Idiopathic Scoliosis
$60,000 – 1 year

PREVIOUS AWARD & RESEARCH GRANT RECIPIENTS

2009

Kirkham Wood, MD
Correlation of Adjacent Segment Degeneration and Quality of Life Outcome: Application an In-Vivo Biomechanics to Assess the Effect of Fusion in AIS
$50,000 – 2 years

Hongbo Liu, MD
United States' Trends and Regional Variations in Lumbar Spine Surgery for Children with Spondylolysis and Spondylolisthesis
$10,000 – 1 year

2010

Lisbet Haglund, PhD
The influence of asymmetric loading on the structure and metabolism of the human invertebral disc
$25,000 – 2 years

Michelle Marks, PT, MA
Prospective Study of Motion Preservation Evaluation below Fusions of the Spine in Adolescent Idiopathic Scoliosis
$24,954 – 2 years

Delphine Perie-Curnier, PhD
Toward the etiology of Idiopathic Scoliosis using the distribution patterns of quantitative MR parameters within the intervertebral discs as predictive factors of progression
$25,000 – 2 years

Eric Varley, DO
Growth Plate and Intervertebral Cellular Responses to Spinal Growth Modulation with Asymmetric Tether: A Pilot Study in a Immature Porcine Model
$10,000 – 1 year

Phillip F. Giampietro, MD, PhD
Identification of a Locus for Idiopathic Scoliosis on Chromosome 12p
$100,000 – 2 years

Guang-Qian Zhou, MD, PhD
Molecular Analysis of the BMP-7 Action of Intervertebral Disc Cells
$25,000 – 2 years

Nobuhiro Kamiya, MD, PhD
Impact of Cartilage-dependent Ras-MAPK Signaling on Scoliosis
$25,000 – 2 years

Kelvin Yeung, MD
"SMART" internal spinal orthosis for gradual correction of spinal deformities
$24,954 – 2 years

Eric Parent, PhD
A Pilot Study for a Randomized Control Trial to Develop a Prediction Rule to Identify Patients with Adolescent Idiopathic Scoliosis and Schroth Curve Type 3c who will Respond to Schroth Exercises
$10,000 – 1 year

BYLAWS

BYLAWS

ARTICLE I

NAME

The name of this corporation shall be the "Scoliosis Research Society" (hereinafter referred to as the "Society). The Society is a nonstock, not-for-profit corporation organized under the Illinois Revised Statutes.

ARTICLE II

OBJECTIVES, PURPOSES AND POWERS

Section 2.1 Objectives and Purposes. The Society has been organized, and shall at all times be operated, exclusively for charitable, educational and scientific purposes within the meaning of section 501(c)(3) of the Code (as defined in Section 20.3, below), which purposes shall include, but not be limited to, the fostering, promotion, support, augmentation, development and encouragement of (a) investigative knowledge of the causes, cures and prevention of Scoliosis and related spinal deformities; (b) standardization of medical terminology in Scoliosis and related spinal deformities; (c) basic research in the field of Scoliosis and related spinal deformities; (d) the teaching and education of the same by developing, publishing and copyrighting educational material and providing specialized training for orthopaedic surgeons, neurosurgeons, and other members of the medical profession; and (e) education of the public with respect to the recognition and prevention of Scoliosis and related spinal deformities.

Section 2.2 Powers. The Society shall possess all powers which a corporation organized under the General Not-For-Profit Corporation Act of the State of Illinois, as the same from time to time may be amended shall possess; all powers which are not in conflict with said purposes; provided, however, the Society shall not engage in any business which would disqualify it from being exempt from taxation under Sections 501(a) or (c) (3) of the Code.

Section 2.3 Prohibited Practices. Notwithstanding anything in these Bylaws or the Society's Articles of Incorporation to the contrary, the Society shall exercise only those powers or engage in or carry on only those activities permitted to be exercised, engaged in or carried on by an organization exempt from federal income tax under Sections 501(c) (3) and 509(a) (1) of the Code and by an organization contributions to which are deductible under Section 170(c) (2) of the Code. The Society shall not engage in any activities which would result in the imposition of federal tax under Sections 4941 through 4945, inclusive, of the Code. No part of the net earnings of the Society shall inure to the benefit of any private individual, except that the Society shall be authorized and empowered to pay reasonable compensation for services rendered and to make payments and distributions in furtherance of the exempt purposes set forth in Section 2.1 of these Bylaws. No substantial part of the activities of the Society shall consist of carrying on propaganda or otherwise attempting to influence legislation, except as otherwise provided in subsection 501(h) of the Code, and the Society shall not participate or intervene in, including the publication or distribution of statements, any political campaign on behalf of or in opposition to any candidate for public office. In the pursuit of its purposes and the exercise of its powers, the Society shall make its services and activities available to the community that it serves regardless of, and shall not discriminate on the basis of, race, color, gender, sexual orientation, creed, religion or national origin.

ARTICLE III

OFFICES

Section 3.1 Principal and Business Offices. The Society may have such principal and other business offices as the Board of Directors may designate. The current principal offices are located at 555 East Wells Street, 11th Floor, Suite 1100, Milwaukee, Wisconsin 53202.

Section 3.2 Registered Agent. The Society shall maintain a registered agent as required by the Illinois Revised Statutes whose address may be, but need not be, identical with the principal office of the Society. The name and address of the registered agent may be changed from time to time by the Board of Directors.

Section 3.3 Records. The Board of Directors may keep the books of the Society in such place or places, including, without limitation, an authorized agent, as they may from time to time determine in accordance with the Illinois Revised Statutes.

ARTICLE IV

CLASSES OF FELLOWSHIP

Section 4.1 Identification of Fellow Classes. The Society shall have members, which shall hereinafter be referred to as "Fellows." There shall be six (6) classes of membership (such term herein after referred to as "Fellowship") in the Society, namely, Candidate, Active, Inactive, Associate, Emeritus, and Honorary. Any reference to Fellows in these Bylaws refers to all six (6) classes of Fellowship, unless otherwise specified. Only Active Fellows shall have the right to vote on matters submitted to a vote of the members of the Society, hold office or serve on the Board of Directors. Otherwise, Fellows of any class shall have the same rights and responsibilities including the right to attend meetings and serve on Committees or Councils. Fellowship status in any class shall be a privilege, not a right, and is dependent upon the applicant for any class of Fellowship demonstrating compliance with the requirements for such Fellowship as defined in the Bylaws and otherwise as determined by the Board of Directors of the Society.

The Board of Directors may from time to time, in its sole discretion, establish membership criteria, rules and procedures applicable to Fellowship in any class in order to implement and carry out the provisions of this Article IV, including, without limitation, specific membership criteria, requirements and procedures for application to Fellowship in any class, and procedures and requirements for transfer between such classes of Fellowship; provided, however, that no such criteria, rules or procedures shall be established which alter the membership criteria and/or classifications set forth in these Bylaws. All determinations whether an individual has met the requirements for or otherwise qualified for membership of any class shall be made by the Board of Directors in its sole discretion after receiving and taking into account the recommendation of the Fellowship Committee (as defined in Section 9.3, below).

Section 4.2 Candidate Fellowship. The following individuals shall be eligible to be Candidate Fellows of the Society: (a) orthopaedic surgeons and neurosurgeons in active clinical practice who have a demonstrated interest and involvement in, and commitment to, the field of Scoliosis and related spinal deformities; and (b) scientists in a field related to Scoliosis and/or related spinal deformities who have a demonstrated interest and involvement in, and commitment to, scientific research and investigation in the field of Scoliosis and/or related spinal deformities. A Candidate Fellow shall be eligible to be considered for Active Fellow status after five (5) years of membership as a Candidate Fellow in good standing.

Section 4.3 Active Fellowship. Individuals who have been Candidate Fellows in good standing for five (5) years shall be eligible to become Active Fellows of the Society upon application made by such individual.

Section 4.4 Inactive Fellowship. Any Active Fellow who has become disabled by sickness or accident or otherwise becomes incapacitated for a period of more than fifteen (15) consecutive calendar months and who is unable to engage in his or her normal professional activities that give rise to his or her eligibility for Active Fellow status may apply to the Board of Directors for a transference to Inactive Fellow status. Individuals whose applications for Inactive Fellow status are approved shall be Inactive Fellows, in which event any rights and privileges accorded to any such individual as Active Fellow shall be suspended for such period as such individual is an Inactive Fellow. An individual who is an Inactive Fellow may apply to the Board of Directors for resumption of Active Fellow status as the case may be, once such individual resumes his or her normal professional activities which qualified him or her as an Active Fellow.

Section 4.5 Associate Fellowship. Individuals engaged in professional, scientific or academic activities and/or allied health specialties who:

(a) have a demonstrated interest and involvement in, and commitment to, the field of Scoliosis and related spinal deformities but who are not otherwise eligible for Candidate Fellow or Active Fellow status; or
(b) are eligible for Candidate Fellow or Active Fellow status but do not desire to become, Candidate Fellows or Active Fellows shall be eligible to be Associate Fellows of the Society.

Section 4.6 Emeritus Fellowship. An Active Fellow or Associate Fellow who has retired from the active conduct of his or her profession or vocation regardless of age or who has otherwise reached the age of sixty-five (65) shall be eligible to apply to the Board of Directors for a transfer to Emeritus Fellowship status. Membership dues shall be waived for Emeritus Fellows.

Section 4.7 Honorary Fellowship. Honorary Fellowship may be conferred, upon the recommendation of the Fellowship Committee and approval by the Board of Directors by a two-thirds (2/3) vote thereof, upon an individual who has contributed significantly to, or is otherwise preeminent in, the field of Scoliosis and/or related spinal deformities. Honorary Fellows shall not be required to pay dues. Honorary Fellows may be issued a certificate, in the discretion of the Board of Directors, signifying their admission as Honorary Fellows.

Section 4.8 Annual Meeting. The annual meeting of the Society shall be held at such time and place each year as may be determined by the Board of Directors from time to time (which time and place shall be specified in a notice of meeting), in order to elect new directors and officers, conduct such scientific sessions and discussions as the Board of Directors may determine and transact such other business as shall come before such meeting.

Section 4.9 Special Meetings. Special meetings of the members may be called for any purpose by (a) the President; (b) the Board of Directors by majority vote thereof; or (c) the written petition of five percent (5%) of the number of Active Fellows delivered to the Secretary of the Society.

Section 4.10 Voting. Each Active Fellow in good standing, and only Active Fellows in good standing, shall be entitled to vote in person on all matters to be voted on by members of the Society, including, without limitation, electing directors and officers of the Society as provided herein. Any matter to be decided by a vote of the members of the Society shall, except as otherwise provided in the Illinois Revised Statutes or as expressly provided herein, be decided by a majority of Active Fellows voting in person at a duly held meeting of Active Fellows at which a quorum is present. Cumulative voting or placing all votes for a particular candidate or a particular issue is prohibited. Whenever within these Bylaws an individual is specified as an Ex-Officio member of a board or committee, said Ex-Officio member shall not have the right to vote as such unless otherwise expressly provided in these Bylaws.

Section 4.11 Quorum. The presence in person of not less than twenty percent (20%) of the total number of Active Fellows shall constitute a quorum for the transaction of business at any annual or special meeting of Active Fellows of the Society. If a quorum is not present at any such meeting, a majority of the Active Fellows present thereat may adjourn the meeting from time to time, without further notice. The Active Fellows present in person at a duly organized meeting at which a quorum is present may continue to transact business until adjournment, notwithstanding the withdrawal during the meeting of that number of Active Fellows whose absence would cause less than a quorum.

Section 4.12 Notice of Meetings. Written notice stating the place (which may be within or without the state of Illinois), day and time of any meeting of Active Fellows (including, without limitation, any annual meeting) shall be signed by the President or Secretary of the Society and shall be delivered either personally or by first class United States mail, electronic mail or facsimile, to each member entitled to vote at such meeting, not less than thirty (30) days nor more than sixty (60) days before the date of such meeting. In case of a special meeting or when otherwise required by Illinois Revised Statutes or by these Bylaws, such notice shall also include the purpose or purposes for which the meeting is called. In the case of a special meeting, no business other than that specified in the notice of such meeting shall be transacted at any such meeting. If mailed, the notice of meeting shall be deemed to be delivered when deposited in the United States mail addressed to the member at his or her address as it appears on the records of the Society, with postage thereon prepaid. If such notice is given by

BYLAWS

electronic mail or facsimile, such notice shall be deemed delivered upon receipt by the sender of confirmation of successful transmission of such notice to the member at his or her electronic mail address or facsimile telephone number, as the case may be.

Section 4.13 Induction of New Fellows. Induction of new Fellows of any class shall take place at each annual meeting.

ARTICLE V

MEMBER COVENANTS

Section 5.1 Confidential Information. Members, directors, officers, committee members and staff of the Society shall abide by such confidentiality policies relating to confidential information of the Society as the Board of Directors may establish from time to time.

Section 5.2 Conflicts of Interest/Disciplinary Process. The Board of Directors may establish from time to time such rules or policies with respect to the ethical conduct of its members, including without limitation, procedures and policies for dealing with conflicts of interest and the discipline of its members in the event of a breach of any rules or policies of the Society.

ARTICLE VI

BOARD OF DIRECTORS

Section 6.1 General Powers and Responsibilities. The Board of Directors shall have full responsibility for the management, direction and control of the business, policies and affairs of the Society, subject only to the limitations set forth in these Articles of Incorporation, these Bylaws, or by applicable law.

Section 6.2 Number, Tenure and Qualification. The Board of Directors shall, except as otherwise provided in this Section, consist of thirteen (13) members and shall be composed of (a) the President, the President-Elect, the Vice President, the Secretary and the Treasurer; (b) the two (2) most immediate Past Presidents; and (c) six (6) at-large directors. In years when there is a Treasurer-Elect and/or Secretary-Elect, as more fully described below, said officers shall also be directors and the number of directors comprising the Board of Directors shall be expanded accordingly. The President, President-Elect, Vice-President, Secretary, Treasurer, Treasurer-Elect and Secretary-Elect shall, by virtue of their positions as such, automatically be members of the Board of Directors for so long as they hold their respective offices. The above-referenced immediate Past-Presidents shall serve on the Board of Directors for terms of two (2) years each immediately after the completion of their respective terms as President, which terms shall not be renewable. At-large directors shall serve for terms of two (2) years, which terms shall be non-renewable. The terms of at-large directors shall be staggered so that, as nearly as possible, the terms of one-half of the at-large directors then in office expire each year. Only Active Fellows of the Society in good standing shall be eligible to be directors of the Society. At-large directors shall be nominated and elected in accordance with, and as part of, the procedure for electing officers of the Society as set forth in Section 7.2, below.

Section 6.3 Regular Meetings. Regular Meetings of the Board of Directors shall be held prior to or after but in conjunction with each annual meeting of the Society and/or at such other times as the President may designate for the transaction of such business that may come before the meeting. The Board of Directors may provide by resolution the time and place, either within or without the State of Illinois, for the holding of additional regular meetings of the Board of Directors without other notice than such resolution.

Section 6.4 Special Meetings. Special Meetings of the Board of Directors may be called by or at the request of the President or any two (2) other directors by delivering such request in writing to the Secretary, designating the time and place, either within or without of the State of Illinois, for such meeting to be held and stating the purpose for such meeting or the items to be considered. In the event the Secretary fails, neglects or refuses to distribute proper notice of such requested special meeting, the persons requesting the meeting may schedule or convene such meeting by proper notice to all directors then in office.

Section 6.5 Notice of Meetings. Notice of any Special Meeting of the Board of Directors shall be given at least 48 hours previous thereto by written notice delivered personally or sent by United States mail, electronic mail or facsimile to each director at his address as shown on the records of the Society. If mailed, such notice shall be deemed to be delivered when deposited in the United States mail in a sealed envelope so addressed with postage thereon prepaid. If notice is given by electronic mail or facsimile, such notice shall be deemed delivered upon receipt by the sender of confirmation of successful transmission of such notice to the director at his or her electronic mail address or facsimile telephone number, as the case may be. Any director may waive notice of any meeting. The attendance of a director at any meeting shall constitute a waiver of notice of such meeting, except where a director attends a meeting for the express purpose of objecting to the transaction of any business because the meeting is not lawfully called or convened. Neither the business to be transacted at, nor the purpose of, any regular or special meeting of the Board of Directors need be specified in the notice or waiver of notice of such meeting, unless specifically required by law or by these Bylaws.

Section 6.6 Quorum. A majority of the number of directors in office shall constitute a quorum for the transaction of business at any meeting of the Board of Directors. If the number of directors necessary to constitute a quorum shall fail to attend at the time and place fixed for any regular or special meeting of the Board of Directors, the directors in attendance may adjourn from time to time without notice or other announcement at the meeting until the requisite number of directors to constitute a quorum shall attend.

Section 6.7 Manner of Acting. The act of a majority of the number of directors present at a meeting at which a quorum is present shall be the act of the Board of Directors, except where otherwise provided by applicable law, the Articles of Incorporation of the Society, or by these Bylaws.

Section 6.8 Officers of the Board of Directors. The President of the Society shall serve as Chairman of the Board of Directors. The Secretary of the Society shall serve as the Secretary of the Board of Directors.

Section 6.9 Informal Action by Directors. Unless specifically prohibited by the Articles of Incorporation or by the Bylaws, any action required to be taken at a meeting of the Board of Directors, or any other action which may be taken at a meeting of the Board of Directors, may be taken without a meeting if a consent in writing, setting forth the action to be taken, shall be signed by all Directors entitled to vote with respect to the subject matter thereof. Any such consent signed by all directors shall have the same effect as a unanimous vote of the Board of Directors.

Section 6.10 Meetings by Electronic Means of Communication. Notwithstanding any place set forth in the notice for a meeting of the Board of Directors, any director may participate in such meeting by, or through the use of, any means of communication by which (a) all participants may simultaneously hear each other, such as by conference telephone; or (b) all communication is immediately transmitted to each participant, and each participant can immediately send messages to all other participants. Before the commencement of any business at a meeting at which any director participates by electronic means, all participating directors shall be informed that a meeting is taking place at which official business may be transacted.

Section 6.11 Executive Committee. There shall be established and maintained an Executive Committee which shall have and may exercise, when the Board of Directors is not in session, the powers of the Board of Directors in the management of the affairs of the Society, except action in respect to election or removal of officers and directors or the filling of vacancies in the Board of Directors or committees created pursuant to this Bylaw, or acts contrary to prior action adopted by the Board of Directors in proper session. The Executive Committee shall consist of the following individuals: the President, the Immediate Past-President, the President-Elect, the Vice President, the Secretary, the Treasurer and, when in office, the Secretary-Elect and the Treasurer-Elect. All members of the Executive Committee shall have voting rights thereon. The Executive Committee may meet from time to time between meetings of the Board of Directors at the discretion of the President and shall be authorized to conduct such business of the Society as may be necessary, subject to the Board of Directors' general direction and the obligation to report to the full Board of Directors. Notwithstanding the foregoing provision, the Executive Committee shall not be authorized to take any of the following actions on behalf of the Board of Directors: (a) elect directors or officers; (b) hire or terminate the executive director, if any; (c) amend these Bylaws; (d) dissolve the Society; or (e) authorize or contract any loan or indebtedness on behalf of the Society other than in accordance with these Bylaws. Meetings of the Executive Committee may be called by the President and shall be called upon written petition of two (2) other members of the Executive Committee. Notice of the time and place of each Executive Committee meeting shall be given in writing to each member of the committee not less than twenty-four (24) hours before such meeting. At any meeting of the Executive Committee, a majority of the number of Executive Committee members then in office shall constitute a quorum for the transaction of any business. The act of the majority of the Executive Committee members present at a meeting at which a quorum is present shall be the act of the Executive Committee.

Section 6.12 Director Vacancies. In case of any vacancy in a directorship for any reason, including, without limitation, the death, resignation or removal, before the expiration of the term of such directorship, the Nominating committee shall, as soon as practicable after such vacancy occurs, recommend to the Board of directors for its approval a qualified individual to fill such a vacancy. The Board of Directors shall as soon as practicable after such recommendation act on such approval. If such recommended individual is so approved, he or she shall serve for the unexpired portion of the term of the vacant directorship.

Section 6.13 Resignation/Removal of Directors. Any director may resign from the Board of directors at any time by giving written notice to the President. Any director may be removed from the Board of Directors with or without cause by the affirmative vote of at least two-thirds (2/3) of the Active Members present at a duly held meeting thereof.

ARTICLE VII

OFFICERS

Section 7.1 Officers/Eligibility. The officers of the Society shall be as follows: President, President-Elect, Vice-President, Secretary, Secretary-Elect, Treasurer, and Treasurer-Elect. The President, President-Elect, Vice President, Secretary-Elect and Treasurer-Elect shall each serve for terms of one (1) year, which terms shall be non renewable, except as provided in Section 7.10 below. The Secretary and Treasurer shall, except as provided in Section 7.10 below, each serve for terms of four (4) years, which terms shall be non renewable (subject, however, to the proviso that individuals having previously served as Secretary and Treasurer respectively, shall be subject to returning to office as more fully described in Section 7.10, below, in the event of a vacancy in such office created by an immediate successor). The terms of the Secretary and Treasurer shall be staggered so that such terms alternatively expire every two (2) years. The President-Elect, the Vice President, the Secretary-Elect and the Treasurer-Elect shall each automatically succeed to the office of President, President-Elect, Secretary or Treasurer, as the case may be, upon the expiration of the term of the individual then serving in such office. Only Active Fellows who are then serving or who have previously served as at-large directors shall be eligible to be nominated as Vice President, Treasurer-Elect or Secretary-Elect.

Section 7.2 Election Procedure. At least sixty (60) days before each annual meeting of the Society, the Nominating Committee shall prepare, and submit for review to the Board of Directors, a list consisting of one individual recommended for each of the following offices: Vice-President, two (2) at-large directors and one (1) member of the Fellowship Committee. In the year immediately preceding any year in which the term of office of the Secretary or the Treasurer is to expire, the Nominating Committee shall also select one individual that it

BYLAWS

recommends for nomination to the office of Secretary-Elect or Treasurer-Elect, as the case may be. Should the Board of Directors have concerns about any individual on the proposed slate, those shall be conveyed to the Nominating Committee within twenty (20) days of receipt of the list. The Nominating Committee shall present a final slate of candidates to the SRS membership after investigation and review of any concerns. Candidates for the positions to which they were nominated shall be elected upon receiving a majority of the votes cast by Active Fellows at such annual meeting. The term of office for those individuals elected to a position at an annual meeting shall commence as of the close of such meeting.

Section 7.3 President. The President shall be the principal executive officer of the Society and shall, subject to the direction and control of the Board of Directors, supervise and be in charge of all the business affairs of the Society. The President shall preside at all general meetings of the Society and of the Board of Directors. The President may sign, with the Secretary or any other proper officer of the corporation authorized by the Board of Directors, any deeds, mortgages, bonds, contracts or other instruments which the Board of Directors has authorized to be executed, except in cases where the signing and execution thereof shall be expressly delegated to the Board of Directors or by these Bylaws with the approval of the Board of Directors and shall be Ex-Officio member of all Committees except the Fellowship and Nominating Committees. The President may fill any vacancies between annual meetings subject to the approval of the Board of Directors unless such vacancies are to be filled as otherwise specified. The President is authorized to act in the event of any contingency or emergency not covered by the Bylaws. The President shall, in general, perform all duties incident to the office of President and such other duties as may be prescribed by the Board of Directors from time to time. The President shall preside at all meetings of the Board of Directors and shall, except as otherwise provided under applicable law or these Bylaws, be responsible for scheduling all meetings of the Board of Directors and to determine the order of business to be conducted at meetings of the Board of Directors. The President shall serve for one (1) year term of office, except in circumstances outlined in Section 7.10.

Section 7.4 President-Elect. The President-Elect shall assume the duties of the President in the absence of the President or in the event of his/her death, inability or refusal to act and when so acting shall have the powers of and be subject to all the restrictions upon the President. The President-Elect shall perform such other duties and have such other powers as the Board of Directors may from time to time prescribe. In addition, the President-Elect shall, as the President-Elect of the Society, carry out such duties in such capacity as the President or the Board of Directors may from time to time determine. The President-Elect shall be an Ex-Officio member of all committees except the Fellowship and Nominating Committees. The President-Elect shall automatically succeed to the office of President at the close of the annual meeting at which the current President's term expires, or as otherwise provided in Section 7.10.

Section 7.5 Vice-President. The Vice President shall assume the duties of the President-Elect in the absence of the President-Elect and in the event of his or her death or inability or refusal to act, and when so acting, shall have all the powers of and be subject to all of the restrictions upon the President-Elect. The Vice President shall also assume the duties of President in the absence of both the President and the President-Elect and in the event of death or inability or refusal to act of both of them, and when so acting the Vice President shall have all of the powers of and be subject to all of the restrictions upon the President. The Vice President shall perform such other duties and have such other powers as the Board of Directors may from time to time prescribe. The Vice President shall be ex-officio member of all committees except the Fellowship and Nominating Committees. The Vice President shall automatically succeed to the office of President-Elect at the close of the annual meeting at which the current President-Elect's term expires, or as otherwise provided in Section 7.10 below.

Section 7.6 Secretary. The Secretary or its designee shall record the minutes of the meetings of the Society and of the Board of Directors and the Executive Committee; undertake to ensure that all notices of meetings are duly given in accordance with the provisions of these Bylaws or as required by applicable law; be custodian of the corporate records of the Society; and perform all duties incident to the office of Secretary. The Secretary shall be an Ex-Officio member of all committees except the Fellowship and Nominating Committees. The Secretary shall maintain a register of the post office address and electronic mail address of each Fellow of any class, which information shall be furnished to the Secretary by such Fellows. The Secretary shall maintain the correspondence of the Society and a record of the names of the Fellows, guests and visitors in attendance at any meeting of the Society.

Section 7.7 Secretary-Elect. The Secretary-Elect shall assume the duties of the Secretary in the absence of the Secretary or in the event of his or her death, inability or refusal to act. The Secretary-Elect shall perform the duties of the Secretary and when so acting shall have the power of and be subject to all the restrictions upon the Secretary. The Secretary-Elect shall automatically succeed to the office of Secretary at the close of the annual meeting at which the then-current Secretary's term of office expires, or as otherwise provided in Section 7.10 below. The Secretary- Elect shall perform such other duties as from time to time may be assigned to him or her by the President or the Board of Directors.

Section 7.8 Treasurer. The Treasurer shall be in charge and have custody of and be responsible for any and all funds, securities and other valuable assets of the Society and other assets of the Society and shall, at the request of the Board of Directors or as otherwise required by applicable law, post a bond at the expense of the Society for the faithful discharge of his or her duties in such sum and with such surety or sureties as the Board of Directors shall determine. The Treasurer shall oversee accurate accounts of the receipts and disbursements of the Board of Directors in books belonging to it. He or she shall ensure that all monies and other valuable effects are deposited in the name and to the credit of the Board of Directors in such accounts and in such depositories as may be designated by

the Board of Directors. He or she shall check monthly the disbursements of funds of the Board of Directors in accordance with authority of the Board of Directors. The Treasurer shall render to the President and the Board of Directors whenever requested or otherwise required, a written detailed account of the transactions and of the financial condition of the Society, including a statement of all its assets, liabilities, and financial transactions. He or she shall perform such other duties as the Board of Directors, through the President, direct, and such other duties as usually pertain to the office of Treasurer. The Treasurer shall be relieved of all responsibility for any securities or monies or the disbursement thereof committed by the Board of Directors to the custody of any other person or the Society, or the supervision of which is delegated by the Board of Directors to any other officer, agent or employee, or for the performance of any other duties of the Treasurer delegated by the Board of Directors to any other officer, agent or employee, and he or she shall not be responsible for any actions of any other officer, agent or employee of the Board of Directors. The Treasurer shall be an Ex-Officio member of all committees except the Membership and Nominating Committees.

Section 7.9 Treasurer-Elect. The Treasurer-Elect shall assume the duties of the Treasurer in the absence of the Treasurer or in the event of his or her death, inability or refusal to act and when so acting shall have the power of and be subject to all restrictions upon the Treasurer. The Treasurer-Elect shall automatically succeed to the office of Treasurer at the close of the annual meeting at which the then-current Treasurer's term of office expires or as otherwise provided in Section 7.10 below. The Treasurer-Elect shall perform such other duties as from time to time may be assigned to him or her by the President or the Board of Directors.

Section 7.10 Vacancies. In the event of the President's death, resignation or removal while in office, the President-Elect shall succeed to the office of President for the remainder of such term and shall continue to serve as President for the immediately succeeding one-year term. In such event, the Vice President shall succeed to the office of President-Elect serving the remainder of such term and shall continue as President-Elect for the immediately succeeding one year term.

In the event of the President-Elect's death, resignation or removal while in office, the Vice President shall succeed to the office of President-Elect for the remainder of such term and shall continue to serve in such office for the immediately succeeding one-year term. The current President shall finish his/her term and will be asked to serve the term originally designated for the President-Elect.

In the event that the Vice President ceases to serve in such office for any reason during his or her term, including, without limitation, by reason of death, resignation or succession to fill a vacancy of the President-Elect as described above, the Board of Directors may (taking into account any recommendations of the Nominating Committee as described in section 9.6 below) appoint a new Vice President to serve the remainder of that term who then becomes President-Elect at the Annual Meeting. In the event the Board of Directors does not appoint a qualified individual to replace the Vice President, a new Vice President shall be elected at the next annual meeting at which officers are elected in accordance with the procedures applicable to the election of officers generally.

In the event of the Secretary's death, resignation or removal while in office with less than six(6) months remaining before the expiration of the term, the immediate past Secretary will be asked to serve the balance of that term and one more additional year. The Secretary-Elect shall then succeed to the office of Secretary for the term for which he or she was originally slated. If the remaining term is greater than six months, then the Secretary-Elect will succeed to become Secretary as originally intended, and the additional year of service by the past Secretary will not be necessary.

In the event of the Secretary-Elect's death, resignation or removal while in office, the Board of Directors shall fill such vacancy as soon as practicable for the unexpired portion of that term and potentially one more year. The Secretary-Elect then becomes Secretary.

In the event of the Treasurer's death, resignation or removal while in office, the immediate past Treasurer will be asked to serve the balance of that term and then one additional year, if the remaining term is less than six months. If the remaining term is greater than six months, the one additional year will not be necessary. The Treasurer –Elect then succeeds to the office of Treasurer considering the above. Following succession of the Treasurer-Elect to the Treasurer, a new Treasurer-Elect is appointed by the Board of Directors as soon as practicable for the same time period.

In the event of the Treasurer-Elect's death, resignation or removal while in office, The Board of Directors will appoint a new Treasurer-Elect for the balance of that term and potentially one more year. This Treasurer-Elect will then become the Treasurer.

In the event of an At-Large Director's death, resignation or removal while in office, The Board of Directors will appoint a new Director in the appropriate category for the balance of that term.

Section 7.11 Resignation/Removal. Any officer may resign from such office at any time by giving written notice to the Secretary of the Society. Any officer may be removed from such office with or without cause by the affirmative vote of at least two-thirds (2/3) vote of the Active Fellows present at a meeting thereof.

ARTICLE VIII

COUNCILS

The Society shall establish and maintain four (4) Councils, namely, the Education Council, the Research Council, the Governance Council and the Finance Council, which Councils shall oversee the functions and operations of those committees placed under their respective jurisdiction from time to time by the President with the approval of the Board of Directors. Councils shall function in the same manner and be subject to the same procedures and restrictions as committees of the Society and as may be otherwise determined by the Board of Directors from time to time. The membership of each such Council shall be comprised of the chairpersons of the committees under the jurisdiction of such Council and the

BYLAWS

President, with the approval of the Board of Directors, shall appoint a chairperson for each such Council from among such Members. The Board of Directors may, at any time, by resolution, create, combine, consolidate and/or terminate any Council and change the composition, terms of membership and any other attribute or aspect of any Council as it deems appropriate in its discretion.

ARTICLE IX

COMMITTEES

Section 9.1 Classification and Organization. There shall be established and maintained the following Standing Committees of the Society:

(a) Education Committee;
(b) Fellowship Committee;
(c) Program Committee;
(d) Bylaws and Policies Committee; and
(e) Nominating Committee.

The President, with the approval of the Board of Directors, may from time to time designate other committees (including standing committees in addition to those described above, ad hoc committees and committees existing and operating under any Council), subcommittees, working groups and task forces. All Standing Committees and other committees, subcommittees, working groups and task forces (collectively referred to for purposes of this Article IX as "Committees") shall have the powers and duties as hereinafter set forth and/or other powers and duties delegated or assigned by the President, with the approval of the Board of Directors and shall make regular reports to President and the Board of Directors. All Committee chairpersons shall be appointed by the President, with the approval of the Board of Directors, except as otherwise provided in these Bylaws. Except for the Nominating Committee and the Fellowship Committee and as otherwise provided in these Bylaws, the President, with the approval of the Board of Directors, may determine the number of members to serve on each Committee and the eligibility requirements for same. Members of any such Committee shall be appointed by the President for such terms and on such terms as the President may determine from time to time, with the approval of the Board of Directors. The President, with the approval of the Board of Directors, shall establish such procedures for each Committee as he or she may determine in his or her discretion, with the approval of the Board of Directors. The Board of Directors may, at any time, by resolution, create, combine, consolidate or terminate any Committee (other than a Standing Committee described in subs. (a) through (e), above) as it deems appropriate in its discretion.

Section 9.2 Education Committee. The Education Committee shall be primarily responsible for the education of, dissemination of new information to, and public relations to promote a better understanding of Scoliosis and related spinal deformities including but not limited to availability of treatments and early symptoms of Scoliosis and related spinal deformities.

Section 9.3 Fellowship Committee. The Fellowship Committee shall be responsible for verifying the professional credentials and qualifications of the applicant for Fellowship in any class. All completed applications, except those for Honorary Fellowship, shall be forwarded by the Secretary of the Society to the Fellowship Committee. The Fellowship Committee shall conduct such investigation, personal interviews, or inquiries it deems necessary in order to determine the qualifications of an applicant for Fellowship in any class.

Section 9.4 Program Committee. The Program Committee shall be responsible for the initiation, organization, implementation and conduct of the annual meeting of the Society. The Program Committee shall be responsible to review all papers, exhibits and audiovisual materials to be used in connection with any program or event held in connection with any annual meeting of the Society, subject to such procedures as the Program Committee and the Board of Directors may establish from time to time.

Section 9.5 Bylaws and Policies Committee. The Bylaws and Policies Committee shall be responsible for considering matters relating to the content of the Articles of Incorporation, the Bylaws and the policies and procedures of the Society, including amendments thereto, and to advise and make recommendations to the Board of Directors with respect to same.

Section 9.6 Nominating Committee. The Nominating Committee shall consist of five (5) Active Fellows, the Chairman of which shall be appointed by the President with the approval of the Board of Directors. The four (4) additional members shall be Active Members elected at each annual meeting of the Society by a majority of the Active Members present at such meeting. The term of each member of the Nominating Committee shall be one year, no Fellow may serve two (2) consecutive terms on the Nominating Committee. The Nominating Committee shall present to the Board of Directors a list of nominees as described in Section 7.2 and otherwise provide recommendations to the Board of Directors with respect to the filling of vacancies in any office or on the Board of Directors.

ARTICLE X

COMPENSATION

No director, officer, Council or Committee member or any other private individual shall receive at any time any of the net earnings or pecuniary profit from the operations of the Society; provided that this provision shall not prevent the payment to any such person of such reasonable compensation for services rendered to or for the Society in effecting any of its purposes. No such person or persons shall be entitled to share in the distribution of any of the corporate assets upon the dissolution of the Society. Notwithstanding the foregoing, no director, officer or Council or Committee member shall receive compensation from the Society for serving in such capacity; provided, however, the Society may reimburse expenses of such persons in attending meetings and conducting other activities on behalf of the Society. Upon such dissolution or winding up of the affairs of the Society, whether voluntary or involuntary, the assets of the Society, remaining in the hands of the Board of Directors after all debts have been satisfied shall be distributed, transferred, conveyed, delivered, and paid over exclusively to charitable and/or educational organizations which would then qualify under the provisions of Section 501(c)(3) of the Internal Revenue Code and its Regulations as they now exist or as they may hereafter be amended.

BYLAWS

ARTICLE XI

AMENDMENTS

Amendments to these Bylaws or to the Articles of Incorporation of the Bylaws may be proposed by the Executive Committee, the Board of Directors on its own motion or the written petition of at least four (4) Active Fellows. Any such proposal must be submitted to the Secretary of the Corporation not less than ninety (90) days before an annual meeting of the Society in order to be eligible for consideration of approval at such annual meeting. Such proposed amendment, once submitted to the Secretary, shall be submitted to the Bylaws and Policies Committee for review and consideration, which Committee shall then make a recommendation with respect to same to the Board of Directors. The Board of Directors shall then make a determination regarding whether to submit such proposed amendment to a vote of the Active Fellows. Any proposed amendment submitted to the Secretary for consideration at least ninety (90) days before an annual meeting of the Active Fellows of the Society which the Board of Directors has determined to be submitted to a vote of the Active fellows as described above shall be submitted to the Active Fellows at least 30 days prior to the Annual Meeting at which they will be voted on.

Any such proposed amendment submitted to the Secretary less than ninety (90) days before such annual meeting which the Board of Directors has determined to be submitted to a vote of the Active Fellows shall be eligible to be considered for approval by the Active Fellows at the next subsequent annual meeting or at the discretion of the Board of Directors at a special meeting of the Active Fellows of the Society. The Secretary shall include a copy of the proposed amendment with the notice of the meeting at which such proposed amendment is to be considered for approval, together with a statement that the Board of Directors recommends such amendment for adoption. Any amendment to these Bylaws or the Articles of Incorporation of the Society shall require approval of the Active Fellows by at least a two-thirds (2/3) majority of the Active Fellows present in person at a duly held meeting at which a quorum is present.

ARTICLE XII

DUES

Section 12.1 Annual Dues. Annual Dues, in amounts to be determined by the Board of Directors, shall be paid by Candidate Fellows, Active Fellows and Associate Fellows in accordance with such procedures as the Board of Directors may from time to time establish.

Section 12.2 Exemption from Dues. The Board of Directors may, in its discretion, exempt a Fellow of any class from dues for good cause in any particular instance.

ARTICLE XIII

RULES OF ORDER

Except to the extent otherwise provided in these Bylaws, all meetings of the Society, the Board of Directors, the Councils or any Committee (as that term is defined in Section 9.1, above) shall, as and when determined by the presiding officer of such body, be governed by the parliamentary rules and usages set forth in the most current edition of Robert's Rules of Order.

ARTICLE XIV

DISSOLUTION

The Board of Directors shall, after paying or making provisions for the payment of the Society's liabilities, if any, distribute the Society's net assets, to such Society(s), association(s), fund(s), and/or foundation(s) engaged in activities substantially similar to those of the Society as are designated by the Executive Committee and in such proportions as are determined thereby, subject to any order of court as provided by law, for charitable, educational or scientific purposes within the meaning of section 501(c)(3) of the Code. Notwithstanding any of the foregoing provisions of this Article, the distribution of any assets of the Society in liquidation shall be made in accordance with Illinois Revised Statutes.

ARTICLE XV

CONTRACTS, CHECKS, DEPOSITS AND GIFTS

Section 15.1 Contracts. The Board of Directors may authorize any officers, agent or agents of the Society, in addition to the officers so authorized by these Bylaws, to enter into any contract or execute and deliver any instrument in the name of and on behalf of the Society and such authority may be general or confined to specific instances.

Section 15.2 Checks, Drafts, Etc. All checks, drafts, or other orders for the payment of money notes or other evidence of indebtedness issued to the name of the Society, shall be signed by such officer or officers, agent or agents of the Society and in such manner as shall be determined by action of the Board of Directors.

Section 15.3 Deposits. All funds of the Society shall be deposited to the credit of the Society in banks, trust companies, or other depositories as the Board of Directors may select.

Section 15.4 Gifts. The Board of Directors may accept on behalf of the Society any contribution, gift, bequest or device for the general purposes or for any special purpose of the Society.

ARTICLE XVI

BOOKS AND RECORDS

The Society shall keep and maintain correct and complete books and records of account and shall also keep minutes of the proceedings of any meeting of the Active Members (including any business session), the Board of Directors and any Council or Committees, and shall keep and maintain at the principal office of the Society a record of the names and addresses of Fellows of any class.

ARTICLE XVII

FISCAL YEAR

The fiscal year of the Society shall be as determined by the Board of Directors from time to time.

BYLAWS

ARTICLE XVIII

SEAL

The Society shall have no seal.

ARTICLE XIX

INDEMNIFICATION

The Society shall, to the fullest extent provided by applicable law, indemnify every director, officer or Committee (as that term is defined in Section 9.1, above) or Council chair or member, and his or her heirs, executors and administrators who was or is a party or is threatened to be made a party to any threatened, pending or completed action, suit or proceeding, whether civil, criminal, administrative or investigative (other than an action by or in the right of the Society) by reason of the fact that he or she is or was a director, officer, employee or agent of the Society, or is or was serving at the request of the Society, partnership, joint venture, trust or other enterprise against expenses (including attorney's fees), judgements, fines and amounts paid in settlement actually and reasonably incurred by him or her in connection with such action, suit or proceeding if he or she acted in good faith and in a manner he or she reasonably believed to be in or not opposed to the best interests of the Society, and, with respect to any criminal action or proceeding, had no reasonable cause to believe his or her conduct was unlawful. The termination of any action, suit or proceeding by judgement, order, settlement conviction, or upon a plea of nolo contendere or its equivalent, shall not of itself, create a presumption that the person did not act in good faith and in a manner which he/she reasonably believed to be in or not opposed to the best interests of the Society, and with respect to any criminal action or proceeding, had no reasonable cause to believe that his or her conduct was unlawful.

ARTICLE XX

MISCELLANEOUS

Section 20.1 Trademarks. No member may use the Society's name or trademarks for personal, commercial purposes or funding purposes without prior approval of the Board of Directors.

Section 20.2 Interpretation. In interpreting these Bylaws, whenever the context so requires, (a) the singular shall include the plural and the plural shall include the singular, and (b) any gender shall include all genders.

Section 20.3 Definition of "Code." All references in these Bylaws to sections of the "Code" shall be considered references to the Internal Revenue Code of 1986, as from time to time amended, and to the corresponding provisions subsequently enacted.

Section 20.4 Headings. The headings in these Bylaws are intended for convenience only and should not affect the meaning or interpretation hereof.

Section 20.5 Executive Director. An Executive Director may be employed directly or by contract by the Board of Directors. The Executive Director shall have general charge of the day-to-day operations and management of the Society. The Executive Director may sign in the name of or on behalf of the Society any contract or agreement authorized by the Board of Directors and shall do and perform such additional duties as may be assigned by the Board of Directors and/or otherwise expressed in a management agreement.

Approved September 6, 2007
Amended September 11, 2008
Amended September 22, 2010

SRS COMMITTEES

BOARD OF DIRECTORS

Lawrence G. Lenke, President	2011
B. Stephens Richards, President Elect	2011
Kamal N. Ibrahim, Vice President	2011
Hubert Labelle, Secretary	2014
Steven M. Mardjetko, Treasurer	2011
Paul D. Sponseller, Treasurer-Elect	2011
Richard E. McCarthy, Past President I	2011
Oheneba Boachie-Adjei, Past President II	2011
George H. Thompson, Past President III	2011
J. Abbott Byrd, Director	2011
Serena S. Hu, Director	2011
John R. Dimar II, Director	2012
Francisco J. Sanchez Perez-Grueso, Director	2012

ADULT DEFORMITY COMMITTEE

Clifford B. Tribus, Chair	2011
Frank J. Schwab, Past Chair	2011
Jacob M. Buchowski (C)	2011
Robert A. Hart (C)	2011
Sigurd H. Berven, Chair Elect	2012
Mark B. Dekutoski	2012
Hossein Mehdian	2012
Jeffrey D. Coe	2013
Christopher DeWald	2013
Andrew K. Cree	2014
Donald A. Deinlein	2014

Adult Deformity Classification Task Force

Frank J. Schwab, Chair
Steven D. Glassman
Sigurd H. Berven
Lawrence G. Lenke
R. Shay Bess (C)
Christopher I. Shaffrey
Oheneba Boachie-Adjei
Clifford B. Tribus, Ex Of.
Keith H. Bridwell
David W. Polly, Jr.

Council: Research
Board Liaison: Oheneba Boachie-Adjei
Staff Liaison: Megan Kelley
Back-up: Katy Kujala-Korpela

ADVOCACY AND PUBLIC POLICY COMMITTEE

John P. Lubicky, Chair	2011
Daniel W. Green, Past Chair	2011
William C. Lauerman	2011
Jochen P. Son-Hing (C)	2011
Richard Holt	2012
Vishwas R. Talwalker, Chair Elect	2012
Jose Herrera-Soto	2013
Brian G. Smith	2013
Baron S. Lonner	2014
Steven M. Mardjetko	2014
Joseph P. O'Brien, advisory	
David W. Polly, advisory	
Stanley E. Sacks, advisory	
Jamie Gregorian, liaison	

RAPID RESPONSE TEAM

David W. Polly, Chair
John P. Lubicky
Steven D. Glassman
Richard E. McCarthy
Daniel W. Green
B. Stephens Richards
Kamal N. Ibrahim
Vishwas R. Talwalkar
Lawrence G. Lenke

Council: Governance
Board Liaison: John R. Dimar
Staff Liaison: Katy Kujala-Korpela
Back-up: Cydni Chapman

AWARDS & SCHOLARSHIP COMMITTEE

Stephen J. Lewis, Chair	2011
Theodore A. Wagner (Global Outreach)	2011
Laurel C. Blakemore (Program)	2011
Dilip K. Sengupta (Research)	2011
Vincent Arlet	2011
Andrew M. Casden	2011
Ensor E. Transfeldt	2011
Khaled Kebaish (C)	2011
Francis H. Shen (C)	2011
Yongjung J. Kim	2012
Preston J. Phillips	2012
Lawrence L. Haber	2013
Hubert Labelle	2013
Hilali Noordeen	2013

Council: Education
Board Liaison: Paul D. Sponseller
Staff Liaison: Cydni Chapman
Back-up: Katy Kujala-Korpela

BYLAWS & POLICIES COMMITTEE

James W. Roach, Chair	2011
Robert J. Huler, Past Chair	2011
Patrick Cahill (C)	2011
Michael C. Albert, Chair Elect	2012
Jose Herrera-Soto	2013
Jeffrey D. Coe	2014

Council: Governance
Board Liaison: Hubert Labelle
Staff Liaison: Nilda Toro
Back-up: Tressa Goulding

SRS COMMITTEES (continued...)

CME COMMITTEE

Glenn R. Rechtine II, Chair	2012
B. Stephens Richards	2011
George H. Thompson, PP III	2011
Steven D. Glassman (Ed. Council Chair)	2011
Joseph W. Perra (Education Ch)	2011
Laurel Blakemore (Program Ch)	2011
John F. Sarwark (Website Ch)	2011
Todd J. Albert (IMAST)	2012
Oheneba Boachie-Adjei, PPII	2012
Mark Dekutoski (Education ChE)	2013
Daniel J. Sucato (Program ChE)	2013
Richard E. McCarthy, PPI	2013
Michael S. Roh (Website Co-Ch)	2013
Frank J. Schwab, Chair Elect	2014
Lawrence G. Lenke, Past Chair	2014
Kamal N. Ibrahim (Vice President)	2014
Ahmet Alanay (WWC)	2014

Non-Conflicted Sub-Committee:

Richard H. Gross	2014
Lori Ann Karol	2014
Yongjung J. Kim	2014

Council: Education
Board Liaison: Oheneba Boachie-Adjei
Staff Liaison: Tressa Goulding
Back-up: Courtney Kissinger

CODING COMMITTEE

Jeffrey B. Neustadt, Chair	2011
Barton L. Sachs, Past Chair	2011
David B. Cohen (C)	2011
Brandon J. Kambach (C)	2011
R. Dale Blasier, Chair Elect	2012
Christopher DeWald	2013
Michael P. Chapman	2014

Council: Governance
Board Liaison: George H. Thompson
Staff Liaison: Katy Kujala-Korpela
Back-up: Megan Kelley

DIRECTED RESEARCH TASK FORCE

B. Stephens Richards, Chair
John B. Emans
John M. (Jack) Flynn
Scott J. Luhmann
Peter O. Newton
Kit M. Song
Michael G. Vitale
Lawrence Lenke, Ex Off

ScoliRisk Subcommittee
Lawrence G. Lenke, Chair
Leah Y. Carreon
Kenneth M.C. Cheung
Christopher I. Shaffrey
Michael G. Fehlings (AO)
Peter Langer (AO)

Staff Liaison: Courtney Kissinger

EARLY ONSET SCOLIOSIS TASK FORCE

Richard E. McCarthy, Chair
Michael G. Vitale, Co-Chair
Behrooz A. Akbarnia
Laurel C. Blakemore
Robert M. Campbell, Jr.
Peter O. Newton
Brian D. Snyder

Staff Liaison: Katy Kujala-Korpela

EDUCATION COMMITTEE

Joseph H. Perra, Chair	2011
Ahmet Alanay	2011
Kamal N. Ibrahim	2011
Laurel C. Blakemore (Program)	2011
Brian Hsu (C)	2011
Amer Samdani (C)	2011
Adam L. Wollowick (C)	2011
Mark B. Dekutoski, Chair Elect	2012
Eric T. Jones	2012
Glenn R. Rechtine II (CME)	2012
Paul D. Sponseller	2013
John R. Dimar	2013
Lori A. Karol	2014
Daniel W. Green	2014

Council: Education
Board Liaison: Kamal N. Ibrahim
Staff Liaison: Courtney Kissinger
Back-up Megan Kelley

ENDOWMENT COMMITTEE

George H. Thompson, Chair	2011
Frances A. Farley, Past Chair	2011
Alvin H. Crawford	2011
Matthew B. Dobbs	2011
Karl E. Rathjen	2011
Oheneba Boachie-Adjei, PP2, Chair Elect	2012
Thomas E. Bailey	2012
John R. Dimar	2012
Kirkham B. Wood	2012
Richard E. McCarthy, PP1	2013
Dennis G. Crandall	2013
Lawrence L. Haber	2013
David W. Polly, Jr.	2013

Council: Finance
Board Liaison: Kamal N. Ibrahim
Staff Liaison: Nilda Toro
Back-up: Cydni Chapman

SRS COMMITTEES (continued...)

ENDOWMENT TASK FORCE

Steven M. Mardjetko, Chair
Kenneth M.C. Cheung
Kamal N. Ibrahim
B. Stephens Richards
Christopher I. Shaffrey
Paul D. Sponseller
George H. Thompson

Staff Liaison: Tressa Goulding
Back-up: Nilda Toro

E-TEXT COMMITTEE

James W. Ogilvie, Chair	2012
James S. Harrop (C)	2011
Todd J. Albert	2012
John P. Dormans	2013
Lawrence G. Lenke	2014
Praveen Mummaneni, Chair Elect	2015
Noriaki Kawakami	2016

Council: Education
Board Liaison: Lawrence G. Lenke
Staff Liaison: Katy Kujala-Korpela
Back-up: Courtney Kissinger

ETHICS & PROFESSIONALISM COMMITTEE

J. Abbott Byrd, Chair	2012
Denis S. Drummond (E), Past Chair	2011
Bettye A. Wright (E)	2011
Jochen P. Son-Hing (C)	2011
Michael A. Edgar	2012
Michael J. Bolesta	2013
James W. Roach	2014
Behrooz A. Akbarnia	2015

Council: Governance
Board Liaison: B. Stephens Richards.
Staff Liaison: Tressa Goulding
Back-up: Nilda Toro

EVIDENCE BASED OUTCOMES COMMITTEE

James O. Sanders, Chair	2011
Douglas C. Burton, Past Chair	2011
Reginald Q. Knight, Past Chair	2011
Richard E. Bowen	2011
Lukas P. Zebala (C)	2011
Gregory C. Mundis (C)	2011
James V. Raso (A)	2011
Dilip K. Sengupta (Research Ch)	2011
Robert B. Campbell	2011
William A. Phillips	2011
J. Bradley Williamson	2011

Council: Research
Board Liaison: Serena S. Hu
Staff Liaison: Cydni Chapman
Back-up: Megan Kelley

EVIDENCE BASED OUTCOMES TASK FORCE

James O. Sanders, Chair
Steven D. Glassman
Serena S. Hu
Kamal N. Ibrahim
David W. Polly, Jr.
Frank J. Schwab

FELLOWSHIP COMMITTEE

Serena S. Hu, Chair	2011
Mark Weidenbaum, Past Chair	2011
Carlos Tello, Chair Elect	2012
Laurel C. Blakemore	2013
Hilali H. Noordeen	2014

Council: Governance
Board Liaison: Steven M. Mardjetko
Staff Liaison: Nilda Toro
Back-up: Tressa Goulding

FELLOWSHIP CRITERIA TASK FORCE

Mark Weidenbaum, Chair
Oheneba Boachie-Adjei
J. Abbott Byrd
Serena S. Hu
Kamal N. Ibrahim
David S. Marks
Richard E. McCarthy
Praveen V. Mummaneni
Carlos A. Tello

Staff Liaison: Nilda Toro
Back-up: Tressa Goulding

50TH ANNIVERSARY TASK FORCE

David W. Polly, Jr., MD, Chair
Behrooz A. Akbarnia, MD
Oheneba Boachie-Adjei, MD
David S. Bradford, MD
Ronald L. DeWald, MD
Denis S. Drummond, MD
Howard A. King, MD
Michael O. LaGrone, MD
Nathan H. Lebwohl, MD
John E. Lonstein, MD
James W. Ogilvie, MD
Joseph H. Perra, MD

Staff Liaison: Tressa Goulding
Back-up: Megan Kelley

FINANCE COMMITTEE

Steven M. Mardjetko, Chair	2011
Paul D. Sponseller, Chair Elect	2015
Richard E. McCarthy, PPI	2011
Lawrence G. Lenke	2012
B. Stephens Richards	2013
Kamal N. Ibrahim (Vice President)	2014
Tressa Goulding, Executive Director	Ad Hoc
Dan Nemec, Accounting Director	Ad Hoc

Council: Finance
Board Liaison: Richard E. McCarthy
Staff Liaison: Tressa Goulding
Back-up: Megan Kelley

SRS COMMITTEES (continued...)

GLOBAL OUTREACH COMMITTEE

Theodore A. Wagner, Chair	2011
Peter F. Sturm, Past Chair	2011
Saumyajit Basu (C)	2011
R. Shay Bess (C)	2011
David H. Clements	2011
Hossein Mehdian	2011
Kenneth J. Paonessa, Chair Elect	2012
Anthony S. Rinella	2012
Youssry MK El-Hawary	2012
Michael J. Mendelow	2013
Mohammed M. Mossaad	2013
Anthony P. Schnuerer (A)	2013
Ahmet Alanay (WWC)	2014

Council: Education
Board Liaison: Francisco J. S. Perez-Grueso
Staff Liaison: Katy Kujala-Korpela
Back-up: Courtney Kissinger

GROWING SPINE COMMITTEE

Lawrence I. Karlin, Chair	2011
Laurel C. Blakemore, Past Chair	2011
Ron El-Hawary (C)	2011
Robert P. Huang (C)	2011
Behrooz A. Akbarnia	2011
Carlos A. Tello	2011
Bruce L. Gillingham	2012
Eric T. Jones	2012
Suken A. Shah, Chair Elect	2012
Michael C. Ain	2013
Michael J. Mendelow	2013
Ernesto Bersusky	2013
Hilali Noordeen	2014
David L. Skaggs	2014
Edward P. Southern	2014

Council: Research
Board Liaison: Richard E. McCarthy
Staff Liaison: Cydni Chapman
Back-up: Megan Kelley

HISTORICAL COMMITTEE

Nathan H. Lebwohl, Historian	2011
Robert Wienecke (C)	2011
John J. Grayhack	2011
George H. Thompson, PPIII	2011
Behrooz A. Akbarnia, Chair Elect	2012
David H. Clements	2012
Azmi Hamzaoglu	2013
Reinhard D. Zeller	2014

Council: Governance
Board Liaison: John R. Dimar
Staff Liaison: Katy Kujala-Korpela
Back-up: Nilda Toro

IMAST COMMITTEE

Todd J. Albert, Chair	2012
Jacob M. Buchowski (C)	2011
Ahmad Nassr (C)	2011
Vishal Sarwahi (C)	2011
Brian A. O'Shaughnessy (C)	2011
Justin S. Smith (C)	2011
Joseph H. Perra (Education Ch)	2011
B. Stephens Richards	2011
Michael F. O'Brien	2012
Glenn R. Rechtine II (CME)	2012
Praveen Mummaneni	2013
Daniel J. Sucato	2013
Christopher I. Shaffrey, Chair Elect	2014

Council: Education
Board Liaison: Lawrence G. Lenke
Staff Liaison: Megan Kelley
Back-up: Tressa Goulding

INDUSTRY RELATIONS COMMITTEE

Richard E. McCarthy, Chair	2011
Oheneba Boachie-Adjei, Past Chair	2011
Steven M. Mardjetko (Treas)	2011
Lawrence G. Lenke, Chair Elect	2012
Vincent Arlet	2011
John P. Dormans	2011
Hansen A. Yuan	2011
Todd J. Albert (IMAST)	2012
Howard M. Place	2012
B. Stephens Richards (Pres Elect)	2013
Kenneth MC Cheung (Res Council)	2014
Ahmet Alanay (WWC)	2014
Serena S. Hu	2014
Kamal N. Ibrahim (Vice President)	2014
Paul D. Sponseller (Treas Elect)	2015

Council: Governance
Board Liaison: J. Abbot Byrd
Staff Liaison: Tressa Goulding
Back-up: Megan Kelley

JOURNAL TASK FORCE

Lawrence G. Lenke, Chair
Randal R. Betz
Vicki Kalen
Richard E. McCarthy
George H. Thompson

Staff Liaison: Tressa Goulding
Back-up: Courtney Kissinger

LONG RANGE PLANNING COMMITTEE

Richard E. McCarthy, Chair	2011
Oheneba Boachie-Adjei, Past Chair	2011
George H. Thompson, PP3	2011
Theodore A. Wagner (Global Outreach)	2011
Todd J. Albert (IMAST)	2012
Lawrence G. Lenke, Chair Elect	2013
Ahmet Alanay (WWC)	2014

Council: Finance
Board Liaison: Lawrence G. Lenke
Staff Liaison: Tressa Goulding
Back-up: Megan Kelley

SRS COMMITTEES (continued...)

MORBIDITY & MORTALITY COMMITTEE

Michael J. Goytan, Chair	2011
D. Raymond Knapp, Past Chair	2011
Amer Samdani (C)	2011
Justin S. Smith (C)	2011
Sigurd H. Berven	2011
Paul A. Broadstone, Chair Elect	2012
Theodore J. Choma	2012
Douglas C. Burton	2013
Yongjung J. Kim	2013
Robert F. Heary	2014
Howard M. Place	2014

Council: Research
Board Liaison: John R. Dimar
Staff Liaison: Nilda Toro
Back-up: Katy Kujala-Korpela

MULTI-SOCIETY SPINE REGISTRY TASK FORCE

Lawrence G. Lenke, Chair
D. Raymond Knapp
Steven D. Glassman
David W. Polly, Jr.

Staff Liaison: Tressa Goulding

NEWSLETTER COMMITTEE

Vicki Kalen, Chair & Editor	2013
Philip S. Anson (C)	2011
John P. Lubicky	2011
Eric H. Buchl (A)	2012
Serena S. Hu	2013

Council: Governance
Board Liaison: Serena S. Hu
Staff Liaison: Katy Kujala-Korpela
Back-up: Cydni Chapman

NOMINATING COMMITTEE

Richard E. McCarthy, Chair	2011
Kenneth M.C. Cheung	2011
John P. Dormans	2011
David W. Polly	2011
Daniel J. Sucato	2011

Council: Reports to Board
Board Liaison: Oheneba Boachie-Adje
Staff Liaison: Tressa Goulding
Back-up: Nilda Toro

NON-OPERATIVE MANAGEMENT COMMITTEE

John G. Thometz, Chair	2011
Brian G. Smith, Past Chair.	2011
Robert P. Huang (C)	2011
John Tis (C)	2011
Richard H. Gross	2011
Nigel J. Price, Chair Elect	2012
Paul D. Sponseller	2012
Michael C. Ain	2013
Timothy S. Oswald	2013
Theodoros B. Grivas, *Advisory*	
Joseph P. O'Brien, *Advisory*	

Council: Research
Board Liaison: Francisco J. S. Perez-Grueso
Staff Liaison: Cydni Chapman
Back-up: Katy Kujala-Korpela

SCOLIOSIS SCREENING TASK FORCE

John G. Thometz, MD, Chair
Theodoros B. Grivas, MD
Marinus De Kleuver, MD, PhD
Noriaki Kawakami, MD
Lawrence G. Lenke, MD
Keith D K Luk, MD
B. Stephens Richards, III, MD
Hee-Kit Wong, MD

Board Liaison: Hubert Labelle, MD
Staff Liaison: Tressa Goulding
Back-up: Katy Kujala-Korpela

PATIENT EDUCATION COMMITTEE

Jay Shapiro, Chair	2011
Ram Mudiyam, Past Chair	2011
Toni Cawley (Assoc)	2011
Walter F. Krengel	2011
Craig P. Eberson (C)	2011
Ahmad Nassr (C)	2011
Glen M. Ginsberg, Chair Elect	2012
Christopher Bergin	2012
Michael C. Albert	2012
Andrew K. Cree	2013
James T. Guille	2013
D. Raymond Knapp	2013
Joseph P. O'Brien, *Advisory*	
Stanley E. Sacks, *Advisory*	

Council: Education
Board Liaison: B. Stephens Richards
Staff Liaison: Katy Kujala-Korpela
Back-up: Courtney Kissinger

PEDIATRIC DEVICE TASK FORCE

Joint project team with POSNA
Michael G. Vitale, Chair
Behrooz A. Akbarnia
Laurel C. Blakemore
Robert M. Campbell, Jr.
Richard E. McCarthy
David W. Polly, Jr.
B. Stephens Richards
Brian D. Snyder
Paul D. Sponseller

SRS COMMITTEES (continued...)

PROGRAM COMMITTEE

Laurel C. Blakemore, Chair	2011
Noriaka Kawakami, Past Chair	2011
Michael J. Yaszemski, Past Chair	2011
Gregory M. Mundis, Jr. (C)	2010
Marinus de Kleuver	2011
R. Haluk Berk	2012
William F. Donaldson, III	2012
Daniel J. Sucato, Chair Elect	2012
Glenn R. Rechtine II (CME)	2012
Daniel W. Green	2013
Timothy S. Oswald	2013
Suken A. Shah	2013

Council: Education
Board Liaison: John R. Dimar
Staff Liaison: Megan Kelley
Back up: Cydni Chapman

Program Reviewers
Michael Ain 2011
Stephen Lewis 2012
Michael Albert 2011
Michael O'Brien (I) 2012
Paul Glazer 2011
Kenneth Paonessa 2012
Henry Iwinski 2011
Michael Roh 2012
Steve Richards (I) 2011
Suken Shah 2012
Hawart Singh 2011
James Guille 2013
Brian Smith 2011
Lawrence Haber 2013
Joseph Verska 2011
Michelle Marks (A) 2013
Michael Flippin (C) 2011
Mohammad Mossaad 2013
Robert A. Hart (C) 2011
P. Mummaneni (I) 2013
Todd J. Albert (I) 2012
Chris Shaffrey (I) 2014
Elizabeth Ames 2012

PUBLIC RELATIONS COMMITTEE

Michael O. LaGrone, Chair	2011
Alan Moskowitz, Past Chair	2011
Paul A. Glazer	2011
Hubert L. Gooch, Jr. (C)	2011
Ajeya P. Joshi (C)	2011
Ian Bruce McPhee	2012
Andrew G. King, Chair Elect	2012
Robert M. Bernstein	2013
Lori A. Karol	2013

Compelling Stories Task Force
John M. (Jack) Flynn, Chair
Richard E. McCarthy
Charles E. Johnston
Robert (Matt) Bernstein
Michael O. LaGrone
Dennis G. Crandall
Baron S. Lonner

Council: Governance
Board Liaison: John R. Dimar
Staff Liaison: Cydni Chapman
Back up: Katy Kujala-Korpela

RESEARCH GRANT COMMITTEE

Dilip K. Sengupta, Chair	2011
Nancy Hadley Miller, Past Chair	2011
Vikas V. Patel (C)	2011
Burt Yaszay (C)	2011
Rajiv Sethi (C)	2011
Michelle Caird (C)	2011
Peter D. Masso	2011
Matthew B. Dobbs	2011
Federico P. Girardi	2012
John M. (Jack) Flynn, Chair Elect	2012
Siavash Haghighi	2012
Kirkham B. Wood	2013
Lori Dolan (A)	2013
Jonathan H. Phillips	2013
Charles E. Johnston II	2014
Michelle C. Marks (A)	2014
Jonathan E. Fuller	2014
Virginie C. Lafage (A)	2014
Andrew G. King	2014

Council: Research
Board Liaison: Paul D. Sponseller
Staff Liaison: Courtney Kissinger
Back-up: Katy Kujala-Korpela

SRS / SPINE LIAISON COMMITTEE

K. Daniel Riew, Chair	2011
Allen W. Carl, Past Chair	2011
Joseph H. Perra, Chair Elect	2012
Frank J. Schwab	2012
Mark Dekutoski (Education Chair Elect)	2013
Matthew D. Hepler	2013
Keith H. Bridwell – *Spine* Liaison	

Council: Education
Board Liaison: Serena Hu
Staff Liaison: Courtney Kissinger
Back-up: Megan Kelley

SRS COMMITTEES (continued...)

3D SCOLIOSIS

Hubert Labelle, Chair	2011
Carl Eric Aubin, Co-Chair	2011
Lawrence G. Lenke	2011
Roger P. Jackson	2011
Peter O. Newton	2011
Stefan Parent (C)	2011
Pierre Roussouly	2011
Virginie C. Lafage	2011
Ian A.F. Stokes, *Advisory*	

Ad Hoc Members

Mark F. Abel	2011
Kenneth M.C. Cheung	2011
Howard A. King	2011
Richard E. McCall	2011
Michael J. Mendelow	2011
Reinhard D. Zeller	2011

Council: Research
Board Liaison: Lawrence G. Lenke
Staff Liaison: Cydni Chapman
Back-up: Nilda Toro

WEBSITE COMMITTEE

John F. Sarwark, Co-Chair	2011
Michael S. Roh, Co-Chair	2013
Andrew A. Merola, Past Chair	2011
Jay Shapiro (Patient Ed)	2011
Joseph H. Perra (Education)	2011
Michael Flippin (C)	2011
Adrian C. Gardner (C)	2011
Mark C. Lee (C)	2011
Michael F. O'Brien	2011
Kit M. Song	2011
Nathan H. Lebwohl (Historian)	2011
Matthew J. Geck	2012
Anthony S. Rinella	2012
Ross R. Moquin	2013
Munish C. Gupta	2014
Mark D. Rahm	2014

Council: Education
Board Liaison: Kamal N. Ibrahim
Staff Liaison: Courtney Kissinger
Back-up: Cydni Chapman

WORLDWIDE CONFERENCE COMMITTEE

Ahmet Alanay, Chair	2013
Kamal N. Ibrahim, Past Chair	2012
Theodore A. Wagner (Global Outreach)	2011
Joseph H. Perra (Education)	2011
R. Shay Bess (C)	2011
William C. Horton	2011
Victor Rositto	2011
Charles E. Johnston II	2011
Christopher L. Hamill	2012
Peter F. Sturm	2012
Ensor E. Transfeldt	2012
Muharrem Yazici	2012
Munish C. Gupta	2013
Youssry El Hawary	2013
Scott D. Hodges	2013

Council: Education
Board Liaison: Francisco J. S. Perez-Grueso
Staff Liaison: Tressa Goulding
Back-up: Courtney Kissinger

GLOBAL AFFAIRS ADVISORY BOARD

Kenneth MC Cheung (Asia), Chair	2010
Oheneba Boachie-Adjei, Past Chair	2010
Osmar Avanzi (The Americas, Co-Chair)	2012
Ernesto S. Bersusky (The Americas)	2012
Dietrich K.A. Schlenzka (Europe)	2012
Michael Ruf (Europe)	2012
Hee-Kit Wong (Asia)	2012
Khalil Kharrat (Middle East/Africa)	2012
Mohammed M. Mossaad (Middle East/Africa)	2012

Council: Governance
Board Liaison: Oheneba Boachie-Adjei
Staff Liaison: Nilda Toro
Back-up: : Cydni Chapman

BOS REPRESENTATIVES

Lawrence G. Lenke (Presidential Line)	2013
Richard E. McCarthy (Communications)	2011
George H. Thompson (Health Policy)	2011
Kamal N. Ibrahim (Research)	2011
B. Stephens Richards (Education)	2012
Tressa Goulding (Executive Director)	indefinite

FOSA REPRESENTATIVES

Timothy R. Kuklo	March 2011
Joseph W. Perra	Mar. 10-Feb. 11

HIBBS SOCIETY LIAISON

Robert W. Gaines	2011

EDUCATION COUNCIL

Steven D. Glassman, Chair – 2011
Daniel J. Sucato, Chair Elect

Awards & Scholarship	Steph J. Lewis
CME	Glenn R. Rechtine
E-Text	James W. Ogilvie
Education	Joseph H. Perra
Global Outreach	Theodore H. Wagner
IMAST	Todd J. Albert
Patient Education	Jay Shapiro
Program	Laurel C. Blakemore
SRS/Spine Liaison	K. Daniel Riew
Website	John F. Sarwark
Website	Michael S. Roh
Worldwide Conference	Ahmet Alanay

Staff Liaison: Megan Kelley
Back-up: Courtney Kissinger

FINANCE COUNCIL

Steven M. Mardjetko, Chair – 2011
Paul D. Sponseller, Chair Elect

Endowment	George H. Thompson
Finance	Steven M. Mardjetko
Long Range Planning	Richard E. McCarthy

Staff Liaison: Tressa Goulding
Back-up: Megan Kelley

SRS COMMITTEES (continued...)

GOVERNANCE COUNCIL

Hubert Labelle, Chair - 2014

Advocacy & Public Policy	John P. Lubicky
Bylaws & Policies	James W. Roach
Coding	Jeffrey B. Neustadt
Ethics	J. Abbott Byrd
Fellowship	Serena S. Hu
Global Affairs Advisory Board	Kenneth Cheung
Historical	Nathan H. Lebwohl
Industry Relations	Richard E. McCarthy
Newsletter	Vicki Kalen
Public Relations	Michael O. LaGrone

Staff Liaison: Tressa Goulding
Back-up: Nilda Toro

RESEARCH COUNCIL

Kenneth M C Cheung, Chair – 2014

Adult Deformity	Clifford B. Tribus
Evidence Based Outcomes	James O. Sanders
Growing Spine	Lawrence I. Karlin
Morbidity & Mortality	Michael J. Goytan
Non-Operative Management	John G. Thometz
Research Grant	Dilip K. Sengupta
3D Scoliosis	Hubert Labelle

Staff Liaison: Courtney Kissinger
Back-up: Tressa Goulding

SCOLIOSIS RESEARCH SOCIETY

AUTHOR INDEX

The Scoliosis Research Society gratefully acknowledges Synthes Spine for their support of the Pre-Meeting Course and Welcome Reception.

SYNTHES® Spine

AUTHOR INDEX

Presentation Number Key: 1-116 = Paper/Podium Presentations; 200 - 252 = E-Posters; 300 - 318 = Traditional Posters

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SCOLIOSIS RESEARCH SOCIETY

46th Annual Meeting & Course
September 14-17, 2011
Louisville, Kentucky, USA

Hubert Labelle, MD, Secretary
Scoliosis Research Society
555 East Wells Street, Suite 1100
Milwaukee, WI 53202-3823
Fax: 1-414-276-3349
E-Mail: info@srs.org

Dear Dr. Labelle:

Please change the listing of my name and address to read as follows:

Full Name: _____

Office Address: _____

City: _____ State: _____ Zip: _____

Country: _____

Telephone: _____ Fax: _____

E-mail: _____

Spouse's Name: _____

*You may now edit your contact information on the member's only section of the SRS web site.
You must enter your username and password to gain access.

SCOLIOSIS RESEARCH SOCIETY *presents*

19th International Meeting on Advanced Spine Techniques

IMAST

July 18-21, 2012

Istanbul, TURKEY

Abstract submission open
November 1, 2011

Abstract deadline
February 1, 2012

www.srs.org

47th Annual Meeting & Course

September 5-8, 2012 CHICAGO, ILLINOIS, USA

Abstract deadline
February 1, 2012

Abstract submission open
November 1, 2011

www.srs.org

MEETING OUTLINE

MONDAY, SEPTEMBER 12, 2011		
7:00 am - 5:00 pm	Board of Directors Meeting	Nunn Room
TUESDAY, SEPTEMBER 13, 2011		
7:00 am - 5:00 pm	SRS Committee Meetings	Combs Chandler; Nunn, Breathitt, Willis, Clements Rooms
1:00 - 5:00 pm	Hibbs Society Meeting*	Caroll Ford
2:00 - 6:00 pm	Poster Set-Up	Wetherby Hall Foyer
2:00 - 6:00 pm	Registration Open	2nd Floor Registration
7:00 - 10:00 pm	SRS Leadership Dinner (by invitation only)	Muhammad Ali Center
WEDNESDAY, SEPTEMBER 14, 2011		
6:30 am - 5:00 pm	Registration Open	2nd Floor Registration
6:30 am - 5:00 pm	Internet Kiosks, E-Posters Open	Wetherby Hall Foyer
8:00 am - 3:30 pm	Pre-Meeting Course	Grand Ballroom ABC; Archibald Cochrane (Rivue Tower)
11:30 am - 12:30 pm	Lunchtime Symposia*	Grand Ballroom ABC; Caroll Ford; Combs Chandler
3:45 - 5:00 pm	Case Discussions	TBD
6:00 - 7:30 pm	Opening Ceremonies	Grand Ballroom ABC
7:30 - 9:00 pm	Welcome Reception	Grand Ballroom & Wetherby Hall Foyers
THURSDAY, SEPTEMBER 15, 2011		
6:30 am - 3:00 pm	Registration Open	2nd Floor Registration
6:30 am - 3:00 pm	Internet Kiosks, E-Posters Open	Wetherby Hall Foyer
6:30 - 7:45 am	Members Business Meeting	Archibald Cochrane (Rivue Tower)
6:30 - 7:45 am	Non-Members Continental Breakfast	Grand Ballroom & Wetherby Hall Foyers
6:30 - 9:00 am	Guest Hospitality Suite	Clements Room
8:00 am - 12:30 pm	Scientific Program	Grand Ballroom ABC
12:30 - 3:00 pm	Instructional Course Lectures	Grand Ballroom ABC; Archibald Cochrane (Rivue Tower); Caroll Ford
FRIDAY, SEPTEMBER 16, 2011		
6:30 am - 5:15 pm	Registration Open	2nd Floor Registration
6:30 am - 5:15 pm	Internet Kiosks, E-Posters Open	Wetherby Hall Foyer
6:30 - 7:45 am	Members Business Meeting	Archibald Cochrane (Rivue Tower)
6:30 - 7:45 am	Non-Members Continental Breakfast & Information Session	Grand Ballroom; Wetherby Hall Foyers
6:30 - 9:00 am	Guest Hospitality Suite	Clements Room
8:00 am - 12:35 pm	Scientific Program	Grand Ballroom ABC
12:35 - 1:25 pm	Lunchtime Symposia*	Grand Ballroom ABC; Caroll Ford; Combs Chandler
1:25 - 5:15 pm	Scientific Program	Grand Ballroom ABC
7:00 - 10:00 pm	Farewell Reception	Kentucky Derby Museum (Shuttles depart from hotel lobby at 6:30pm; Return shuttles run 9:00 -10:00pm)
SATURDAY, SEPTEMBER 17, 2011		
6:30 am - 12:35 pm	Registration Open	2nd Floor Registration
6:30 am - 12:35 pm	Internet Kiosks, E-Posters Open	Wetherby Hall Foyer
6:30 - 7:45 am	Members Business Meeting	Archibald Cochrane (Rivue Tower)
6:30 - 7:45 am	Non-Members Continental Breakfast	Grand Ballroom; Wetherby Hall Foyers
6:30 - 9:00 am	Guest Hospitality Suite	Clements Room
8:00 am - 12:30 pm	Scientific Program	Grand Ballroom ABC
12:45 pm	Meeting Adjourns	
1:00 - 3:30 pm	Board of Directors Meeting	Nunn Room