



Contact the Harms Study Group via email at:
HarmsStudyGroupFoundation@gmail.com

2007 Annual Report



MISSION STATEMENT:

The Harms Study Group (HSG) is a group of surgeons dedicated to the advancement of treatment for children and adolescents with spine deformity.

Through comprehensive, multicenter prospective research studies, questions regarding treatment approach and techniques to achieve desired outcomes are studied.

The Harms Study Group is sponsored in part by an educational grant from DePuy Spine, Inc.

A Reason and a Season: Tribute to Thomas G. Lowe, MD

by Oheneba Boachie-Adjei, MD, SRS Vice President, April 7, 2007

Thou shall come to thy grave in full age, like a shock of corn cometh in his season.
Job 5:26

It is with deep sorrow and regret that I stand before you on behalf of the Scoliosis Research Society; President, Dr. George Thompson, the Board of Directors, the entire membership and the staff, to pay tribute to our 38th President, Dr. Thomas George Lowe.

As the wise King Solomon once said, there is a time to be born and a time to die. A time to plant and a time to uproot. A time to weep and a time to laugh. A time to speak and a time to be silent. We cannot understand why such a time has come upon us in this season of Lent. But we know that a new life has been ushered into eternity where there is immortality and painless existence with our creator.

Dr. Lowe was Clinical Professor of Orthopaedics at the University of Colorado Medical School, where he was Co-Director of the Spine Fellowship Program at the U.C. Health Sciences Center. He served as Co-Director of the Spine Clinic at Denver General Hospital, and was on the staffs of the Children's Hospital Scoliosis Clinic and Denver General Hospital. Tom served the professional organizations of which he was a member with distinction, serving on numerous committees of the American Academy of Orthopedic Surgeons, the Orthopedic Research & Education Foundation, the Russell Hibbs Society, North American Spine Society, Western Orthopedic Association and the American Orthopedic Association. At the Annual Meeting in 2005, Tom was elected Vice President of the Scoliosis Research Society. In all of his life, he served his profession, community and his beloved Society with gentleness, enthusiasm, dignity, compassion, wisdom, selfless dedication, and with the interests of others foremost in his mind.

As an internationally renowned spine surgeon, educator, researcher, author and inventor, Tom touched many lives through his work with patients and teaching and training residents and fellows from all walks of life. He was a frequent contributor to peer-reviewed journals and to medical textbooks. He performed high quality research to find causes, cures and treatment methods for spine deformities.

Tom came into our lives for a reason, and a season. He met many needs, assisted others through difficulties, provided guidance and support, and aided many physically, emotionally and spiritually.

Then, without any wrongdoing on his part and at an inconvenient time, these relationships have been brought to a sudden end. I can personally attest to his wish to reach out to places he had never been and people he had never met when he humbly submitted a volunteer application to go to Africa. In his personal statement he wrote,

“I have very much enjoyed the challenges of my profession and would like to share that expertise with underserved countries such as Ghana and Barbados while I am still actively participating in spinal surgery.”

What we must realize is that our needs have been met, our desires fulfilled, and his work is done.

Thank you, Tom, for being a part of our lives, for a reason and a season. A mighty tree has been cut down prematurely and our hearts go out to the bereaved: to you, Sally, his children Michael, Liz, Scott, his grandchildren and other family members and friends, we offer our deepest sympathy.

Farewell to our friend, colleague, teacher, counselor, board member and our 38th president. You have fought a good fight, you have kept the faith and you have finished your course. It is our prayer to meet again on a glorious Easter Sunday – and remember, we will be counting again on your wisdom and experience.



OBJECTIVE:

To be internationally recognized for the highest quality published research on new spinal deformity surgery techniques.

The presence of this study group at national meetings and in the literature is without comparison. Through current (and past) membership, the HSG has produced the largest volume of podium presentations on adolescent spinal deformity at annual meetings and the largest number of peer-reviewed journal articles and book chapters. Current surgeon members of the HSG include several members of the board of directors as well as three past presidents of the Scoliosis Research Society.

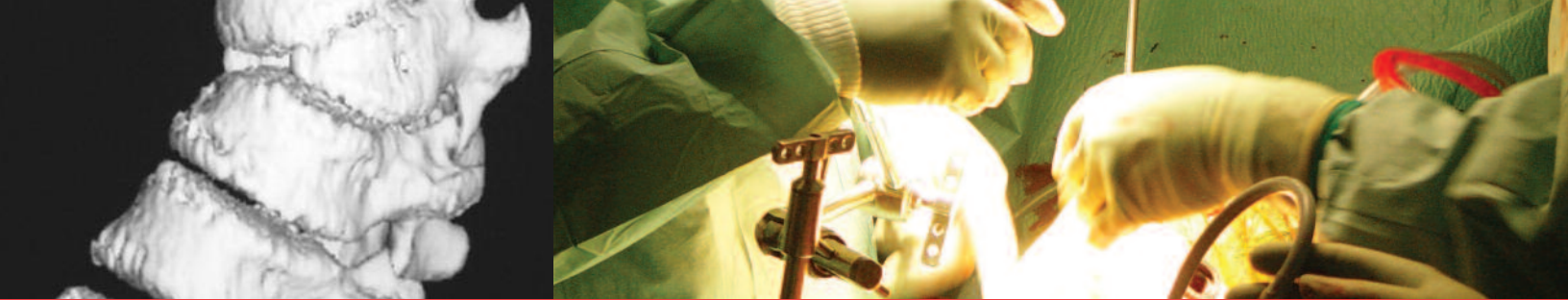
The development and maintenance of a strong infrastructure and a robust database system has been the link to this group's success. This infrastructure consists of personnel with expertise in multi-center research study coordination, protocol development and implementation, database design and management (data verification and quality assurance practices), statistical analysis and interpretation as well as expertise in contracting and budget management. This infrastructure supports the group's current involvement in four prospective studies and one retrospective study:

- 1) Prospective study of Motion Preservation Evaluation
- 2) Prospective study of Scheuermann's Kyphosis
- 3) Prospective Scoliosis Outcomes Database Registry
- 4) Prospective study of Scoliosis in Children with Cerebral Palsy (to launch in '08)
- 5) Retrospective study of Posterior Vertebral Column Resection in Pediatric Spinal Deformity



Plans for 2008:

- 1) Launch the prospective study of spinal deformities in Cerebral Palsy**
- 2) Launch of central x-ray measuring**
- 3) Perform multicenter retrospective VCR study**
- 4) "Refining" of the database to include only gold-standard data in all future abstract generation.**
- 5) Revise and restructure the current database structure, create 'version 2' of the HSG database.**



Long Term Goals:

The long term goals of the study group involve maintaining a consistent level of high quality research. Important, clinical answers and treatment recommendations will be provided by the clinical questions investigated by our group's research studies.

The most recent and innovative treatment techniques and evaluative procedures will be the primary focus of our group's work. Long term follow-up data is and will continue to be the group's strength and commitment.

The HSG is dedicated to advancing the techniques used to analyze treatment outcomes and has implemented radiographic digital scanning procedures and digital image acquisition in all study group sites to enable central digital radiographic measuring capabilities. The group is also currently investigating the possibilities of utilizing 3-Dimensional radiographic measures in their research. Collaborations with software and hardware companies for these goals are currently underway. All data entered in the central, web-based database undergoes central data quality assurance evaluation before it is utilized in our data queries.

The goal to achieve and define the gold standard for conducting multicenter research is the group's primary focus with a "refining" of the current data in the database underway to ensure all data meets this gold standard (i.e. prospectively consented enrollment, consecutive cases, and Institutional Review Board research study approval in place).

The book project entitled *Scoliosis: The Evaluation and Treatment of Idiopathic Spinal Deformity in Children and Adults*, is the current focus of the educational goals for the HSG. This up-to-date summary of idiopathic scoliosis is planned to be completed by December 2008. Additional educational outreach plans include the Peer-to-Peer group which is facilitated by the executive committee members of the Harms Study Group.

HISTORY:

The Harms Study Group (HSG) was established in 1994 under the direction of Professor Jürgen Harms and Randal Betz.

For the past decade the group has been internationally recognized for producing the highest quality published research on new spinal deformity surgery techniques (70+ peer reviewed publications). The group has achieved this standard by conducting comprehensive, multi-center prospective research studies aimed at answering important clinical questions regarding treatment approach and techniques. Currently, the executive committee consists of: Professor Jürgen Harms, Randal Betz, Peter Newton, Harry Shufflebarger, Michael O'Brien and Michelle Marks.

Funding for the group from DePuy formally began in October 2000 with a grant which consisted of an administration budget for three managing sites (Philadelphia, St. Louis and San Diego) and a data reimbursement budget for the additional study group sites. The group functioned under this yearly budget from 2000-2001 and annual spending patterns were consistent with the budgeted amounts.

In 2001, under the direction of Peter Newton and Randal Betz, the potential of the study group advanced with the development of a multi-user, web-driven, scoliosis database. All of the previous data collected by the study group was imported into this secure, multifaceted, comprehensive database. The ability to collect, manage and extract data was immediately more efficient and technologically advanced, as the new database incorporated digital images of radiographs and clinical photographs. To optimize the utility of the new database, formal prospective study protocols were updated for the two main studies of the group: The "Lenke 1 Study", comparing three different surgical approaches in thoracic curves and the "Algorithm Study", comparing the approaches for all curve types in order to establish recommended treatment algorithms.





In 2002, both prospective studies were underway and the improvements and growth of the group were apparent with the implementation of standardized data collection practices and the organized dissemination of individual member database mining projects. The administration of the group was split between the Philadelphia and San Diego managing sites.

In 2003, additional formalization of the study group occurred with comprehensive data verification measures implemented and major database upgrades. In addition, the San Diego site assumed the main administrative tasks of the study group; subcontracting with each site and managing the data verification, invoicing and reimbursements. The group grew from 12 surgeon members to 16 surgeon members and the database became the largest Adolescent Idiopathic Scoliosis database in existence. The productivity of the group also grew with a total of nine podium presentations presented at society annual meetings.

In 2004, in addition to the ongoing prospective data collection, the study group performed its first multi-center, retrospective study, evaluating the operative management of Scheuermann's Kyphosis. The data for 71 patients, including radiographic outcomes, complications, and surgical techniques was included. The results of this study were presented as a podium in addition to six other podiums that year.

In 2005, the prospective study of Scheuermann's Kyphosis was launched and three multi-center retrospective studies were developed and implemented by the group:

- 1) Defining the Incidence of Complications and Risk Factors Associated with the Use of Single Lung Ventilation for Thoracoscopic Surgery in Pediatric Spinal Deformity
- 2) Retrospective Cerebral Palsy Scoliosis Study: Quantifying Outcomes and Risks
- 3) A Multicenter Retrospective Review of the Results of Three Classes of Surgical Treatment for Congenital Scoliosis Due to Hemivertebrae

Productivity for the group continued with five podium presentations at annual meetings.



In 2006, an additional retrospective study was implemented, Comparison of Severe Scoliosis treated with or without Halo Traction, which included the involvement of the Peer-to-Peer group of surgeons, facilitated by the HSG. This provided the opportunity for the educational outreach efforts of the HSG to unite with the HSG research endeavors. The HSG also embarked on a book project entitled Scoliosis: The Evaluation and Treatment of Idiopathic Spinal Deformity in Children and Adults, to be published by Thieme Medical Publishers. This book will be an up-to-date summary of idiopathic scoliosis, focusing on new research findings in etiology, assessment, and treatment, as well as covering the fundamentals and basic principles of spinal deformity. All members of the HSG will provide chapter contributions. In addition, a prospective study of motion preservation evaluation was launched. Productivity for the group remained constant with five podium presentations at annual meetings.

In 2007, a HSG research organization infrastructure was launched to sustain the evolution of the group specifically with regards to a) central digital x-ray measuring and storage b) data organization, analysis and interpretation assistance to the members of the group for their individual member projects and c) data quality assurance and analysis procedures for the prospective studies. The productivity of the group soared to 15 podium presentations. The mechanism for digital image transfer was developed and hardcopy films were scanned into digital images for more than half of the 1500 patients in the HSG database. The “Lenke 1” study was completed and the “Algorithm Study” was converted into a Long-term Database Registry of AIS, in which operative and non-operative cases will be included with follow-up spanning 25 years.

The past decade has seen tremendous growth, evolution and advancement in the member participation, infrastructure and productivity of the Harms Study Group.

HSG EXECUTIVE COMMITTEE MEMBER PROFILES:



Prof Dr Med Jürgen Harms

Prof Dr Med Jürgen Harms, is a founding member of the Harms Study Group and active participant since 1994 and a current member of the Executive Committee. He has been an active participant in two prospective and three retrospective studies. He completed his medical specialization in orthopaedic and Trauma Surgery in Neuburg/Donau, and Ludwigshafen and Homburg/Saar. He has been a professor of Orthopaedic Surgery since 1977. He is currently Chief of Spine Surgery at Klinikum Karlsbad-Lagensteinbach, Germany (an institution affiliated to the University of Heidelberg Medical School) a position he has held since 1980. He also an honorary member of the Scoliosis Research Society.



Randal R. Betz, MD

Randal R. Betz, MD, is a founding member of the Harms Study Group and active participant since 1994 and a current member of the Executive Committee. He has been an active participant in four prospective and six retrospective studies. He is currently Chief of Staff and Medical Director of Spinal Cord Injury Unit at Shriners' Hospitals for Children in Philadelphia while serving as Professor of Orthopedic Surgery at Temple University School of Medicine. He completed his orthopedic training at Temple University, Philadelphia, with fellowship training at Alfred I. duPont Institute in Delaware. He was the President of the Scoliosis Research Society in 2005 and currently serves on the Board of the SRS, the American Paraplegia Society, as well as the North American Spine Society.



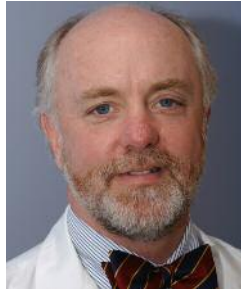
Peter O. Newton, MD

Peter O. Newton, MD, is a member of the Executive Committee of the Harms Study Group. He joined the group in 1998 and has been an active participant in four prospective and six retrospective studies. He is currently Chief of Orthopedic Research and the Scoliosis Service at Rady Children's Hospital in San Diego, while serving as Associate Clinical Professor of Orthopaedic Surgery at the University of California, San Diego. He completed his orthopedic training at the University of California, San Diego, with fellowship training at the Texas Scottish Rite Hospital for Children. He is the Research Council Chair and member of the Board of the Scoliosis Research Society and is currently the treasurer and on the Board of the Pediatric Orthopedic Society of North America.



Harry Shufflebarger, MD

Harry Shufflebarger, MD, was an original member of the Harms Study Group in 1995 and reactivated his participation in 2003 and is a current member of the Executive Committee. He is an active participant in four prospective and five retrospective studies. He is currently Clinical Professor of Orthopaedics and Rehabilitation at Miami Children's Hospital while serving as Clinical Professor, Department of Orthopedics & Rehabilitation at the University of Miami. He completed his orthopedic training at Emory University, Atlanta, Georgia. He was the President of the Scoliosis Research Society in 1999 and presently serves on the IMAST program committee.



Michael O'Brien, MD

Michael O'Brien, MD, is a member of the Executive Committee of the Harms Study Group. He joined the group in 2003 and has been an active participant in four prospective and five retrospective studies. He is currently Orthopedic Spine Surgeon and Co-Director of the spine fellowship program at Miami Children's Hospital. He completed his orthopedic training at State University of New York at Downstate with fellowship training at Washington University Medical Center in St. Louis. He is the past chair and current member of the Global Outreach Council for the Scoliosis Research Society as well as a member of the North American Spine Society and the Cervical Spine Research Society.



Michelle Marks, PT, MA

Michelle Marks, PT, MA, is a member of the Executive Committee of the Harms Study Group. Her participation in the group began in 1999 as the San Diego site coordinator for Peter Newton. She has been the administrator and multicenter research coordinator for the group since 2002. She currently manages the Harms Study Group research organization, while designing the new version of the multi-user web-based database. She obtained her bachelor's degree in Physical Therapy from Mount St. Mary's College in Los Angeles and her master's degree in Kinesiology and Biomechanics from San Diego State University. She is a current associate member of the Scoliosis Research Society.

HSG CORE MEMBER PROFILES:



David Clements, MD, is a founding member of the Harms Study Group and active participant since 1994. He has participated in four prospective and six retrospective studies. He is currently Director of the Spine and Scoliosis Service at Cooper Bone & Joint Institute, New Jersey, while serving as Associate Professor in the Department of Orthopaedic Surgery, Robert Wood Johnson School of Medicine and Attending Surgeon, Shriner's Hospital for Children, Philadelphia Unit. He completed an Orthopaedic Surgery Residency at Temple University Hospital in Philadelphia, PA and a Fellowship in Spine and Scoliosis at Hospital for Special Surgery/Cornell University Medical Center in New York. He is a current member of the Scoliosis Research Society as well as the Cervical Spine Research Society.



Lynn Letko, MD, is a core member of the Harms Study Group. She joined the group in 2003 and has been an active participant in two prospective and three retrospective studies. Since 2001, she is a spinal surgeon at Klinikum Karlsbad Langensteinbach, Karlsbad Germany. She completed her orthopedic training at the Long Island Jewish Medical Center, with fellowship training at Hospital for Joint Diseases Orthopaedic Institute. She is a candidate member of the Scoliosis Research Society.



Baron Lonner, MD, is a core member of the Harms Study Group. He joined the group in 2004 and has been an active participant in four prospective and four retrospective studies. He is currently serving as director of Scoliosis Associates and the Spinal Deformity Center at the Hospital for Joint Diseases in New York while serving as Clinical Associate Professor of Orthopaedic Surgery at New York University Medical School. He completed his orthopedic training at Albert Einstein College of Medicine, NY with fellowship training at the Hospital for Special Surgery, NY. He is the current chair-elect of the Endowment Committee of the Scoliosis Research Society. He is the primary investigator of the Prospective Study of Scheuermann's Kyphosis, being conducted by the Harms Study Group.



Paul Sponseller, MD, is a core member of the Harms Study Group. He joined the group in 2004 and has been an active participant in four prospective and five retrospective studies. He is currently Head of the Division of Pediatric Orthopaedics at Johns Hopkins Hospital in Baltimore. He completed his orthopedic training at the University of Wisconsin, with fellowship training at Boston Children's Hospital. He is the current program committee chair and Spine journal liaison chair of the Scoliosis Research Society and is the history committee chair and member of the board of directors of the Pediatric Orthopedic Society of North America. He is the primary investigator of the Prospective Study of Scoliosis in Children with Cerebral Palsy, being conducted by the Harms Study Group.



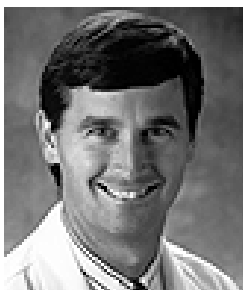
Suken Shah, MD, is a core member of the Harms Study Group. He joined the group in 2005 and has been an active participant in five prospective and four retrospective studies. He is currently Co-Director of the Spine and Scoliosis Service at the Alfred I. duPont Hospital for Children in Wilmington, Delaware, while serving as Assistant Professor of Orthopaedic Surgery at Thomas Jefferson University in Philadelphia, Pennsylvania. He completed his orthopedic training at the Thomas Jefferson University, with fellowship training at Alfred I. duPont Hospital for Children. He is a current member of the research committee of the Pediatric Orthopedic Society of North America as well as an active member of the Scoliosis Research Society and serves on the Bylaws and Policy Committee and Worldwide Course Committee.



Amer Samdani, MD, is a core member of the Harms Study Group. He joined the group in 2006 and has been an active participant in three prospective and three retrospective studies. He is currently director of the spine service at the Shriner's Hospital for Children in Philadelphia. He completed his neurosurgery training at Johns Hopkins Medical School with a chief residency at Johns Hopkins Hospital, followed by Fellowship training at Cornell University in New York and at the Children's Hospital of Philadelphia. He is a current member of American Association of Neurological Surgeons.



Mark Abel, MD, is a core member of the Harms Study Group. He joined the group in 2006 and has been an active participant in one prospective and two retrospective studies. He is currently head of the division of Pediatric Orthopaedics in the Department of Orthopaedic Surgery at the University of Virginia in Charlottesville. He completed his orthopedic training at the University of California, San Diego. He is a current member of the Subspecialty Certification committee of the Scoliosis Research Society and a member of the Treatment Outcome Committee of the American Academy of Cerebral Palsy and Developmental Medicine.



Jack Flynn, MD, is a core member of the Harms Study Group. He joined the group in 2006 and has been an active participant in three prospective and two retrospective studies. He is currently Associate Chief in the Division of Orthopaedics, at the Children's Hospital of Philadelphia and Associate Professor of Orthopaedic Surgery at the University of Pennsylvania. He completed his orthopedic training at Harvard, with a Chief Residency at Boston Children's Hospital, followed by Fellowship training at Alfred I. duPont Hospital for Children. He is the current IPOS program chair for the Pediatric Orthopedic Society of North America as well the recent past chair of the Growing Spine Committee of the Scoliosis Research Society.

HSG ASSOCIATE MEMBER PROFILES:

Alvin Crawford, MD, participated in the Harms Study Group as a core member from 2001–2007. He currently participates as an associate member by contributing follow-up data on his previously enrolled patients. He currently practices in the Division of Pediatric Orthopaedic Surgery at Cincinnati Children's Hospital Medical Center.

Larry Lenke, MD, participated in the Harms Study Group as a core member from 1995–2006. He currently participates as an associate member by contributing follow-up data on his previously enrolled patients. He is the current Chief of Spinal Surgery at Shriner's Hospital for Children in St. Louis.

Daniel J. Sucato, MD, participated in the Harms Study Group as a core member from 2001–2007. He currently participates as an associate member by contributing patient data to the Prospective Study of Scoliosis in Children with Cerebral Palsy. He currently practices at the Texas Scottish Rite Hospital for Children in Dallas.

Tom Maher, MD, participated in the Harms Study Group as a core member from 1996–2004. He currently participates as an associate member by contributing to the book project. He currently practices at Lutheran Medical Center in New York.

Andrew Merola, MD, participated in the Harms Study Group as a core member from 1996–2005. He currently participates as an associate member. He currently practices in New York.

Rubens Jensen, MD, has participated in the Harms Study Group as an associate member since 2000. He currently practices at Klinikum Karlsbad-Lagensteinbach, Germany.

James Guille, MD, participated in the Harms Study Group as a core member from 2003–2007. He currently participates as an associate member. He currently practices at Brandywine Orthopedics in Pottstown, Pennsylvania.

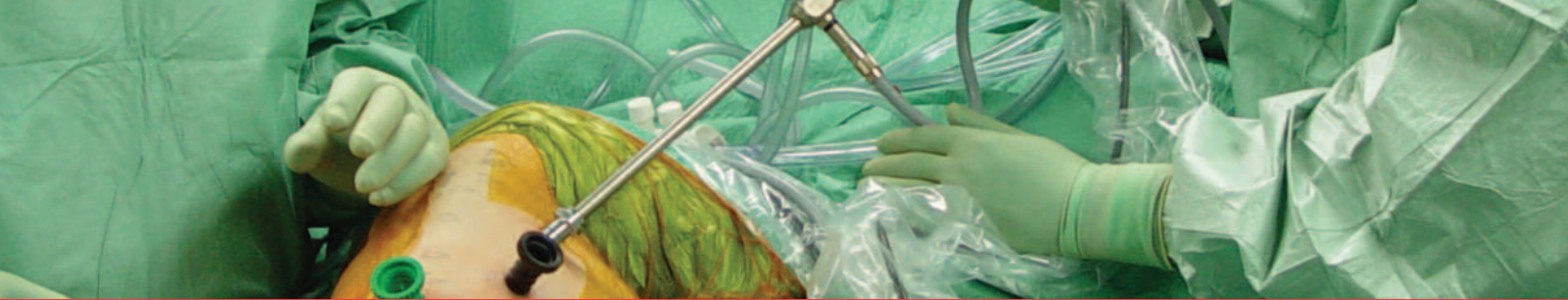
Linda D'Andrea, MD, participated in the Harms Study Group as a core member from 2000–2007. She currently participates as an associate member. She currently practices at Brandywine Orthopedics in Pottstown, Pennsylvania.

Christopher Reilly, MD, has participated in the Harms Study Group as an associate member since 2007, by contributing patients to three prospective studies. He is the current head of the department of pediatric orthopedics at the British Columbia Children's Hospital.

Firoz Miyangi, MD, has participated in the Harms Study Group as an associate member since 2007, by contributing patients to three prospective studies. He currently practices at the British Columbia Children's Hospital.

Munish Gupta, MD, has participated in the Harms Study Group as an associate member since 2008, by contributing patients to the Prospective Study of Scheuermann's Kyphosis. He currently practices at the Shriner's Hospital for Children in Sacramento.

Alexis Shelokov, MD, has participated in the Harms Study Group as an associate member since 2008, by contributing patients to the Prospective Study of Scheuermann's Kyphosis. He currently practices at the Baylor Scoliosis Center in Plano, Texas.



Harms Study Group Yearly Productivity:

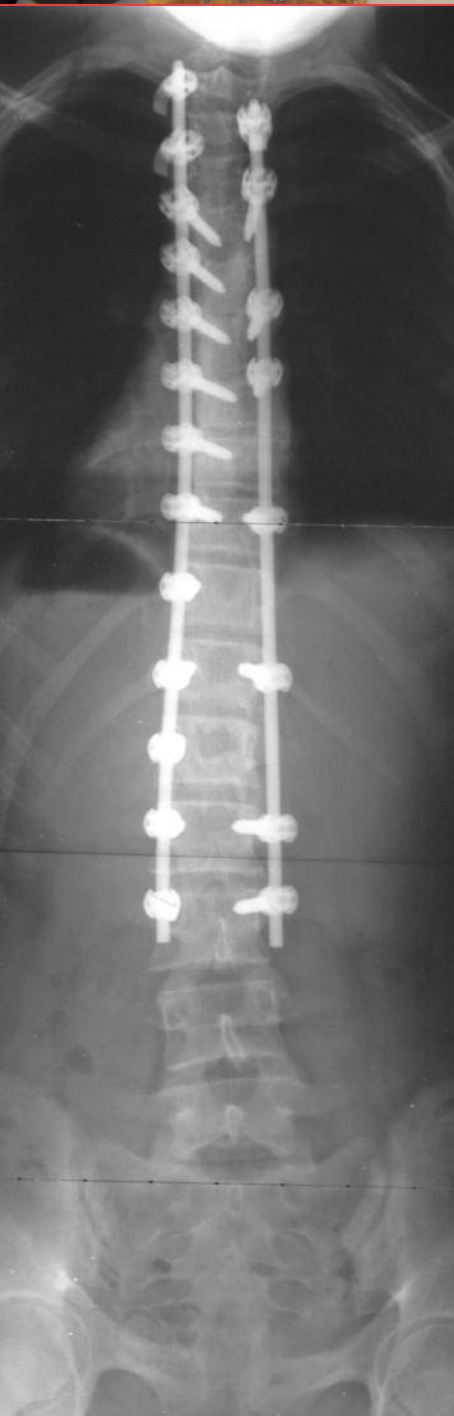
YEAR	PODIUM PRESENTATIONS*	POSTER PRESENTATIONS*	MANUSCRIPTS PUBLISHED^
2000	18	18	8
2001	10	10	8
2002	14	14	6
2003	13	13	6
2004	9	3	8
2005	7	17	6
2006	5	12	2
2007	20	47	7

* at SRS, NASS, POSNA, or AAOS

^ in a peer-reviewed journal



2007 PUBLISHED MANUSCRIPTS:



1. Marks, MC, Petcharaporn M, Betz, RR, Clements D, Lenke LG, Newton PO: Outcomes of Surgical Treatment in Male vs Female Adolescent Idiopathic Scoliosis Patients. Spine. 2007 Mar 1;32(5):544-9.
2. Kishan S, Bastrom T, Betz RR, Lenke LG, Lowe TG, Clements D, D'Andrea L, Sucato DJ, Newton PO. Thoracoscopic scoliosis surgery affects pulmonary function less than thoracotomy at 2 years postsurgery. Spine. 2007 Feb 15;32(4):453-8.
3. Petcharaporn M, Pawelek J, Bastrom T, Lonner B, Newton PO. The Relationship Between Thoracic Hyperkyphosis and the Scoliosis Research Society Outcomes Instrument. Spine. 2007 Sept 15: 32(20): 2226-2231.
4. Newton PO, Perry A, Bastrom T, Lenke LG, Betz RR, Clements D, D'Andrea L: Predictors of Change in Postoperative Pulmonary Function in Adolescent Idiopathic Scoliosis. Spine. 2007 Aug 1: 32(17): 1875-1882.
5. Upasani VV, Tis J, Bastrom T, Pawelek J, Marks M, Lonner B, Crawford A, Newton PO Analysis of sagittal alignment in thoracic and thoracolumbar curves in adolescent idiopathic scoliosis: how do these two curve types differ? Spine. 2007 May 20;32(12):1355-9.
6. Lonner B, Scharf C, Newton P, O'Brien M, Sponseller P, Betz R, Shufflebarger H: Operative management of Scheuermann's kyphosis in 71 patients: radiographic outcomes, complications, and technique. Spine. 2007 Nov 15;32(24):2644-52.
7. Upasani VV, Newton PO Anterior and thoracoscopic scoliosis surgery for idiopathic scoliosis. Orthop Clin North Am. 2007 Oct;38(4):531-40, vi.

2007 ABSTRACT SUBMISSIONS – Table of Contents

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	16	Comparison of Severe Scoliosis treated With or Without Halo Traction	Rejected	Podium	Not Submitted	
	17	Infection after Spine Surgery in Cerebral Palsy: Risk factors and Treatment	Podium	Poster	Not Submitted	
	18	Scoliosis Surgery in Cerebral Palsy: Differences between Unit Rod and Custom Rods	Podium	Poster	Not Submitted	
Lowe	19	A Retrospective Radiographic and Clinical comparison of Adolescent Idiopathic Double Thoracic (Lenke II) Curves Treated by Selective Anterior Instrumentation and Fusion of the Main Thoracic Curve Versus Posterior Instrumentation and Fusion of Both Curves	Rejected	Poster	Not Submitted	
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	21	Defining the Incidence of Complications and Risk Factors Associated with the Use of Single Lung Ventilation for Thoracoscopic Surgery in Pediatric Spinal Deformity	Rejected	Poster	Not Submitted	
	22	Large Thoracic AIS Curves Greater than 70°: Do They Need an Anterior Release?	Rejected	Poster	Not Submitted	
Shah	23	Evolution of Thoracic Pedicle Screws in AIS Over a Ten Year Period: Are the Outcomes Better?	Podium	Poster	Poster	
	24	Evaluation of Proximal Junctional Kyphosis in Adolescent Idiopathic Scoliosis Following Pedicle Screw, Hook, and Hybrid Instrumentation	Podium	Poster	Podium	
	25	Anterior / Posterior Surgery for Cerebral Palsy Scoliosis: Staged or Same Day?	Poster	Poster	Poster	
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	28	The Development of Scoliosis after Hemivertebra Resection and Instrumentation	Rejected	Poster	Not Submitted	
	29	The Development of Thoracic Hypokyphosis/ Lordosis After Dorsal Hemivertebra Resection and Instrumentation in 3 Cases of Complex Thoracic Congenital Scoliosis	Rejected	Poster	Not Submitted	
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	31	Double and Triple Curvatures in Idiopathic: Scoliosis Incidence and Surgical Outcomes	Rejected	Poster	Rejected	
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	33	Results of Three Classes of Surgical Treatment for Congenital Scoliosis due to Hemivertebrae: A Multicenter Retrospective Review	Rejected	Poster	Not Submitted	
Shufflebarger	34	Blood Loss and Operative Time in Scoliosis Surgery as a Function of Construct Type and Surgeon Experience	Poster	Poster	Not Submitted	
	35	The Rate of Unplanned Second Surgeries in Adolescent Idiopathic Scoliosis	Podium	Poster	Not Submitted	

SURGEON	PAGE	ABSTRACT TITLE	SRS	IMAST	NASS	OTHER
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	37	Correlation of Scoliosis Curve Correction with the Number and Type of Fixation Anchors	Podium	Poster	Not Submitted	
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	44	Adolescent Idiopathic Scoliosis Patients Report Increased Pain at 5 Years Compared to 2 Years After Surgical Treatment	Podium	Poster	Not Submitted	
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	47	Comparison of Compensatory Curve Spontaneous Derotation After Selective Lumbar or Thoracic Fusions	Rejected	Poster	Not Submitted	
	48	The Variation in How Surgeons Contour Rods for Scoliosis Correction is Substantial	Poster	Podium	Not Submitted	
	49	Spontaneous Lumbar Curve Correction in Selective Thoracic Fusions of Idiopathic Scoliosis - Anterior versus Posterior Approaches	Podium	Poster	Not Submitted	
Lenke	50	Comparison of Lowest Instrumented Vertebra (LIV) Selection in Lenke 1 Main Thoracic Adolescent Idiopathic Scoliosis Curves by the Surgical Approach: A Minimum 5-year Follow-up Study	Rejected	Poster	Not Submitted	
	51	Radiographic and Surgeon-Rationale for NOT Performing a Selective Thoracic Fusion in Lenke 1C Adolescent Idiopathic Scoliosis Curves	Rejected	Poster	Not Submitted	
Betz	52	Effect of Selective Fusion on Trunk Flexibility for Lenke 5 Adolescent Idiopathic Scoliosis (PORTER)	Rejected	Poster	Not Submitted	
	53	Can MRI Axial Rotation Measurements in Adolescent Idiopathic Scoliosis Correlate with CT?	Rejected	Poster	Not Submitted	
Samdani	54	CT Evaluation of Rotation Correction in AIS: A Comparison of All Pedicle Screw Construct versus a Hook-Rod System	Podium	Poster	Not Submitted	
TOTAL Total = 22 podiums, 48 posters			15 Podium 5 Posters	3 Podium 38 Posters	2 Podium 4 Posters	2 Podium 1 Posters

2007 SRS / IMAST ABSTRACT SUBMISSIONS:

Differences in Curve Behavior After Fusion in AIS with Open TRC

Paul Sponseller, MD; Randal Betz, MD; Peter Newton, MD; Larry Lenke, MD; Thomas Lowe, MD; Alvin Crawford, MD; Barry Lonner, MD; Harms Study Group

SUMMARY: An analysis of spinal fusion outcomes comparing patients with open tri-radiate cartilage with older patients revealed a loss of correction in the main curve, and levels added on proximally with the anterior-only procedure in the younger patients. Results of the combined procedure in both groups were similar.

INTRODUCTION: Patients with open triradiate cartilages at time of spinal fusion may be at increased risk of postoperative change. The purpose of this study was to compare the results of fusion in this group with those of more mature patients.

METHODS: 44 patients with open TRC (OTRC) having a mean age of 11.6 years were identified from a database of AIS patients. They were compared with 450 patients with closed TRC (CTRC) having mean age of 15.6 y from the database. The groups were similar in curve type distribution and size. Minimum follow up was 2 years in all groups. Mean pre-op curve was similar in each group. OTRC patients had 30 Lenke 1, 10 Lenke 2, 1 Lenke 3, 1 Lenke 4, and 2 Lenke 5 curves. OTRC patients underwent 25 ASF alone, 3 PSF alone and 16 ASF/PSF. Clinical and radiographic comparisons were performed.

RESULTS: The main curve in OTRC increased significantly more from post-op to follow-up when instrumented anteriorly or posteriorly than with combined approaches (4.4 and 7.3 degrees vs 0 degrees, $p=0.002$). This difference was not seen in the CTRC patients. More OTRC patients had proximal levels added on postoperatively than older patients (18% vs 8%, $p=0.02$) and there was a trend toward this phenomenon distally (29% vs 19%, $p=0.10$). However, proximal and distal junctional kyphosis was not significantly different between the two groups. Reoperation rate was 11% for OTRC patients and 7% for the CTRC. Sub-analysis of the selectively fused Lenke 1C curves revealed a trend in the change from pre-op to 2 yr FU of the uninstrumented lumbar curve with OTRC patients exhibiting a smaller lumbar curve pre-op and larger curve post-op than CTRC patients (36° to 27° vs 41° to 24° , $p=0.07$).

CONCLUSIONS: AIS patients with OTRC have greater risk of adding on levels proximally, as well as loss of correction with anterior-only instrumentation. However, after combined surgery they have results similar to that of more mature patients.

KEY WORDS: adolescent idiopathic scoliosis, open tri-radiate cartilage, spinal fusion outcomes

TABLE:

	OPEN-TRIRADIATE CARTILAGE PATIENTS	CLOSED-TRIRADIATE CARTILAGE PATIENTS
N	44	450
Mean Age	11	15
ASF	25	233
PSF	3	190
A+PSF	16	27
Pre-op Main Cobb	55 \pm 12	52 \pm 11
2 Yr Main Cobb	20 \pm 12	21 \pm 10
Levels added on Proximally	18%	8%

Comparison of Severe Scoliosis Treated With or Without Halo Traction

Paul Sponseller, MD; Peter Newton, MD; Oheneba Boachie-Adjei, MD; Jack Flynn, MD; Linda D'Andrea, MD; Keith Bridwell, MD; Munish Gupta, MD

SUMMARY: Retrospective comparison of large curves with and without preoperative traction showed that curve correction, spinal length and complications were similar but vertebral column resection was more commonly employed in the absence of traction.

INTRODUCTION: Preoperative traction has been used to assist in correcting large, rigid curves; however, a study with controls without traction has not been done. This study compares the safety and efficacy of treating large curves with and without preoperative traction.

METHODS: Consecutive cases treated after 1995 with external traction (Tx) prior to definitive fusion from 11 centers were analyzed. "Control" cases (C) of curves greater than 100° or having correction of less than 25% on traction or bending films were analyzed from 9 centers. All patients were under 18 years at surgery and were followed for a minimum of two years.

RESULTS: There were 30 patients treated with traction and 23 without traction. The most common diagnosis was AIS (18 Tx and 11 C). Main curve size averaged 93° ± 30° (Tx) and 104° ± 15° (C) (NS), and in both groups had a mean 21% flexibility. Mean age at surgery was 13 years (Tx) and 12 years (C). 20 patients had a release prior to traction. Traction was used for a mean of 4.9 weeks prior to surgery (range, 1-19). Femoral pins were used as distal counter-traction in 6 patients; in all others it was gravity in bed, wheelchair (14) or walker (8). There was one transient leg paresis in Tx but no other serious complications. At main surgery, vertebral column resection was more commonly performed in C (87%) than Tx (13%); $p=0.13$. Blood loss at main surgery was not significantly different (1957 Tx vs 2020cc C). There was one neurologic complication at main surgery in each group. Hospital stay averaged 34 days (Tx) and 14 days (C) ($p=0.01$). Main and compensatory curve correction was similar in both groups: Tx = 62±17%, C = 59±15% and Tx = 34±95%, C = 51±27%, respectively; NS. There were no differences in sagittal plane correction, or spinal length gained. Rates of complications were 27% (Tx) and 52% (C) ($p=0.05$).

CONCLUSIONS: There was no clinically significant difference between traction and control groups in spinal correction or complications. Some selection bias was possible in this retrospective study. Traction allows similar correction without the need for vertebral column resection. This may be preferred for patients with pulmonary or cardiac problems.

SIGNIFICANCE: Strategies for correction of large curves with or without traction have similar safety and efficacy.

Infection After Spine Surgery in Cerebral Palsy: Risk Factors and Treatment

Paul Sponseller, MD; Suken Shah, MD; Daniel Sucato, MD; Mark Abel, MD; Peter Newton, MD; Larry Lenke, MD; Harry Shufflebarger, MD; Lynn Letko, MD; Michelle Marks, PT, MA; Harms Study Group

SUMMARY: A multicenter study revealed a 10% rate of infection after scoliosis surgery in Cerebral Palsy. The only predictive patient variable was elevated preoperative white blood cell count.

INTRODUCTION: Infection is a serious complication of surgery to correct scoliosis in Cerebral Palsy (CP). The purpose of this study was to use a multicenter analysis to obtain a representative figure for the rates of deep and superficial infections after posterior spinal fusion (PSF) for CP. We also wanted to analyze risk factors and treatment outcomes.

METHODS: 157 patients underwent PSF for Cerebral Palsy at one of eight centers. Preoperative and intra-operative variables were subject to multivariate analysis to determine factors predictive of infection.

RESULTS: There were 16 wound infections (10%). 9 were deep and 7 were superficial. Unit rods were associated with a 15% rate and custom-bent rods were associated with a 5% rate ($p=0.03$). Organisms included pseudomonas, proteus, s. aureus, and MRSA. Patients with infections had higher preoperative white blood cell counts than those without (8.5 vs 6.4, $p=0.003$). However, age, mental retardation, ambulatory status, weight for age, presence of feeding tubes, total protein and total lymphocyte count preoperatively, EBL, use of spectrum of prophylactic antibiotics and performance of a posterior only vs a 1-or 2-stage AP procedure were not predictive of infection.

Fourteen patients required I & D procedures. Five infections required 2 months or longer to resolve. Two required implant removal. Final curve correction was significantly lower for those with deep infections (67% vs 53%, $p=0.04$). There was a trend toward greater pain at last follow up in those with deep infection (50% vs 18%; $p=0.09$).

CONCLUSIONS: This study provides a representative figure for the infection rate in scoliosis surgery for Cerebral Palsy. It is clearly higher than in most elective spinal deformity surgery. Higher preoperative white blood cell count and use of a unit rod were the two factors associated with an increased risk of infection. The final result may be compromised, and implant removal is sometimes required to clear infection in these compromised hosts.

SIGNIFICANCE: There were few patient factors which were predictive of infection in patients with cerebral palsy. Prevention strategy should involve improving the operative process for all patients.

Scoliosis Surgery in Cerebral Palsy: Differences Between Unit Rod and Custom Rods

Paul Sponseller, MD; Suken Shah, MD; Mark Abel, MD; Peter Newton, MD; Daniel Sucato, MD; Lynn Letko, MD; Randal Betz, MD; Harry Shufflebarger, MD; Linda D'Andrea, MD; David Clements, MD; Michelle Marks, PT, MA

SUMMARY: Unit rods provide superior correction of pelvic obliquity but have a higher incidence of problems with proximal fixation. Their insertion was associated with higher blood replacement, ICU and hospital stays.

INTRODUCTION: The process of curve correction differs between the unit rod and custom-bent rods. This study was designed to examine the differences in intraoperative factors and postoperative results in patients with CP using unit rods versus custom-bent rods.

METHODS: 157 children with cerebral palsy who had a posterior spinal fusion at one of 9 centers were retrospectively analyzed. 79 had unit rods (U) and 78 had custom-bent rods (C). Minimum follow up was 2 years. Clinical and radiographic data from the preoperative, intra-operative and postoperative period were analyzed.

RESULTS: Unit rod surgeries had EBL 2124cc versus 1885 for custom ($p=0.3$). Surgical time averaged 339 min for unit rods and 379 min for custom rods ($p=0.04$). However, unit rod patients required more allogenic blood replacement and spent more time in the ICU (4 vs 3 days; $p=0.001$) and in hospital (14 vs 13 days; $p=0.006$). Final major Cobb correction was similar for both groups (63% U, 66% C), while final pelvic obliquity correction was 74% U vs 22% C ($p=0.002$). Patients with unit rods had more clinically-apparent implant prominence at 2 year follow up (12 vs 2 instances, $p=0.03$); most of these were proximal. Implant-related reoperations were 8 for each group. Neurologic complications were seen in 5 Custom and 4 Unit (NS). The only factor which predicted overall complication rate for both groups was absolute curve magnitude ($p=0.04$). Caregiver assessment of utility of surgery was higher for the patients who received custom-bent rods ($p=0.05$).

CONCLUSIONS: Unit rod provides superior correction of pelvic obliquity but more proximal fixation problems. It may be associated with increased transfusion requirement, infection rate, ICU and hospital stay.

SIGNIFICANCE: Both implant types have positive features which should be employed for optimal deformity correction and safety.

A Retrospective Radiographic and Clinical Comparison of Adolescent Idiopathic Double Thoracic (Lenke II) Curves Treated by Selective Anterior Instrumentation and Fusion of the Main Thoracic Curve Versus Posterior Instrumentation and Fusion of Both Curves

Thomas Lowe, MD; Jui-Teng Chien, MD; Randal Betz, MD; Larry Lenke, MD; Peter Newton, MD;
David Clements, MD; Breton Line, BSc

SUMMARY: Analysis of radiographic, PFT, and SRS outcomes data revealed increased T1 tilt following selective ASF for Lenke II curves and little change following PSF of both curves. Sagittal T2-T5 decreased in the ASF group and increased in the PSF group. PFTs decreased slightly in the ASF open and PSF thoracoplasty groups, and increased slightly in the ASF thoracoscopic and PSF without thoracoplasty groups. SRS Self Image scores improved in both groups.

INTRODUCTION: This is a retrospective radiographic and clinical review of 102 AIS patients with double structural thoracic curves. The purpose is to analyze factors involved in decision to perform selective anterior spinal instrumentation and fusion (ASF, n=25) of the main thoracic (MT) curve or posterior spinal instrumentation and fusion (PSF, n=77) of MT and proximal thoracic (PT) curves. Traditionally PSF of both curves is required to treat AIS double thoracic curves.

METHODS: Coronal and sagittal measurements were obtained from erect preoperative, first, and final follow-up (≥ 2 yr) 36" radiographs. Clinical photos were reviewed for shoulder line asymmetry and correlated with T1 tilt. Pulmonary function tests were reviewed to relate the effects of approach, with or without thoracoplasty, on changes in predicted PFTs at final follow-up. SRS 24 outcomes were evaluated to determine the effects of treatment on clinical outcome.

RESULTS: The pre- and postoperative mean MT curves were similar in both the ASF and PSF groups. Preoperatively, the mean PT curve was larger in the PSIF group ($p < 0.001$). Postoperatively, the PT curve correction in the PSF group was greater than the mean PT curve correction in the ASF group. Mean T1 tilt increased postoperatively in the ASF group $+4.0^\circ (\pm 2.8^\circ)$ to $+6.2^\circ (\pm 3.2^\circ)$ and was unchanged in the PSF group $+7.5^\circ (\pm 5.4^\circ)$ to $+6.9^\circ (\pm 4.7^\circ)$ ($p = 0.024$). Postoperatively in the ASF group, T2-T5 kyphosis decreased while in the PSF group it increased ($p = 0.145$). Conversely, T5-T12 increased in the ASF group and decreased in the PSF group ($p < 0.001$). A positive relationship was noted between clinical shoulder asymmetry and T1 tilt $> 5^\circ$. Percent predicted PFTs in the ASF open group were decreased -4.8% at final follow-up and increased +4.3% in the thoracoscopic group ($n = 7$) ($p = 0.092$); in the PSF group they increased +5.6% unless a thoracoplasty ($n = 38$) was performed where they decreased -1.1% ($p = 0.074$). In the ASF group 57% showed improvement in SRS self image scores as compared to 46% in the PSF group.

CONCLUSIONS: With a larger MT/PT curve ratio, neutral or negative preoperative T1 tilt, and no positive shoulder asymmetry, selective ASF of the MT curve can be considered. If the converse is true, PSF of both PT and MT curves is mandated.

Patients Who Have a Selective Thoracic Fusion for Lenke 1 and 2 Curves Have Similar Coronal Balance But Improved Functional Outcome Scores at Two Years When Compared to Those Fused into the Lumbar Spine

Daniel Sucato, MD; Peter Newton, MD; Randal Betz, MD; Larry Lenke, MD; Thomas Lowe, MD; Alvin Crawford, MD; Lynn Letko, MD; Baron Lonner, MD

SUMMARY: A comparison of selective thoracic fusion and fusion of both curves in 230 Lenke 1B, 1C, 2B or 2C curves demonstrated similar coronal balance. The selective fusion patients had superior SRS scores at two years.

INTRODUCTION: Selective thoracic fusion for Lenke 1 and 2 curves offers the advantage of maintaining a mobile lumbar spine; however, further surgery into the lumbar spine may be necessary. There are no large studies analyzing radiographic and functional outcome data comparing these two groups.

METHODS: A prospective database was reviewed to identify all patients who had Lenke 1B, 1C, 2B and 2 C curves. Patients who had a selective fusion of only the thoracic curve (selective group) were compared to those who had fusion of the thoracic and lumbar spine (non-selective group).

RESULTS: 230 patients were reviewed: 184 in the selective and 46 in the non-selective groups. The average age, gender and ethnicity were similar between groups. The thoracic curve magnitude (52.6 vs. 56.1°), flexibility (48.0 vs. 43.0%) and apical vertebral translation (AVT)(3.3 vs. 3.7cm); and the lumbar curve magnitude (37.6 vs. 41.4°), flexibility (74.2 vs. 70.0%) and AVT (2.1 vs. 2.5cm) were similar between selective and non-selective groups. Postoperative correction of the thoracic (61.7 vs. 68.1%) ($p=0.01$) and lumbar curves (41.4 vs. 61.8%)($p=0.001$) was less in the selective group. Coronal balance was similar in both groups. At 2-year follow-up, a larger thoracic curve (24.6 vs. 21.4°)($p=0.01$), and lumbar curve (21.0 vs. 17.9°)($p=0.07$) were seen in the selective group, however, coronal balance was similar. Only 3 patients (1.6%) in the selective group required later extension of the fusion into the lumbar spine. At 2 years, the SRS outcomes questionnaire total score was higher in the selective fusion group (82.5 vs. 59.2)($p<0.05$). The domains of function after surgery, functional level of activity, general self image, pain and patient satisfaction were all significantly greater.

CONCLUSION: Selective thoracic fusion for Lenke 1 and 2 curves resulted in a well-balanced patient with little risk for decompensation and the need for distal fusion extension. Functional outcomes for these patients were superior to those who had fusion into the lumbar spine.

SIGNIFICANCE: This large cohort study demonstrates that selective thoracic fusion for Lenke 1B, 1C, 2B and 2C curves have similar coronal balance but improved SRS outcome scores when compared to patients fused into the lumbar spine.

Defining the Incidence of Complications and Risk Factors Associated with the Use of Single Lung Ventilation for Thoracoscopic Surgery in Pediatric Spinal Deformity

Daniel Sucato, MD; Peter Newton, MD; Baron Lonner, MD; Randal Betz, MD; Linda D'Andrea, MD; Alvin Crawford, MD; Larry Lenke, MD; Todd Milbrandt, MD; Vishwas Talwalkar, MD; Anna McClung, MD

SUMMARY: The incidence of complications from the use of SLV in a multicenter retrospective study of 501 patients was 8%, with only 0.8% of procedures aborted secondary to these difficulties. Those most likely to have difficulties with SLV are younger, smaller patients with PFT's <70% predicted. Surgeons should be aware of the potential problems with single lung ventilation and develop strategies to avoid these problems.

INTRODUCTION: Single lung ventilation (SLV) is utilized during thoracoscopic surgery to gain access to the thoracic spine, and can be associated with complications. The purpose of this study is to identify the incidence of complications and risk factors for the development of these complications when using SLV.

METHODS: A multi-center review of the experience using SLV was performed. Preoperative factors, pulmonary functions, preoperative radiographs, and intraoperative factors for the development of complications were reviewed. Complications were identified through the review of the operative and postoperative medical record for each patient.

RESULTS: There were 501 patients, 71.1% female, with an average age of 13.9 years at the time of surgery. The most common diagnosis was idiopathic scoliosis in 360 patients (71.9%). The mean coronal main thoracic curve preoperatively was 56.7°, and sagittal thoracic kyphosis was 33.5°. SLV was achieved with a double lumen tube in 318(63.5%) and an endotracheal tube with a bronchial blocker in 158(31.5%). Intraoperative difficulties achieving or maintaining SLV occurred in 40(8.0%) patients. Factors which predicted difficulties were: younger age (13.0 vs. 14.3 years), and lower preoperative FEV1-%pred (67.3% vs 75.3%)($p<0.05$). Four patients (0.8%) had the procedure abandoned directly related to challenges with SLV. Factors which predicted abandoning the procedure were: age (10.8 vs. 13.9 years), BMI (16.0 vs. 21.5 cm/kg²), and FVC% predicted (63.7% vs. 79.9%)($p<0.05$). The likelihood of difficulties with SLV or abandoning the procedure varied amongst institutions. ($p<0.05$)

CONCLUSION: The incidence of complications with SLV when performing thoracoscopic surgery for spinal deformity is approximately 8%, however only <1% had a change in surgical plan directly due to SLV. Predictive factors for the occurrence of complications include younger age, smaller patients and worse preoperative PFTs. Surgeons should be careful using SLV in younger, smaller patients with marginal PFTs.

SIGNIFICANCE: This study establishes the incidence of complications when using single lung ventilation in the pediatric patient and defines risk factors which predispose to these complications.

Large Thoracic AIS Curves Greater than 70°: Do They Need an Anterior Release?

Daniel Sucato, MD; Randal Betz, MD; David Clements, MD; Peter Newton, MD; Alvin Crawford, MD; Larry Lenke, MD; Thomas Lowe, MD; Harms Study Group

SUMMARY: A comparison of patients with thoracic curves measuring greater than 70° demonstrated similar coronal plane correction of the MT curve when comparing an anterior/posterior procedure with a posterior alone procedure. An anterior procedure may improve coronal plane correction if the flexibility of the curve is <40%.

INTRODUCTION: Anterior release has previously been recommended for thoracic curves measuring greater than 70°, however, recent advances in posterior segmental pedicle fixation may obviate the need for anterior surgery.

METHODS: A series of patients who had AIS curves measuring greater than 70° preoperatively were reviewed. Patients either had anterior release followed by posterior spinal fusion and instrumentation (A/P group) or had posterior only surgery (P group). The groups were compared and statistical significance was defined as $p < 0.05$.

RESULTS: There were 55 patients analyzed: AP group (N=32); P group (N=23). The AP group had greater preoperative proximal thoracic (PT) curve (41.7 vs. 36.1°) ($p < 0.05$), main thoracic (MT) curve (95.5 vs 82.3°) ($p < 0.05$) with less flexibility (28.0 vs. 38.9%) ($p < 0.05$) but similar lumbar curve magnitudes (49.9 vs. 46.9°). The immediate first postoperative radiograph demonstrated no difference between the AP and the P group in PT curve (19.0 vs. 17.4°), MT curve (23.6 vs. 24.5°), percent MT curve correction (72.0 vs. 68.6%), lumbar curve magnitude (20.6 vs. 17.6°) or percent lumbar curve correction (61.0 vs. 58.4%). Coronal balance and sagittal balance were the same. At 2 years, MT curve (26.4 vs. 28.4°), percent MT curve correction (69.3 vs. 62.2%), lumbar curve (21.3 vs. 17.6°), and percent lumbar curve correction (62.6 vs. 58.8%) were similar between AP and P groups. MT curves greater than 80° demonstrated no difference curve correction between groups. Patients with a flexibility index less than 40% had greater improvement in percent MT curve correction (83.1 vs. 73.3%) ($p < 0.05$) in the AP group.

CONCLUSION: This series of patients does not demonstrate an improvement in coronal plane MT curve correction when an anterior release is added to a posterior surgery for curves greater than 70°. However, very stiff curves with a flexibility index less than 40% may benefit from an anterior release.

SIGNIFICANCE: This study suggests that surgeons, in general, can avoid an anterior release for curves greater than 70 degrees, however, it may be beneficial if curve flexibility is <40%.

Evolution of Thoracic Pedicle Screws in AIS Over a Ten Year Period: Are the Outcomes Better?

Suken Shah, MD; Randal Betz, MD; Peter Newton, MD; David Clements, MD; Harry Shufflebarger, MD; Thomas Lowe, MD; Alvin Crawford, MD; Harms Study Group

SUMMARY: When compared to hook and hybrid cohorts, patients treated with segmental pedicle screw fixation for AIS had improved major Cobb correction, restoration of LIV tilt, rib hump reduction, patient-reported function and self image and shorter fusion.

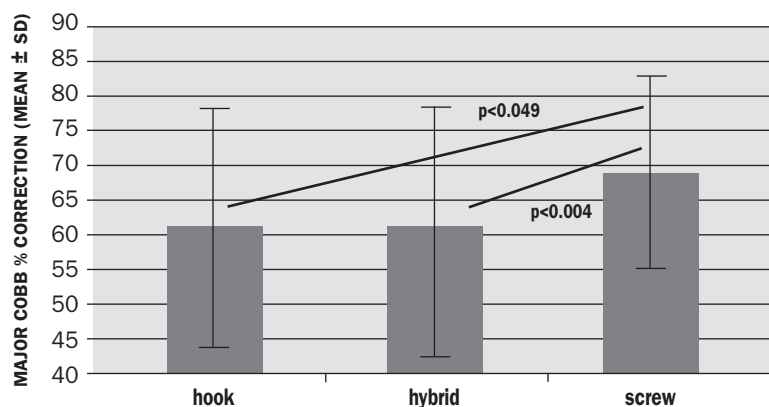
INTRODUCTION: What benefits to the patient have resulted with the evolution of thoracic pedicle screws in AIS? The purpose was to characterize the outcomes of surgery over a ten year period among surgeons across multiple centers.

METHODS: A prospective, multi-center database of over 1200 patients identified 292 patients that were treated with posterior-only surgery from 1995-2004 with minimum 2 year follow-up, then divided into 3 groups based on type of instrumentation: hooks, hybrid (proximal hooks and distal pedicle screws) and segmental pedicle screw instrumentation. Patients were compared by radiographic and clinical parameters, pulmonary function tests, and SRS-24/22 outcome scores.

RESULTS: The cohorts were comparable with regard to age, gender, curve magnitude and curve type. Correction of the major curve was significantly better in the screw group (69%) than the hybrid (60%) and hook group (59%) at two years, $p < 0.05$. Lower instrumented vertebral tilt correction was better in the screw group, $p < 0.05$. There were no differences in lumbar curve correction among the groups. Length of fusion was one level shorter in the screw group versus the hook and hybrid groups. Patients in the screw group had the lowest rate of thoracoplasty, but nonetheless had the best rib hump correction postoperatively. Screw constructs did result in some loss of T5-T12 kyphosis and an increase in PJK. Pulmonary function testing showed no differences between the groups postoperatively. SRS 24/22 outcomes, when separated by domain, showed patients with screw instrumentation reported better function at 2 years (as well as earlier time periods) and a trend toward better self image when compared to hook and hybrid groups.

CONCLUSION: Patients treated with segmental pedicle screw fixation for AIS had improved major Cobb correction, restoration of LIV tilt, rib hump reduction, patient-reported function and self image and shorter fusion.

SIGNIFICANCE: The trend of increasing pedicle use of segmental pedicle screw instrumentation for the treatment of AIS appears to be fundamentally sound and reproducible across multiple centers. This technique results in significantly improved radiographic and clinical parameters, better patient function and self image without an increase in complications.



Evaluation of Proximal Junctional Kyphosis in Adolescent Idiopathic Scoliosis Following Pedicle Screw, Hook, and Hybrid Instrumentation

Matt Helgeson, MD; Suken Shah, MD; Randal Betz, MD; David Clements, MD; Peter Newton, MD; Tracey Bastrom, MD; Michelle Marks, PT, MA; Harms Study Group

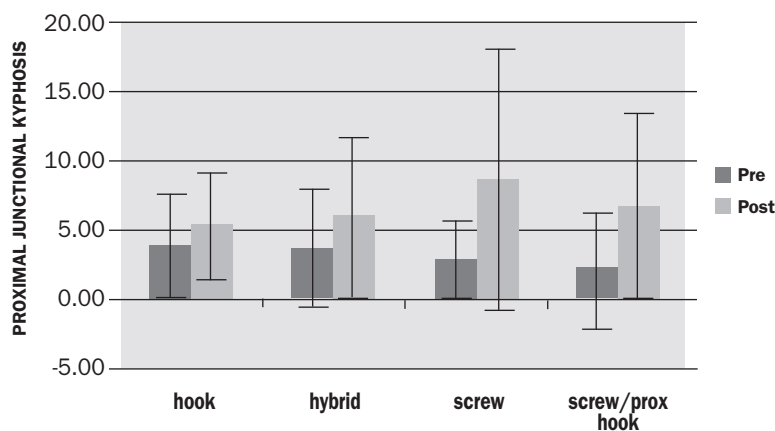
INTRODUCTION: The purpose of this study was to compare the incidence and risk factors for proximal junctional kyphosis in adolescent idiopathic scoliosis following posterior spinal fusion using hook, pedicle screw, and hybrid constructs.

METHODS: The preoperative and two year follow-up radiographic measurements from 283 patients with AIS in a multicenter database treated with posterior spinal fusion using hooks (Group 1, n=51), hybrid constructs (Group 2, n=177), pedicle screws (Group 3, n=37), and pedicle screws with hooks only at the top level (Group 4, n=18) were compared. Proximal kyphosis was measured from the inferior endplate of the upper instrumented vertebra to the superior endplate of the spinal segment immediately cephalad to the instrumentation.

RESULTS: The average proximal level kyphosis at 2 years postoperatively was 8.2° (range -1 to 18) in the all screw constructs, representing a significant increase when compared to hybrid and all hook constructs, 5.7° (p=0.02) and 5.0° (p=0.014), respectively. Conversely, average postoperative T5-T12 kyphosis was significantly less (p=0.016) in the screw group compared to the all hook group. Of potential interest, but currently not significant, was the trend towards a decrease in proximal kyphosis in constructs with all pedicle screws except hooks at the most cephalad segment, 6.4° (range 0 to 13). The incidence of PJK (assuming PJK is kyphosis greater than 15 degrees or 2 SD above normal) was 0 % in Group 1, 2.3% in Group 2, 8.1% in Group 3, and 5.6% in Group 4 (p=0.18).

CONCLUSIONS: Adjacent level proximal kyphosis was significantly increased with pedicle screws, but the clinical significance of this is unclear and the incidence of PJK among various constructs was not significant. A potential solution is the substitution of hooks at the upper-instrumented vertebrae, but further investigation is required.

SUMMARY: In a review of 283 cases of AIS treated with posterior spinal fusion, all pedicle screw constructs had significantly increased proximal level kyphosis when compared to all hook or hybrid constructs at two year minimum follow up. The clinical significance of this is unclear and the incidence of PJK among various constructs was not different. A potential solution is the substitution of hooks at the upper-instrumented vertebrae, but further investigation is required.



Anterior / Posterior Surgery for Cerebral Palsy Scoliosis: Staged or Same Day?

Suken Shah, MD; Paul Sponseller, MD; Mark Abel, MD; Peter Newton, MD; Daniel Sucato, MD; Lynn Letko, MD; Randal Betz, MD; Harms Study Group

SUMMARY: Anterior and posterior (AP) surgery is occasionally performed for management of scoliosis due to cerebral palsy (CP). When possible, anterior surgery should be performed on the same day, as this results in lower blood loss, operative time and hospital stay without increased complications. AP surgery as compared with posterior surgery for patients with scoliosis due to CP resulted in only modestly better final correction of the major and minor curves, no difference in pelvic obliquity but required longer operative time.

INTRODUCTION: Although posterior surgery remains the preferred approach for the treatment of scoliosis due to CP, occasionally anterior and posterior (AP) surgery is performed for larger, rigid curves. The purpose was to define the utility and timing for anterior surgery when a subsequent posterior procedure is planned.

METHODS: A multicenter database of 157 children with CP and scoliosis who underwent surgery with minimum 2-year follow up was reviewed. Forty-eight patients had anterior surgery, 9 were staged on different days (STG) and 39 were done on the same day (SD). Radiographic parameters, OR/hospital data and complications were compared between AP and posterior patients and STG and SD patients using repeated measures ANOVA. Preoperative risk assessment including cognition, feeding method, verbal ability, ambulation, GMFCS scores and radiographic variables showed that the groups were quite homogenous, i.e., the STG patients were not necessarily "sicker."

RESULTS: The length of stay was 9 days for the SD group and 46 days for the STG group ($p=0.001$). EBL was 1617 cc for SD versus 3428 cc for STG ($p=0.001$). OR time was 484 min for SD versus 524 min for STG ($p=0.2$). Overall complications were not significantly different based on the timing of anterior surgery. Also, the complication rate for anterior/posterior (AP) surgery was not higher compared to posterior only surgery. AP surgery patients had 182 min longer OR time than posterior only patients, but no difference in overall EBL (1919 vs. 2006 cc), ICU stay (3.8 vs. 3.7 days), or total hospital stay (13.2 vs. 13.9 days). Coronal curve correction at final follow up was 61% for the AP patients and 52% for the posterior only patients ($p=0.055$), but no differences were noted for correction of pelvic obliquity, kyphosis, instrumentation complications, or caregiver assessment of utility.

CONCLUSIONS: There does not appear to be a clear advantage of staged anterior plus posterior surgery compared to same day. When anterior surgery was performed on the same day versus staged, the result was lower blood loss, operative time and hospital stay without increased complications. AP surgery as compared with posterior surgery for patients with scoliosis due to CP resulted in only modestly better final correction of the major and minor curves, no difference in pelvic obliquity but required longer operative time.

The Feasibility of Neuromonitoring for Cerebral Palsy Scoliosis and the Outcome of Neurological Complications

Suken Shah, MD; Paul Sponseller, MD; Mark Abel, MD; Peter Newton, MD; Daniel Sucato, MD; Lynn Letko, MD; Randal Betz, MD; Harms Study Group

SUMMARY: The usefulness of intraoperative neurophysiologic monitoring in scoliosis surgery for patients with CP is questioned by some. The rate, severity and outcome of neurological injuries during surgery in these patients are not well reported. Monitoring of MEP and SSEP in these patients undergoing spinal deformity is feasible and useful to detect impending neurologic deficits. The rate of neurologic adverse events was 4.3% in this series. Most deficits improved over time.

INTRODUCTION: The purposes of this study were 1.) to study the feasibility and reliability of intraoperative neurophysiologic monitoring (IONM) in patients with scoliosis due to CP and 2.) determine the rate, nature and outcome of neurological complications in spinal deformity surgery in these patients.

METHODS: A multicenter database of 163 children with CP and scoliosis who underwent surgery with minimum 2 year follow up was reviewed; 121 had IONM, and of those with complete records, 71% had good or fair potentials that were useful during surgery, and 22% had IONM attempted and abandoned due to poor baseline signals.

RESULTS: Seven patients (4.3%) had an adverse neurologic event, 5 intraoperative and 2 were noted postoperatively (both of these had no IONM). All intraoperative events were detected by IONM with a decrease from baseline MEP and SSEP. The treatment was typically a surgical pause, elevation of BP, administration of methylprednisolone, and/or adjustment of instrumentation. All but one recovered fully over time (range: immediately to 6 months postoperatively.) The course of recovery was accompanied by increased spasticity and contractures. Of the two patients with postoperative deficits noted 1-2 days after surgery, one had removal of instrumentation for motor and sensory deficits, recovered and was re-instrumented, and the other was treated for a neurogenic bladder that recovered after 4 months. No correlation to curve size, apex or EBL could be identified with the numbers available. The patients who had IONM attempted and abandoned due to poor baseline signals were typically severely involved spastic quadriplegic patients with MR. No postoperative deficits were detected in patients with reliable baseline signals that were stable throughout surgery (no false negatives).

CONCLUSIONS: The rate of neurologic complication in this population of patients with CP undergoing spinal deformity surgery for scoliosis was 4.3%. IONM was feasible in 71% and provided reliable information regarding an impending neurologic deficit and was 100% specific. When neurologic complications did occur, the prognosis was fair and improvement was noted over time.

SIGNIFICANCE: Intraoperative neurologic monitoring should be utilized when possible in scoliosis surgery even in patients with CP to detect neurological adverse events. In view of the increased incidence of neurologic deficit, the difficulty of monitoring, patient variability, and potential for recovery similar to pre-op status, the surgeon and parents should come to explicit agreement preoperatively about a course of action if changes occurred.

The Role of Stagnara (True Lateral, Plan d'élection) X-rays in the Evaluation of the Sagittal Profile Pre-operatively in AIS

Lynn Letko, MD; Thomas Welk, MD; Rubens Jensen, MD; Prof Dr Med Jürgen Harms

PRÉCIS: Pre-operative assessment of the thoracic sagittal profile is important in operative planning in AIS. The Stagnara (true lateral) view provides useful information in accurate assessment of this parameter.

OBJECTIVES: To examine the role of the Stagnara x-ray in sagittal profile evaluation of AIS.

METHODS: Retrospective review of pre-operative T5 – T12 sagittal plane measurements in 45 (38F, 7M) AIS patients. Stagnara (true lateral, plan d'élection) x-rays were compared to T5 – T12 measurements on full length pre-operative lateral x- rays. Patients were operated between 1/ 03 and 11/06. Lenke classification was: 1 in 26, 2 in 5, 3 in 10 and 4 in 4 patients.

RESULTS: In 4/45 cases, the Stagnara view was not accurately measurable. These curves were Lenke 3 & 4 curves $>80^{\circ}$ T and $>70^{\circ}$ TL/L. In the remaining 41 patients, the kyphosis T5 –12 on the standard lateral x-ray ranged from (-) 20° – 40° (mean: 16.7°); on the Stagnara view: (-) 25° – 70° (mean: 14°). The differences measured between the 2 views ranged from 0 – 30° (mean: 9.4°). The measurements were the same on both views in 9 patients. Stagnara measurements were greater in 12 patients; less in 20 patients. Differences in thoracic kyphosis/ lordosis on the Stagnara & full length lateral x-rays affected only the thoracic sagittal profile modifier (11/41 cases). This did not change the operative approach in any case.

The choice of metal and the goal of reduction of kyphosis post-op was influenced in 4 cases.

CONCLUSIONS: Accurate pre-op assessment of the thoracic sagittal profile is of major importance in AIS with a structural thoracic curve.

It is important in consideration of operative approach; choice metal implants used & desired sagittal correction. The Stagnara view proved inaccurate in Lenke 3 and 4 curves with magnitude $>80^{\circ}$ T and $>70^{\circ}$ TL/L. It is, otherwise, useful in pre-op sagittal plane assessment of thoracic curves in AIS.

The Development of Scoliosis After Hemivertebra Resection and Instrumentation

Lynn Letko, MD; Prof Dr Med Jürgen Harms

SUMMARY: Dorsal hemivertebra resection and pedicle screw instrumentation provides complete lasting scoliosis correction in almost all single or double hemivertebrae cases. We report 4 cases in which scoliosis developed above and/or below the original surgically corrected deformity.

INTRODUCTION: Since 1994, our standard treatment of congenital scoliosis resulting from single or double hemivertebrae is dorsal hemivertebra resection and pedicle screw instrumentation. This method has provided excellent lasting correction in almost all of our approximately 55 cases. We report 4 cases which developed unexpected scoliosis above and/or below the surgically corrected deformity to bring attention to this phenomenon and possible etiologies.

METHODS: Retrospective review of 4 congenital scoliosis patients (3 F, 1M) with single (3 patients) or double hemivertebrae (1 patient). Patients were surgically treated between 12/04 - 8/06, with of dorsal hemivertebra resection and instrumentation. All patients had pre-operative x-rays, MRI, 3D CT and myelogram. MRI was normal in 2 patients. 1 patient had a tethered cord (surgically released at the time of surgery). The second had a thoracic syrinx and Arnold Chiari malformation not requiring surgical intervention. Mean age at surgery was 5 yrs 2 mos (range 22 mos - 13 years). Follow-up ranged from 4 – 18 mos (mean 10 mos).

RESULTS: All 5 hemivertebrae were between T9 and L2. Mean pre-op scoliosis in the curve including the hemivertebra(e) was 52 ° (range 30° - 80°.) This corrected to 0° post-op and 12° (0° -50°) at last follow-up. Mean pre-op kyphosis was 37° (range 20° - 45°). This corrected to 0° post-op (range -2° - 5°) and -1° (range -10° -5°) at last follow-up. Post-operatively, 2 patients developed a C shaped scoliosis above & below the operated region. 1 patient developed a scoliosis above, 1 below. These were noted to increase at 4 mos post-op in 2 cases and significant increase was noted after removal of a temporary screw in 2 cases. See Table 1.

CONCLUSIONS: Not all congenital scolioses resulting from single or double hemivertebra will be fully corrected above and/or below the operated region as expected despite hemivertebra resection and rigid segmental instrumentation. Intra-spinal abnormalities may be the cause in the 2 cases that developed curves above and below the hemivertebrae. Further attention needs to be paid to such cases to determine additional predetermining characteristics pre-operatively

Table 1. Scoliosis Development Above and/or Below Dorsal Hemivertebra Resection and Instrumentation

CASE	HEMIVERTEBRA LOCATION	SCOLIOSIS	PRE-OP	POST-OP	AFTER REMOVAL OF SINGLE TEMPORARY SCREW	LAST FOLLOW-UP
1	T10	L1-L4	10°	10°	NA	30°
2	L2a	T11- L3	50°	30°		50°
3	L1a	T5 –T11	0°	30°		42°
4	T9a, T11a	T8 – L3	45°	15°	NA	30°

The Development of Thoracic Hypokyphosis/ Lordosis After Dorsal Hemivertebra Resection and Instrumentation in 3 Cases of Complex Thoracic Congenital Scoliosis

Lynn Letko, MD; Rubens Jensen, MD; Prof Dr Med Jürgen Harms

SUMMARY: 3 patients with complex thoracic congenital scoliosis developed thoracic hypokyphosis/ lordosis after dorsal complex resection and pedicle screw instrumentation. Rod removal has resulted in improvement in the thoracic sagittal profile with rod reinsertion required in cases of scoliosis progression.

INTRODUCTION: Since 1997, our standard treatment of complex congenital thoracic scoliosis is dorsal hemivertebra resection with or without bar resection and rib synostosis resection and pedicle screw instrumentation. We report 3 cases which developed thoracic hypokyphosis/lordosis after this procedure with improvement noted in the sagittal profile after rod removal.

METHODS: Retrospective review of 3 patients (3 M) with complex thoracic congenital scoliosis deformity who underwent dorsal hemivertebrae with or without bar resection with pedicle screw instrumentation between 12/97 & 2/03. Mean age at index surgery was 27 mos (range 19 –33 mos). Mean follow-up 74 mos(range 45-116 mos). Mean number of vertebrae resected was 3 (Range 3-4). Mean number of segments instrumented was 8 (range 8-9) all between T2 and L1.

RESULTS: Mean scoliosis pre-op 82° (range 70°– 102°). Mean thoracic kyphosis pre-op 37° (range 22° - 60°). Mean scoliosis post-op 6° (range 0 –13°). Mean thoracic kyphosis post-op 27° (range 20° -30°). Development of thoracic hypokyphosis/lordosis surgically treated with rod removal a mean of 56 mos after index procedure (range 37 – 92 mos) . Mean kyphosis prior to rod removal was 5°(range minus 5 °– 10°). Mean kyphosis after rod removal was 13° (range 0 –20°). Mean kyphosis at last follow- up or before rod reinsertion was 21° (range 10 – 32°). Rod reinsertion was indicated in 2 cases of increasing scoliosis.

CONCLUSIONS: Dorsal hemivertebra resection and pedicle screw instrumentation provides excellent scoliosis correction in cases of complex thoracic congenital deformity. The posterior pedicle screw instrumentation may act as a tether resulting in the development of hypokyphosis/lordosis as the anterior column continues to grow especially in cases of multilevel instrumentation. Rod removal has allowed for improvement of the thoracic sagittal profile (plastic deformation vs and/or growth?) Rod reinsertion with the rods bent to match the improved sagittal profile may be necessary in cases of scoliosis progression. This patient population requires continued follow-up until cessation of growth

Treatment of Thoracic Scoliosis: Are Monoaxial Thoracic Pedicle Screws the Best Form of Fixation for Correction?

Baron Lonner, MD; Oheneba Boachie-Adjei, MD; Suken Shah, MD; Naobumu Hosgane, MD; Peter Newton, MD

SUMMARY: The choice of anchor type in scoliosis constructs has evolved over time. We found no differences in coronal plane and clinical ATR between three different fixation types. The hybrid construct did result in a better restoration of thoracic kyphosis than did the polyaxial or monoaxial screw constructs.

INTRODUCTION: Instrumentation for the treatment of scoliosis has evolved. Current techniques include use of a combination of hooks, sublaminar wires, and pedicle screws (HYBRID), as well as segmental pedicle screw fixation with either monoaxial (MONO) or polyaxial (POLY) screw anchors. The purpose of this study is to compare radiographic and clinical results of these three constructs for the treatment of thoracic adolescent idiopathic scoliosis.

METHODS: A multicenter retrospective study with minimum 2-year follow-up was conducted to compare the results of three instrumentation constructs for structural thoracic adolescent idiopathic scoliosis. Standard radiographic assessment including coronal and sagittal parameters was performed preoperatively and 2 years postoperatively. In addition, evaluation of the angle of trunk rotation (ATR) was done with an inclinometer.

RESULTS: The study included 99 patients with similar preoperative curve features in each surgical group. Pre-operative thoracic curvature and curve flexibility, age, Lenke curve type, and number of levels fused was similar for each group although more anchors per level were used in the MONO group and in the HYBRID group compared to the POLY group. Additionally, the HYBRID group was instrumented with 6.35 mm rods while the MONO and POLY groups had 5.5 mm rods. Curve correction was similar between the groups but an increase in T5-12 kyphosis was noted in the HYBRID group compared to the other 2 groups ($p < 0.02$). Thoracoplasty was done in 69%, 9%, and 0% of HYBRID, MONO, POLY patients, respectively with no difference in the change in the thoracic ATR between the groups.

CONCLUSION: Similar coronal plane correction was achieved in thoracic AIS with three different constructs. The HYBRID construct tended to improve thoracic kyphosis over the other two constructs although the effect of rod diameter can not be discounted. Similar axial plane correction of rib prominence was achieved with screw constructs with less reliance on thoracoplasty than with the HYBRID constructs.

CONSTRUCT	PRE-OP TH CURVE	PRE-OP CURVE FLEXIBILITY	# OF LEVELS FUSED	ANCHORS AND LEVELS	% THOR CURVE CORRECTION	ATR (THORACIC)	% OF CORRECTION OF ATR
Poly (n=33)	49.5+/- 7.1	62% +/- 18.6	10+/- 1	1.16+/- 0.18	62+/- 0.13	7.9+/- 4.1	47%
Mono (n=34)	53.1+/- 9.2	53% +/- 21.8	11+/- 2	1.69+/- 0.17	69+/- 0.16	6.4+/- 3.6	55%
Hybrid (n=32)	52.6+/- 10.4	55% +/- 16.0	10+/- 1	1.36+/- 0.20	66+/- 0.11	6.8+/- 2.4	43%
P value	(P=0.247)	(P=0.124)	(P=0.08)	(P=0.001)	(P=0.357)	(P=0.139)	(P<0.05)

Double and Triple Curvatures in Idiopathic Scoliosis: Incidence and Surgical Outcomes

Baron Lonner, MD; David Clements, MD; Paul Sponseller, MD; Randal Betz, MD; Peter Newton, MD

SUMMARY: Little has been reported on the surgical management of double and triple curve patterns in recent literature. The incidence of Lenke 3, 4, and 6 idiopathic scoliotic curvature is 3.9%, 3.5%, and 5.4%, respectively in a prospective operative database. Improvements in radiographic and SRS-24 outcomes were noted in these patients with a relatively low complication rate.

INTRODUCTION: Much has been reported on the surgical outcomes of single thoracic (Lenke 1) curvature, the most common curve type in AIS. Little has been reported about the incidence and surgical outcomes of double and triple curve patterns (Lenke 3, 4, 6) as classified by the Lenke classification in recent literature. The purpose of this study was to report the incidence, demographic data, and radiographic, and SRS-24 HRQOL outcomes following surgical treatment of Lenke 3, 4, and 6 curvatures.

METHODS: Demographic, radiographic, and SRS-24 questionnaire data after a minimum of two year follow-up was collected from a multicenter, prospective AIS database. Patients with Lenke 3, 4, and 6 scoliosis were evaluated separately as were the results of selective versus non-selective fusion.

RESULTS: Of the total of 1,217 patients in the database, 3.9% had Lenke 3, 3.5% Lenke 4, and 5.4% had Lenke 6 curvature. Selective fusion of the major curvature was done in 9 Lenke 3, 4 Lenke 4, and 2 Lenke 6 patients. Anterior surgery for both curves through a single exposure was done in 2 and 11 Lenke 3 and 6 curvatures, respectively. Extension of the fusion to include both structural curves was done in 1 patient each in the Lenke 3 and 6 groups for selective fusions that failed. For Lenke 3 patients significant improvements in SRS-24 pain (0.7_┐), self image (0.5_┐), and activity (0.7_┐) domains occurred ($p < 0.05$). For Lenke 4 patients, significant improvements occurred in pain (0.7_┐) and activity (1.1_┐) and for Lenke 6 patients, self image (0.6_┐) and activity (0.8_┐).

CONCLUSION: Double and triple adolescent idiopathic scoliotic curvatures comprise a small percentage of the overall AIS population. Improvements in radiographic and clinical outcome measures were demonstrated in most patients with few major complications.

LENKE CLASS (N)	GENDER (% FEMALE)	AGE (MEAN)	MAJOR CURVE PRE/POST (%CXN)	SECONDARY CURVE (S) (% CXN)	LEVELS FUSED	C7-CSVL PRE/POST (CM)
3	82	14.8+/-2.5	65/25 (59)	66	10.7+/-2.5	-0.3/-0.2
4	83	14.6+/-2.4	78/24 (69)	60	12.6+/-1.4	-0.3/-0.1
6	88	14.5+/-2.1	62/20 (66)	67	11.2+/-2.1	-2.3/-0.7

Complications in the Surgical Treatment of Adolescent Idiopathic Scoliosis (AIS): A Ten Year Review of a Prospective Database with 1292 Patients

Michael O'Brien, MD; Peter Newton, MD; Randy Betz, MD; Michelle Marks PT, MA; Harms Study Group

SUMMARY: We performed a 10 year review of a prospective AIS database of 1292 surgically treated patients to categorize and quantify the complications encountered in their care. The overall complication rate was 17.8%. Overall, major complications accounted for 7.5% and minor complications accounted for 10.3% of all complications. The complication rate for all posterior procedures was 13.4% and for all anterior procedures was 24.2%.

INTRODUCTION: Many factors can affect the complication rate in the surgical treatment of spinal deformity: patient age, pathology, surgical approach, instrumentation techniques and co-morbidities. We reviewed the complication rate in a prospective AIS database of 1292 surgically treated patients collected over 10 years.

METHODS: A prospective multi-center AIS database with 1292 patient enrollees was queried to identify all reported complications. These were classified into complication groups and analyzed (see Table 1).

RESULTS: The overall complication rate was 17.8% (231/1292). Neurologic complications were infrequent 0.77% (10/1292) and evenly distributed between anterior and posterior procedures. Cardiac complications were absent from this group.

Posterior spinal surgery was associated with an 13.4% complication rate (103/764). Infection was more common after posterior surgery (n=17) than anterior surgery (n=5). In those treated with anterior procedures there was a 24.2% complication rate (128/528). There was a higher rate of pulmonary complications and hardware failure after anterior surgeries. Pseudoarthrosis was 4x more common in anterior (n=14) procedures vs. posterior (n=4). Revision surgery was slightly more common after anterior surgeries. Overall, major complications accounted for 7.5% and minor complications accounted for 10.3% of all complications.

CONCLUSION: These results compare favorably with the literature. Faceszewski reported an overall 29% complication rate in 1223 adults treated for spinal deformity. Grossfield reported a 7.5% major and 32% minor complication rate in 599 anterior procedures performed in pediatric patients during anterior spinal surgery. In that study, the AIS subpopulation had a 2.8% major and a 45% minor complication rate.

KEY WORDS: Adolescent Idiopathic Scoliosis, spinal fusion, complications

Table 1. Complications in 1292 AIS patients treated with fusion and instrumentation

COMPLICATIONS	TOTAL: N=1292		MAJOR: N=1292		MINOR: N=1292		ANTERIOR: N=528		POSTERIOR: N=764	
	N	%	N	%	N	%	N	%	N	%
Medical	5	0.39	0	0.00	5	0.39	2	0.38	3	0.39
Gastrointestinal	3	0.23	0	0.00	3	0.23	1	0.19	2	0.26
Pulmonary	39	3.02	4	0.31	35	2.71	24	4.55	15	1.96
Neurologic	10	0.77	1	0.08	9	0.70	4	0.76	6	0.79
Wound Problems	29	2.24	11	0.85	18	1.39	8	1.52	21	2.75
Transfusion	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Instrumentation	67	5.19	3	0.23	64	4.95	47	8.90	20	2.62
Revision	60	4.64	60	4.64	0	0.00	28	5.30	32	4.19
Pseudoarthrosis	18	1.39	18	1.39	0	0.00	14	2.65	4	0.52
TOTAL	231	17.88	97	7.51	134	10.37	128	24.24	103	13.48

Results of Three Classes of Surgical Treatment for Congenital Scoliosis Due to Hemivertebrae: A Multicenter Retrospective Review

Michael O'Brien, MD; Peter Newton, MD; Randal Betz, MD; Harry Shufflebarger, MD; Baron Lonner, MD; Lynn Letko, MD; Prof Dr Med Jürgen Harms, MD; Alvin Crawford, MD; Suken Shah, MD; Paul Sponseller, MD; Michelle Marks, PT, MA; Angel Macagno, MD

SUMMARY: 42 patients with hemivertebrae (HV) and congenital scoliosis were compared based on one of three surgical treatments. HV resections with posterior instrumentation results in reduced surgical time, shorter fusions, less blood loss, and improved % correction but slightly higher rates of instrumentation and neurologic complications.

INTRODUCTION: We compare the outcomes of 3 surgical treatments for congenital deformities due to a focal hemivertebra (HV).

METHODS: A retrospective multi-center database was compiled from 8 centers to evaluate patients treated surgically for congenital spinal deformity due to 1 or 2 level HV. The surgical treatment were: Group 1, fusion without correction (hemi-epiphysiodesis or in-situ fusion), Group 2, correction without HV resection (with or without anterior or posterior release) and posterior instrumentation, and Group 3, correction with HV resection (anterior and/or posterior) and posterior instrumentation.

RESULTS: Forty-two patients, with two year follow-up, were treated between 1991 and 2004. The congenital anomalies were: fully segmented, non incarcerated HV (n=32, 76.2%), incarcerated HV (n=1, 2.4%), and semi-segmented HV (n=9, 21.4%). The distribution of surgical treatments were: Group 1: n=10(24%), Group 2: n=9 (21%), Group 3: n=23 (55%). Pre-operative curve sizes were statistically different: Group 1, 37° and Group 3, 34° were significantly smaller than Group 2, 55° (p=0.04 and p<0.01, respectively). The mean age of the patients was 8 years (range 1-18). The complication rate was 25%: Group 1, 20%, Group 2, 11%, Group 3, 35%. The % coronal correction at 2 years post-op was better for Group 3 (74%) compared to Group 1 (30%) and Group 2 (45%) (both p<0.01). A sub-analysis of Group 3 revealed shorter fusions in those treated with posterior only resection compared to the anterior/ posterior techniques (p=0.05).

CONCLUSION: HV resection gave the best % correction 2 years post-op. It had a slightly higher complication rate than the other two techniques. HV resection in younger patients results in better correction with fewer levels fused than either of the other two techniques.

KEY WORDS: congenital spinal deformity, surgical approaches, operative outcomes.

Table 1. Treatment groups for Congenital Spinal Deformity

	N	PRE-OP CURVE SIZE	AGE @ SURGERY	# LEVEL FUSED	COMPLICATIONS	EBL	OPERATIVE TIME	2 YR % CORRECT
Group 1: Fusion without Correction	10	37° ± 15°	11 ± 6	3 ± 5	1 infection 1 other	363 ± 329	223 ± 110	30 ± 12
Group 2: Correction without HV Resection	9	55° ± 19°	9 ± 5	7 ± 3	1 neurological	643 ± 449	286 ± 117	45 ± 18
Group 3: Correction with HV Resection	23	34° ± 10°	6 ± 4	3 ± 3	1 infection 4 neurological 3 instrumentation	613 ± 767	281 ± 141	74 ± 21

Blood Loss and Operative Time in Scoliosis Surgery as a Function of Construct Type and Surgeon Experience

Harry Shufflebarger, MD; Michelle Marks, PT, MA; Peter Newton, MD; Harms Study Group

SUMMARY: Increasing surgeon experience with all pedicle screw constructs in scoliosis surgery results in decreasing operative time and decreasing blood loss. These important parameters equal those in all hook constructs.

INTRODUCTION: Blood loss and operative time in adolescent idiopathic scoliosis surgery are important variables which must be planned in advance.

METHODS: A prospective multi-center database initiated in 1995 was queried for blood loss and operative times for adolescent idiopathic scoliosis patients who had underwent instrumented posterior spinal fusion. Construct categories investigated were all hooks, hybrid (hooks, screws, wires) and all screws. All screw constructs were further divided into the initial database entries (1st year of entries) for all screw constructs (early screws) and entries subsequent to the first year of all screw constructs. (late screws).

RESULTS: The results are summarized in the table. Using hook constructs as a comparison baseline, hybrid and early screws demonstrate significant increase in both operative time ($p < .001$) and blood loss ($p < .001$). Implant number likewise increases. Late screw constructs demonstrate significant decrease in operative time ($p < .001$) and blood loss ($p < .001$), similar to the all screw baseline. Implant number remains the same as the early screw and hybrid categories.

CONCLUSION: As a surgeon becomes experienced with all pedicle screw constructs in adolescent idiopathic scoliosis, the operative time and blood loss become equivalent to those with all hook constructs.

SIGNIFICANCE: This knowledge permits surgical planning relative to autogenous or designated donor blood and surgical time. The surgeon is also able to advise the patient regarding these parameters.

Table 1. Operative time, blood loss, & implants in AIS surgery

	HOOKS	HYBRID	EARLY SCREWS	LATE SCREWS
# patients	53	207	57	242
Implants/case	10	21	21	22
Blood loss/case	1090 cc	1410	1472	918
Op time/case	283 min	347	350	246

The Rate of Unplanned Second Surgeries in Adolescent Idiopathic Scoliosis

Harry Shufflebarger, MD; Peter Newton, MD; Michelle Marks, PT, MA; Harms Study Group

SUMMARY: In a series of 1216 patients over 10 years there was a 1.5% incidence of revision surgery occurring within 60 days of the index procedure and a 7.3% incidence of late revision surgery occurring >2 years after the initial correction of AIS. Implant removal occurred only after index posterior surgery, while pseudoarthrosis repair was more common after anterior index surgery. Imbalance requiring revision occurred with equal frequency relative to approach.

INTRODUCTION: This study is undertaken to determine the incidence and nature of unplanned second surgery in AIS. This complication rate is also determined relative to anterior or posterior surgical approach.

METHODS: A prospective multi-center database of 1216 surgically treated patients (1995-2006) was queried for unplanned second surgeries. These were divided into early (<60 days from index) and late (>2 years from index) returns to the operating room, with none in the intermediate period.

RESULTS: 20 of 1216 patients had an early second surgery or 1.6%. The rate of an early second operation was 1.0% (5/508) when the initial surgery was an anterior procedure, and 2.1% (15/703) when the initial surgery was posterior. Indications for early revision included: wound infection (4), implant displacement requiring replacement (10), neurological change (1 anterior, 3 posterior, 0 permanent), and chest tube reinsertion (2). 681 patients had >2 year follow-up, with 50 (7.3%) requiring a late second surgery. The rate was similar for anterior index surgery (7.0%, 20/355) and posterior index surgery (7.7%, 25/324). Implant removal was required for 4 late infections and 8 prominent implants, all after posterior index procedures. 5 late thoracoplasties were done, 2 after initial anterior and 3 after initial posterior procedures. 2.5% (17/681) required fusion extension for imbalance, 2.8% (10/355) with initial anterior surgery and 2.2% (7/324) with initial posterior surgery. 16 (2.3%) required pseudoarthrosis repair, 3.7% with an initial anterior surgery and 0.9% with an initial posterior procedure.

CONCLUSION: The early unplanned second surgery rate was 1.6%, irrespective of the approach. Unplanned surgeries >2 years after the index procedure had an incidence of 7.3%, with no difference relative to anterior or posterior index procedures. However, implant removal occurred only after index posterior surgery, while pseudoarthrosis repair was more common after anterior index surgery.

Sagittal Contour Correlated with Hook versus Screw Posterior Constructs for Lenke 1 Curves

David Clements, MD; Randal Betz, MD; Peter Newton, MD; Suken Shah, MD; Michelle Marks, PT, MA; Scott Porter, MEd; Harms Study Group

SUMMARY: We compared the change in thoracic sagittal alignment that occurs after surgical correction of thoracic AIS with hook versus screw constructs.

INTRODUCTION: Purpose: To compare the change in thoracic sagittal alignment that occurs after surgical correction of thoracic AIS with hook versus screw constructs. This study was performed using the data prospectively entered in a multicenter database of AIS patients treated with posterior spinal instrumentation and fusion.

METHODS: Patients who had a diagnosis of Lenke 1 AIS with a curve of sufficient magnitude to require surgery were eligible for this IRB-approved study. Patients were divided into two groups, those with hook (Group 1) or screw (Group 2) constructs in the structural curve. After obtaining informed consent, patients were evaluated with preoperative and subsequent two-year postoperative erect AP and lateral radiographs. The mean pre-op and 2 year post-op correction of the sagittal curve measurement was recorded for the levels T2-T5, T2-T12, T5-T12 and lateral C7 plumb to sacrum. Correlation was then made between these measurements for both the screw and hook groups comparing pre-op to post-op, and comparing pre-op and 2 year post-op curve means between the two groups. 200 patients were available for review, 162 in the hook anchor Group 1 and 38 in the screw anchor Group 2.

RESULTS: The hook Group 1 saw a significant decrease in kyphosis post-op at T2-T12 and T5-T12 compared to pre-op, while T2-T5 kyphosis increased. The screw Group 2 only saw a significant decrease in kyphosis in T5-T12, no significant change at T2-T5, T2-T12. There was no significant change in C7 plumb to sacrum in either group. There was no difference between groups. The mean number of levels instrumented was 13 for both groups. Coronal % correction of the upper thoracic, main thoracic and lumbar curves were not significantly different between groups, although there was a trend toward better correction of the main curve in the screw group (60 vs. 55%).

CONCLUSION: When treating Lenke 1 curves, both implant types correlate to a decrease in sagittal contour and kyphosis T5-T12. Hook constructs decrease sagittal contour in addition T2-T12, and increase kyphosis T2-T5. Screw constructs may decrease kyphosis due to attempts at greater thoracic transverse plane correction. These findings may indicate the need to address sagittal plane correction in pre-op planning.

Correlation of Scoliosis Curve Correction with the Number and Type of Fixation Anchors

David Clements, MD; Randal Betz, MD; Peter Newton, MD; Michelle Marks, PT, MA; Tracey Bastrom, MD; Scott Porter, MEd; Harms Study Group

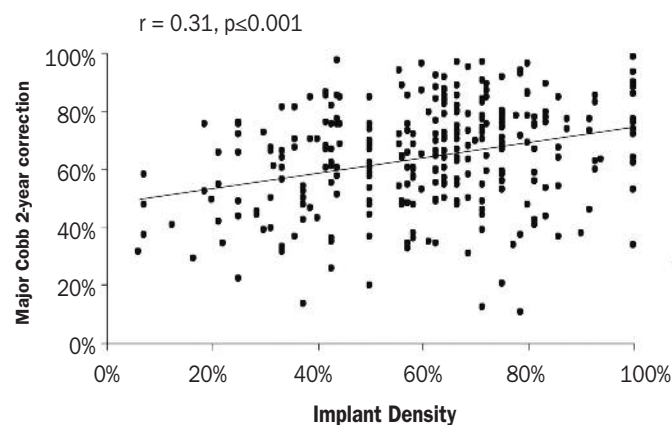
SUMMARY: We analyzed correction of structural thoracic curves in adolescent idiopathic scoliosis and correlated it with "implant density": the number of implants that could fill available sites. We also analyzed the type of implant utilized to fill the implant sites. We found a significant correlation between implant density and percent correction. The average percent correction was greater with all screws compared to all hooks. We recommend considering screws and filling as many implant sites as possible to improve thoracic curve correction.

INTRODUCTION: Controversy exists regarding number and type of spinal anchors and the number of implant sites utilized that result in improved correction in adolescent idiopathic scoliosis (AIS). Coronal structural curve correction may depend on many variables including: implant type (hook, wire or screw) and available implant sites (implant density, max 2 per level). We investigated if "implant density" or the number of screws correlated with the major curve (thoracic or lumbar) correction at 2 years in patients with AIS.

METHODS: A prospective database of patients with AIS treated by posterior instrumentation between 1995 and 2004 was analyzed. The major curve correction expressed as % correction (from pre-op to 2 years post-op) was correlated with the percentage of implants relative to the number of available implant sites within the measured Cobb angle. For example: a T5-12 curve (8 implants/16 potential sites) with 8 total implants in those levels would have an implant density of 50% (8 implants/16 sites). Correlation of % correction to the number of hooks, wires and screws was also performed.

RESULTS: There were 292 patients included with all six Lenke curve types represented (250 with major thoracic curves and 42 with major lumbar curves). The overall % coronal Cobb correction was 64% (range 11-98%). The implant density within the major curve averaged 61% (range 6-100%). There was a significant correlation between implant density and % curve correction ($r=.31$, $p<0.001$). The number of each implant type (hooks, wires, screws) in the construct did not correlate with the % correction; however, the average % correction of the major curve was greater when the Cobb levels were instrumented only with screws (64%) compared to hooks alone (55%), $p<0.01$. The greatest % correction 78% was achieved when bilateral segmental screws were utilized (100% screw density).

CONCLUSION: Major curve correction at 2 years correlates most with the implant density. That is, correction increases with the number of implants utilized within the measured Cobb levels. Although the absolute number of screws utilized did not correlate with correction, there was an advantage in lumbar and thoracic curves to using screws compared to hooks.



A New Radiographic Classification of Complications from the Surgical Management of Adolescent Idiopathic Scoliosis

John Flynn, MD; Randal Betz, MD; Michael O'Brien, MD; Scott Porter, MEd; Peter Newton, MD; Harms Study Group

SUMMARY: A new system of adverse events based on radiographic findings was used to analyze 466 patients who had surgical management of their AIS. There was no difference in rate between surgical approach or anchor type.

INTRODUCTION: In spinal deformity surgery, rapidly changing techniques and implants must be assessed for their safety and efficacy. We have developed a classification of adverse events based entirely on objective, plain radiographic criteria.

METHODS: We analyzed the adverse events in the treatment of 466 patients, prospectively registered in a database after AIS surgery for a Lenke 1 curve, and a minimum of 2 yr f/u. Using plain radiographic findings alone, we defined complications as either Serious Adverse Events (SAE), or Adverse Events (AE) adhering to the following definitions: SAE: unplanned trip to OR, post-op progression beyond initial deformity magnitude, pain or other symptoms from radiographically identifiable problem (deformity progression or implant-related problem). AE: asymptomatic loss of correction in the coronal or sagittal plain $>10^\circ$, asymptomatic progression above or below instrumentation $>10^\circ$, asymptomatic loss of fixation, or implant failure. 4 technique groups: 1) PSFH: PSF with hooks and/or hybrid systems, 2) PSFS: PSF with a majority of pedicle screws 3) OASF: open anterior instrumentation; 4) TASF: thoracoscopic anterior instrumentation. In patients >1 AE, the most significant AE was identified. Multiple variables, including anchor types and surgical approaches, were analyzed for the frequency of adverse events.

RESULTS: The table below shows the frequency of the SAE's and AE's for each treatment group. Differences between techniques were not significant. All SAE's were for surgical revision, with a re-operation rate ranging from 4.5% (OASF) to 8.8% (PSFH). Among SAEs, the most common problems in the ASF groups were revision for lumbar progression, rod breakage and proximal screw pullout, and in the PSFs, instrumentation removal for pain, and infection.

CONCLUSION: We have defined a radiographic system of adverse events and analyzed 466 patients with Lenke 1 AIS. The SAE's type differ by treatment, but no technique was inherently "safer".

SIGNIFICANCE: Regulatory bodies and patients will increasingly scrutinize treatment methods based on the frequency of adverse events.

	OASF N = 178	TASF N = 94	PSF C/HOOKS N = 136	PSF C/SCREWS N = 58
SAE (p=0.429)	8 (4.5%)	5 (5.3%)	12 (8.8%)	3 (5.2%)
AE (p=0.923)	11 (6.2%)	8 (8.5%)	11 (8.1%)	4 (6.8%)

The Effect of Fusion Levels on Trunk Flexibility and Outcome Measures in Lenke 1&2 Curve Types

Linda D'Andrea, MD; James Guille, MD; Lynn Letko, MD; Scott Porter, MEd; Baron Lonner, MD; Michelle Marks, PT, MA; Peter Newton, MD

SUMMARY: Results of this study lend support to the treatment of Lenke 1&2 curves with selective fusion to preserve spinal motion.

INTRODUCTION: One would expect incremental loss of trunk flexibility with spinal fusion to more distal levels. In accordance, fusion to more distal levels should result in a decreased self-image and level of activity.

METHODS: To test our hypotheses, information from prospectively collected database of AIS patients with Lenke 1&2 curves was evaluated for correlation between pre-op & post-op: trunk flexibility (thoracolumbar flexion & extension; right/left lateral bending; right/left trunk rotation); SRS-22 domains for pain, patient satisfaction, health, activity levels; radiographic measures trunk shift, & coronal decompensation. All patients (N=54) had PSF with instrumentation; pre-op, 1 & 2 yr post-op radiographic & physical flexibility measurements & completed SRS-22 questionnaires. Patients were separated into groups based on the end-instrumented vertebra (EIV) of fusion of T10-T12(N=9), L1(N=14), L2(N=15), L3(N=11), L4(N=5). Comparison among & between groups showed no statistically significant differences for the radiographic parameters, SRS-22 domains, or clinical measures of flexibility.

RESULTS: Pre-op to 2 yr t-test values for all clinical, radiographic and SRS-22 variables showed statistically significant improvement ($p < .04$). All EIV groups show statistically significant differences in % correction of thoracic/lumbar curves, but mean difference of residual thoracic/lumbar curves between those fused to T10-12 vs L4 is $7.5^{\circ}/6.5^{\circ}$ respectively. There are statistically significant differences in clinical trunk flexibility measures at 2 yr post-op when comparing by EIV: right lateral bending T10-12 vs L3 & L4; L1 & L2 vs L4, $p < .005$; left lateral bending T10-12, L1, L2 & L3 vs L4, $p < .012$; thoracolumbar extension T10-12 vs L3 & L4, $p < .03$. Radiographic measures at 2 yr post-op are comparable for all groups. Greater lumbar curve correction did correlate with less post-op pain, better self-image, & greater satisfaction, $p < .05$.

CONCLUSION: Results suggests that for Lenke type 1 & 2 curves, fusion to L1 or above did yield improved outcomes, compared with more distal fusion levels, for postoperative clinical flexibility and trunk motion; however, self-image and activity level scores did not decrease with more distal fusion levels as expected.

Are Clinical Measures of Trunk Shape Sensitive to Changes in Radiographic Measures/Scores, or Pain and Self-Image SRS-22 Scores?

Linda D'Andrea, MD; James Guille, MD; Lynn Letko, MD; Michelle Marks, PT, MA; Peter Newton, MD; Scott Porter, MEd; Baron Lonner, MD

SUMMARY: Improved post-op clinical trunk shape measures in patients with Lenke 1&2 curves correlated with several radiographic measures, but not necessarily those which we expected, and did not correlate with self-image and pain scores.

INTRODUCTION: It would be expected that postoperative clinical trunk shape measures would correlate with improved radiographic, or self-image and pain scores.

METHODS: Preoperative, 1 & 2 year postoperative information from a prospectively collected database of AIS patients with Lenke type 1&2 curves treated with a posterior spinal fusion with instrumentation was evaluated for: radiographic measures (thoracic & lumbar curve magnitudes; T1 rib angle; thoracic kyphosis, lumbar lordosis, & thoracolumbar kyphosis; proximal & distal junctional kyphosis; coronal & sagittal balance; coronal, sagittal & total radiographic scores), clinical trunk shape measures (coronal decompensation; trunk shift; lumbar and thoracic rib prominences (using the maximum scoliometer reading); shoulder height difference), & SRS-22 responses for self-image (#, 14, 19) & pain (#1, 11).

RESULTS: There were statistically significant improvements from pre-op to 2 yr. post-op values for: all curve magnitudes, coronal decompensation, trunk shift, shoulder height difference, thoracic rib and lumbar prominences, SRS-22 questions 6 and 19, $p=.000$; thoracic kyphosis, trunk shift, shoulder height, proximal, $p=.001$; SRS-22 question 1, $p=.002$; SRS-22 question 14, $p=.026$; distal junctional kyphosis & lumbar lordosis, $p<.048$.

The post-op increase in the total radiographic deformity score did correlate with: decreased coronal decompensation, $p=.000$, change in lumbar prominence (scoliometer reading) $p=.004$, & the change in shoulder height, $P=.001$. As the trunk shift decreased from pre-op to 2 yr post-op, it correlated with the decreased coronal decompensation, $p=.025$. Post-op self-image and pain scores did not correlate with clinical trunk shape or radiographic measures.

CONCLUSION: Unexpectedly, improved clinical trunk shape measurements correlated with few changes in radiographic scores. The SRS-22 responses did not correlate with clinical or radiographic changes.

Anterior Treatment of Structural Thoracolumbar and Lumbar Curves: A Comparison of Dual versus Single Rod Constructs in 100 Patients

James Guille, MD; Linda D'Andrea, MD; Baron Lonner, MD; Suken Shah, MD; Scott Porter, MEd

SUMMARY: For the anterior treatment of Lenke 5 curves, single rod instrumentation, compared with dual rods, yielded similar radiographic correction with better percent correction at 2yr follow-up, less blood loss, and shorter operative times.

INTRODUCTION: Anterior treatment of thoracolumbar and lumbar scoliosis can be with either single or dual rod instrumentation, with no study showing superiority of either method.

METHODS: One hundred patients with Lenke Type 5 thoracolumbar and lumbar scoliosis underwent anterior spinal fusion with instrumentation and structural interbody grafting. Sixty-one patients were treated with dual rods, and 39 with a single rod. Minimum follow-up was 2 yrs. There were no statistically significant differences in any pre-op measurements between the 2 groups.

RESULTS: Mean pre-op/2-yr follow-up lumbar curve magnitude was 46o/14o for the single rods and 48o/18o for the dual rods, with significant improvement in both groups ($p < 0.01$). The mean lumbar curve correction for the single rods at 1st post-op, 1 yr, and 2 yr visits were 83%, 71%, and 71%, respectively. Mean lumbar curve correction for the dual rods at 1st post-op, 1 yr, and 2 yr visits were 72%, 65%, and 63%, respectively. Both groups had significant improvement in the percent correction at 2-yr follow-up ($p < 0.02$). Mean pre-op/2-yr follow-up main thoracic curve magnitude was 26o/16o for the single rods and 24o/16o for the dual rods. Mean pre-op/2-yr follow-up T2-T12 kyphosis was 24o/25o for the single rods and 25o/26o for the dual rods. Mean pre-op/2-yr follow-up lumbar lordosis was 61o/58o for the single rods and 59o/57o for the dual rods. There was significant improvement in the coronal C7 to CSVL measurements made pre-op and at 2-yr follow-up in both groups ($p < 0.001$). There was no significant difference in either the PJK or DJK measurements made pre-op and at 2-yr follow-up. Mean blood loss was lower (415 vs 620 cc) and operative time shorter (263 vs 319 min) for the single rods ($p < 0.03$). Four patients with dual rods had a pseudarthrosis. One patient with dual rods had a screw misplacement causing nerve root irritation requiring revision. There were no infections.

CONCLUSION: At 2-yr follow-up, the radiographic results of single versus dual rod instrumentation appear comparable, but with better maintenance of coronal percent correction, shorter operative times, and less blood loss in the single rod group.

Does Body Mass Affect Surgical Outcomes in Adolescent Idiopathic Scoliosis?

Vid Upasani, MD; Christine Caltroum, MD; Maty Petcharaporn, BS; Tracey Bastrom, MD; Jeff Pawelek, BS; Michelle Marks, PT, MA; Randal Betz, MD; Lynn Lenke, MD; Peter Newton, MD

SUMMARY: Although obesity has been associated with an increased rate of postoperative complications in other surgical conditions, in this cohort of adolescent idiopathic scoliosis (AIS) patients, a BMI % ≥ 85 did not affect surgical outcomes. Overweight adolescents, however, were noted to have a greater preoperative thoracic kyphosis compared to healthy weight peers.

INTRODUCTION: Obesity has reached epidemic proportions globally, and has been associated with a greater risk of co-morbidities and an increased rate of postoperative complications in adult and adolescent populations. The objective of this study was to determine if an association exists between body mass and surgical outcomes in AIS patients.

METHODS: Radiographic measures, perioperative data, and Scoliosis Research Society (SRS) Outcomes Instrument scores were collected on surgically treated AIS patients. The body mass index (BMI; kg/m²) was calculated for each patient and normalized to sex and age (BMI %). Analysis of variance was used to identify differences between healthy weight (BMI % < 85) and overweight patients (BMI % ≥ 85). The data was checked for normality and equal variances, and the level of significance was set at $p < 0.01$.

RESULTS: In 241 patients (204 females, 37 males; 14.3 ± 2.0 years old) with a minimum of 2-year follow-up the average BMI was 20.7 ± 3.7 kg/m² (BMI % average: 54.5%, range: 1-99). No significant differences were found between the overweight (n=48) and healthy weight (n=193) patients with regards to surgical time, estimated blood loss, major Cobb percent correction, postoperative infection rate, rate of implant failure, rate of perioperative neurologic compromise, and SRS scores (preoperative and 2-year postoperative). However, the preoperative thoracic kyphosis was significantly greater in the overweight group ($27.0^\circ \pm 12.6$) compared with the healthy weight patients ($21.8^\circ \pm 12.5$) ($p=0.004$).

CONCLUSION: Even though our sample size was limited, this study did not find an association between body mass and perioperative morbidity, the ability to achieve and maintain coronal and sagittal deformity correction, and patient-based outcome measures. The significantly greater preoperative thoracic kyphosis in overweight patients may be related to increased compressive forces on the anterior vertebral growth plates and warrants further investigation.

Do Discs “Open” Anteriorly with Posterior Only Correction of Scheuermann’s Kyphosis?

Shunzi Tsutsui, MD; Jeff Pawelek, BS; Tracey Bastrom, MD; Suken Shah, MD; Peter Newton, MD

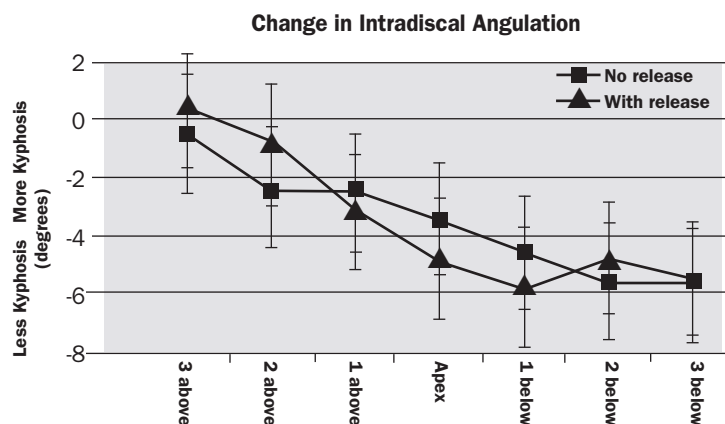
SUMMARY: Scheuermann’s kyphosis can be corrected using a posterior construct with or without the addition of an anterior disc release; however, the change in disc shape that accounts for correction has not been well described for either of these procedures. A radiographic comparison between the two procedures revealed no significant difference in the degree of kyphosis correction or the change in disc shape that led to the reduction in kyphosis. Anterior disc heights increased up to 3 mm near the apex for both procedures.

INTRODUCTION: Scheuermann’s kyphosis is generally corrected with a posterior construct, either with or without a prior anterior disc release. The purpose of this study was to examine post-operative segmental disc shape changes between two different surgical approaches: posterior instrumentation only and posterior instrumentation with an anterior disc release.

METHODS: A retrospective review of 11 patients with Scheuermann’s kyphosis treated by a posterior only (Ponte) approach and 11 patients treated with a thoracoscopic release and posterior instrumentation was preformed. Segmental measures of disc angulation and disc height were made pre- and post-operatively to identify where and to what degree the correction of kyphosis occurred in these two surgical groups.

RESULTS: Overall the thoracic hyperkyphosis was corrected to similar degrees in both groups ($p=0.87$). The posterior only group pre-operatively averaged 79 ± 7 degrees and corrected to 55 ± 10 degrees; while the anterior and posterior group averaged 78 ± 14 degrees and corrected to 54 ± 10 degrees. The segmental analysis demonstrated similar degrees of angular change at each of the disc levels for the two surgical groups. The majority of the correction occurred at, and below, the apex and was independent of an anterior release (Figure). The change in both anterior and posterior disc thicknesses were also similar between those treated with and without an anterior release. Both groups’ anterior disc spaces opened at T8 and below, while maximum anterior disc opening occurred at the thoracolumbar junction. To a lesser extent the posterior disc heights were reduced, but also to similar degrees for both surgical approaches.

DISCUSSION: In both surgical groups, anterior disc heights increased up to 3 mm at or below the apex – twice as much as posterior disc heights shortened. The addition of the anterior release did not significantly alter the degree of correction or the changes in disc shape that accounted for the kyphosis reduction. For both surgical procedures, the majority of the kyphosis correction occurred in the lower thoracic levels.



Adolescent Idiopathic Scoliosis Patients Report Increased Pain at 5 Years Compared to 2 Years After Surgical Treatment

Vid Upasani, MD; Christine Caltoun, MD; Maty Petcharaporn, BS; Tracey Bastrom, MD; Jeff Pawelek, BS; Randal Betz, MD; David Clements, MD; Larry Lenke, MD; Thomas Lowe, MD; Peter Newton, MD

SUMMARY: An analysis of changes in SRS Outcomes Instrument measures between the 2-year and 5-year follow-up visits revealed a significant increase in reported pain 5 years following the surgical treatment of adolescent idiopathic scoliosis (AIS). Correlation with radiographic parameters revealed no significant associations.

INTRODUCTION: At 2 years follow-up, current surgical procedures have been shown to improve subjective measures in patients with AIS. The major Cobb angle was positively correlated with preoperative scores in the Pain, General Self Image and General Function domains. The objective of this study was to evaluate changes in patient determined outcome measures between the 2 years and 5 years after surgery time points, and to correlate those changes to radiographic findings.

METHODS: A 5-year minimum follow up of prospectively collected data was used to compare radiographic and SRS outcomes instrument measures in patients surgically treated for AIS. Repeated measures analysis of variance was used to compare differences in patient responses in each of the seven outcome domains. A correlation analysis was used to determine if a change in radiographic variables was related to changes in SRS scores. The data was checked for normality and equal variances, and the level of significance was set at $p < 0.01$.

RESULTS: 49 patients (42 female, 7 male; 14.1 ± 2.1 years old; 5.4 ± 0.6 years follow-up) met the inclusion criteria for this study. Although SRS scores improved significantly in three out of the four preoperative domains at the 2-year visit, a significant decrease in the Pain score was observed at the 5-year visit (4.2 ± 0.6 to 3.9 ± 0.9 , $p=0.004$), and a trend towards decreased scores was noted in most other domains (Table 1). No radiographic measures could be significantly correlated with changes in SRS scores.

CONCLUSION: Although there was a statistically significant decline in the pain domain scores indicating increased pain symptoms, the clinical significance of a 0.3 point average drop remains unclear. Patient satisfaction remained quite high 5 years post operatively despite the increase in reported pain. The generalized drop in scores may represent the expected change with aging in the cohort. Radiographic variables currently monitored postoperatively did not correlate with the observed SRS score changes. Other factors need to be evaluated over time to determine the etiology of decreasing SRS outcome measures.

Table 1. SRS Domain Scores for all 3 groups

	PAIN †*	SELF IMAGE †	FUNCTION †	ACTIVITY LEVEL	POST-OP SELF IMAGE	POST-OP FUNCTION	SATISFACTION
Pre-operative	3.2 ± 0.6	3.7 ± 1.0	3.9 ± 0.8	4.4 ± 0.9	n/a	n/a	n/a
2 year follow-up	4.2 ± 0.6	4.3 ± 0.6	4.2 ± 0.5	4.5 ± 0.8	3.5 ± 0.6	2.9 ± 1.0	4.4 ± 0.6
5 year follow-up	3.9 ± 0.9	4.1 ± 0.7	4.0 ± 0.8	4.3 ± 0.8	3.4 ± 0.6	3.0 ± 1.2	4.4 ± 0.7

The Isolated Effect of a Scoliosis Fusion on SRS Outcomes Questionnaire Measures is Modest

Shunzi Tsutsui, MD; Jeff Pawelek, BS; Tracey Bastrom, MD; Peter Newton, MD; Harms Study Group

SUMMARY: Previous literature suggests patients report higher SRS scores after undergoing spinal fusion for adolescent idiopathic scoliosis; however, patients' perception may be positively influenced by having had corrective surgery. In order to eliminate the effect of improved spinal alignment on patient reported outcomes, SRS scores were compared between untreated and surgically treated patients with similar scoliosis deformities. The analysis revealed that the isolated effect of spinal fusion on post-operative SRS scores appears to be limited to activity and total score.

INTRODUCTION: Historically patients report improved SRS-24 scores after surgical adolescent idiopathic scoliosis (AIS) treatment despite having an operation that reduces spinal motion. Since deformity correction may influence patient perception, it has been difficult to isolate the effect of a spinal fusion on patient perceived outcomes. The purpose of this study was to quantify the effect of spinal fusion, independent of the degree of spinal deformity, by comparing SRS scores for two groups of patients (untreated and surgically fused) with similar degrees of scoliosis.

METHODS: A group of post-op (n=199) AIS patients with residual major curves measuring 20-40 degrees who completed SRS-24 questionnaires at their two-year postoperative visit were compared to a group of non-treated patients (n=112) who were identified with curves of similar magnitude. The surgically treated patients were divided based on the levels fused: thoracic (T) only, lumbar (L) only, thoracic and lumbar (T+L). The SRS domain scores were normalized by dividing the total domain score by the number of questions answered (normalized range 0-5). An ANOVA was used for the comparison; p<0.05 was considered significant.

RESULTS: Patients in the three fusion groups reported no significant difference in scores for the domains of Pain, Self Image, and General Function compared to the non-treated group. The Overall Activity domain scores were significantly lower in the T and T+L groups (4.5 ± 0.7 and 4.4 ± 0.7 , respectively) compared to the non-treated group (4.8 ± 0.5). This trend also carried over to the Total score with significantly lower scores for all three surgical groups (T: 4.2 ± 0.4 ; L: 4.0 ± 0.4 ; T+L: 4.1 ± 0.5) than the non-treated group (4.4 ± 0.4).

DISCUSSION: Patients with 20-40 degrees of scoliosis after spinal fusion did not report increased pain, lower self image, or reduced general function when compared to untreated patients with the same deformity. Although a surgical fusion did result in a statistically significant reduction in activity as well as in the total SRS score, the clinical effect of a scoliosis fusion on patient reported outcomes two years postoperatively appears to be modest (SRS domain scores reduced 0.2-0.4) and limited to the activity domain.

DOMAIN	N GROUP	T GROUP	L GROUP	T+L GROUP	p VALUE
Pain	4.29 ± 0.57	4.26 ± 0.64	4.24 ± 0.60	4.39 ± 0.57	0.77
Self-Image	4.24 ± 0.79	4.38 ± 0.60	4.40 ± 0.67	4.29 ± 0.54	0.40
Function	4.29 ± 0.34	4.29 ± 0.50	4.17 ± 0.48	4.06 ± 0.63	0.09
Activity	4.77 ± 0.46	4.53 ± 0.70	4.54 ± 0.73	4.36 ± 0.72	0.003*
Total Score	4.39 ± 0.42	4.16 ± 0.44	4.03 ± 0.38	4.13 ± 0.49	0.000†

*The N Group is significantly greater than the T Group (p<0.05) and the T+L Group (p<0.05).

†The N Group is significantly greater than the T Group (p<0.05), the L Group (p<0.05) and the T+L Group (p<0.05).

Return of Shoulder Girdle Function after Anterior versus Posterior Adolescent Idiopathic Scoliosis Surgery

Todd Ritzman, MD; Vid Upasani, MD; Tracey Bastrom, MD; Jeff Pawelek, BS; Randal Betz, MD; Peter Newton, MD; Harms Study Group

SUMMARY: This study compared shoulder strength and range of motion (ROM) after posterior (PSF), open anterior (OASF) and thoracoscopic anterior (TASF) spinal instrumentation and fusion of primary thoracic curves. A significant negative effect attributed to the open anterior approach was identified in this adolescent idiopathic scoliosis (AIS) patient population.

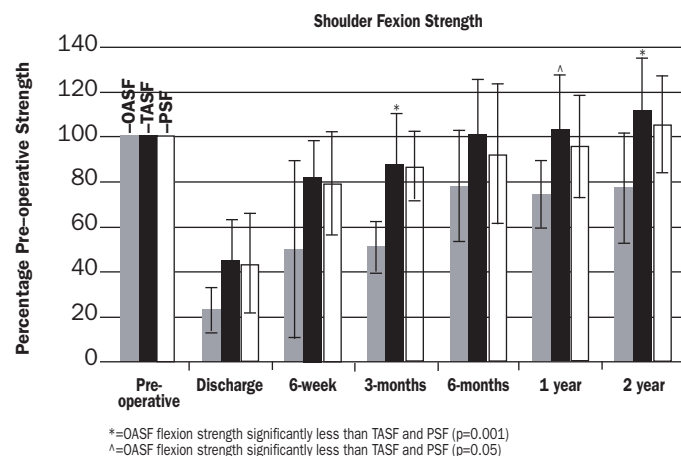
INTRODUCTION: Selective thoracic fusions can be achieved via posterior, open anterior, or thoracoscopic anterior fusions. Although the morbidity of these varying surgical approaches is beginning to be understood, no reports have been published comparing the effect of these three surgical approaches on 2-year post-operative shoulder function.

METHODS: AIS patients that underwent selective fusion of primary thoracic curves via PSF (n=39), OASF (n=66), or TASF (n=18) were identified from a multicenter, prospective database. Shoulder ROM (flexion, extension, abduction) and strength (flexion, abduction) data collected prospectively at selected intervals, were compared using a univariate ANOVA at each time point, to examine differences between the three approaches. Patients were thought to have returned to normal shoulder function once they reached an 80% threshold of their pre-operative value. The data was checked for normality and equal variances, and the level of significance was set at $p < 0.05$.

RESULTS: In terms of ROM, at the time of hospital discharge, the OASF group lagged behind the TASF and PSF groups in bilateral flexion, extension and abduction ($p < 0.05$). However, by 6 weeks post-op, patients from all three groups achieved at least 80% of their pre-operative motion, and no significant differences were exhibited between the groups for ROM throughout the rest of the follow-up period. In terms of shoulder strength, the OASF group failed to regain 80% of pre-operative flexion strength during the entire 2-year post-operative period, whereas those in the TASF and PSF groups attained this at 6 weeks post-op (Figure 1). Flexion strength in the OASF group lagged behind that in the TASF and PSF groups at every time interval ($p < 0.05$ at 3, 12, and 24 mos). Abduction strength in the OASF group lagged behind that in the TASF and PSF groups at discharge, 6 wks, and 3 mos ($p < 0.05$). Eighty percent shoulder abduction strength was achieved at 6 months post-op for the OASF group versus 6 weeks for the TASF and PSF groups.

CONCLUSION: A significant negative effect on postoperative shoulder function (ROM and strength) was attributed to OASF as compared to TASF and PSF in the treatment of primary thoracic curves. In the case of shoulder forward flexion strength this negative effect was evident even at the 2-year follow-up examination.

Figure 1.



Comparison of Compensatory Curve Spontaneous Derotation After Selective Lumbar or Thoracic Fusions

Todd Ritzman, MD; Vid Upasani, MD; Tracey Bastrom, MD; Jeff Pawelek, BS; Randal Betz, MD; Baron Lonner, MD; Peter Newton, MD

SUMMARY: A significantly greater spontaneous derotation of the unfused minor lumbar curve occurred during selective thoracic fusion as compared to the spontaneous derotation of the thoracic spine after selective lumbar fusion in the treatment of adolescent idiopathic scoliosis (AIS).

INTRODUCTION: The coronal correction of the unfused, minor curve following selective fusions for AIS is well documented. However, little has been reported evaluating spontaneous correction in the axial plane of the unfused, minor curve following selective AIS surgery. The purpose of this study was to compare the spontaneous rib and lumbar hump corrections after selective lumbar and thoracic fusions.

METHODS: Patients with a minimum 2-year follow-up that underwent either a selective thoracic fusion (STF) (lowest instrumented vertebrae L2 or above), or a selective lumbar fusion (SLF) (upper instrumented vertebrae T9 or below) for AIS, with an initial scoliometer value of $\geq 5^\circ$ in the minor curve, were identified from a multicenter database. Prospectively acquired pre-operative and 2-year post-operative scoliometer measurements of both the fused and unfused curves were compared using repeated measures and univariate ANOVA. The data was checked for normality and equal variances, and the level of significance was set at $p < 0.05$.

RESULTS: In patients that underwent STF (n=60), the mean thoracic rib hump improved significantly from a pre-operative value of $15 \pm 5^\circ$, to $8 \pm 4^\circ$ at the 2-year follow-up ($p < 0.001$). The mean lumbar prominence of the unfused curve also spontaneously improved significantly in this group of patients during the follow-up period from $9 \pm 4^\circ$ to $4 \pm 3^\circ$ ($p < 0.001$). In patients that underwent SLF (n=13), the mean lumbar prominence corrected significantly from a pre-operative value of $9 \pm 6^\circ$, to a 2-year post-operative value of $3 \pm 3^\circ$ ($p = 0.01$). The mean thoracic rib hump changed from $7 \pm 3^\circ$ pre-operatively to $5 \pm 3^\circ$ at the 2-year follow-up; however this was not found to be statistically significant ($p = 0.146$). The spontaneous lumbar prominence correction (56%) was significantly greater than the spontaneous thoracic rib hump correction (26%; $p < 0.05$). Table 1 shows coronal and axial plane corrections.

CONCLUSION: Axial plane, rotational correction of the unfused, minor curve in patients undergoing selective fusions does occur. Significant spontaneous correction of a thoracic rib hump after a selective lumbar fusion should not be anticipated, while an approximate 50% reduction in the lumbar prominence was the average after selective thoracic fusions.

Table 1.

SUB-GROUPS	N	LENKE TYPES		PRE-OPERATIVE	2-YR-POST-OPERATIVE	PERCENT CORRECTION	P-VALUE
STF	60	49 Lenke 1A,B,C 7 Lenke 2A,B,C 3 Lenke 3B,C 1 Lenke 4C	Thoracic Cobb	54 ± 11	20 ± 9	64	$p < 0.001$
			Lumbar Cobb	34 ± 10	17 ± 9	51	$p < 0.001$
			Rib Hump	15 ± 5	8 ± 4	46	$p < 0.001$
			Lumbar Prominence	9 ± 4	4 ± 3	56	$p < 0.001$
p<0.001 SLF	13	13 Lenke 5C	Thoracic Cobb	27 ± 13	15 ± 9	45	
			Lumbar Cobb	44 ± 7	13 ± 8	72	$p < 0.001$
			Rib Hump	7 ± 3	5 ± 3	26	$p = 0.146$
			Lumbar Prominence	9 ± 6	3 ± 3	62	$p = 0.01$

* instrumented correction

The Variation in How Surgeons Contour Rods for Scoliosis Correction is Substantial

Jeff Pawelek, BS; Peter Newton, MD; Andrew Perry, MD; Harms Study Group

SUMMARY: Rod contour plays a major role in correcting scoliosis; however, the amount of contour surgeons put into rods has not been well studied. Experienced scoliosis surgeons contoured rods for posterior correction of a right thoracic curve. There was substantial variation (26°) in the sagittal rod contour and inter-rated reliability between surgeons was modest (0.4). Such high variation may cause avoidable variability in correction, thus warranting the need to examine surgeons' accuracy in rod contouring and its impact on postoperative outcomes.

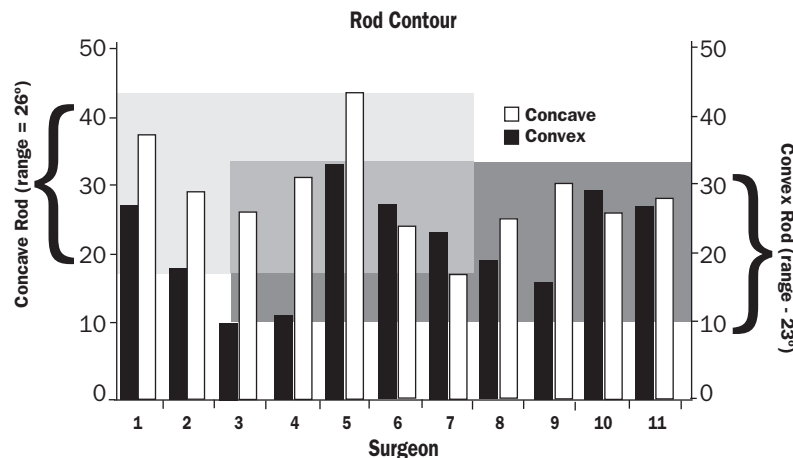
PURPOSE: Contouring the rods is a critical step in posterior scoliosis correction. The purpose of this study was to evaluate the variation in rod contouring amongst scoliosis surgeons.

METHODS: Eleven experienced scoliosis surgeons were shown radiographs of an idiopathic thoracic curve measuring 74° and thoracic kyphosis measuring 9°. The surgeons contoured both titanium and stainless steel 5.5 mm rods and completed a questionnaire. Thoracic kyphosis measurements were collected from each rod's sagittal contour.

RESULTS: Most (10 of 11) surgeons reported an intention to over-contour the sagittal rod bend for concave rods compared to convex rods. The average concave rod contour was 30 ± 7 degrees for stainless steel and 30 ± 8 degrees for titanium. Convex rods were contoured to an average of 23 ± 8 degrees and 23 ± 7 degrees for stainless steel and titanium, respectively. Rod contour ranged from 18 to 44 degrees for concave rods and 11 to 34 degrees for convex rods. Inter-rated reliability between surgeons was low to moderate with an Interclass Correlation Coefficient of 0.4.

CONCLUSION: Although there was general agreement that the concave rod should be over-contoured, there was substantial variation in the actual degree of rod contouring. The "ideal" rod contour remains unknown, but it is unlikely a rod contour of 18 degrees will give the same outcome as one contoured 44 degrees. An additional study may be needed to evaluate post-operative consequences of such variation in rod contour, and surgeons may need an intra-operative rod contour template to accurately measure and achieve their desired contour.

SIGNIFICANCE: Rod contouring is rarely considered in reporting scoliosis outcomes and the variation reported likely effects correction in the sagittal and transverse planes.



Spontaneous Lumbar Curve Correction in Selective Thoracic Fusions of Idiopathic Scoliosis – Anterior Versus Posterior Approaches

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SUMMARY: Controversy exists regarding the effect of approach (anterior versus posterior instrumented thoracic fusions) on spontaneous lumbar curve correction for the compensatory lumbar curve in adolescent idiopathic scoliosis. A comparison between anterior and posterior selective thoracic fusions revealed the spontaneous correction of the lumbar curve is independent of surgical approach and can be achieved equally with either technique.

INTRODUCTION: Controversy exists regarding the effect of approach (anterior versus posterior instrumented thoracic fusions) on spontaneous lumbar curve correction (SLCC) for a given compensatory lumbar curve in adolescent idiopathic scoliosis. We propose that no difference truly exists between approaches, with the most important factor affecting SLCC being the lowest instrumented vertebra.

METHODS: 134 anterior and 45 posterior selective thoracic instrumented fusions for Lenke B or C lumbar modifier curves instrumented distally to T11, T12, or L1 were identified in a multi-center adolescent idiopathic scoliosis database. Anterior and posterior approaches were compared directly using a one-way ANOVA. A secondary analysis was performed based on factors that correlated highly with improved spontaneous lumbar curve correction. 28 pairs of curves were matched by these factors and re-examined based on the surgical approach.

RESULTS: The average SLCC for ASF ($44 \pm 19\%$) was less for PSF ($49 \pm 19\%$) in the unmatched comparison ($p = 0.07$). Analysis of the correlation studies comparing the groups revealed the strongest correlations for SLCC to occur with lumbar curve flexibility on preoperative bending films ($r = 0.20$) and percent thoracic curve correction ($r = 0.47$). The primary analysis also found a significant ($p=0.03$) increase in SLCC with more distal lower instrumented vertebrae (LIV), so LIV was also included in the secondary analysis. Secondary analysis of paired curves matched by these criteria revealed no difference between anterior and posterior approaches, with spontaneous lumbar curve correction of 48% via anterior approach and 49% by posterior approach ($p = 0.75$).

CONCLUSIONS: Anterior and posterior instrumented fusions performed selectively on the appropriate curves result in equal spontaneous lumbar curve correction when matched by lowest instrumented vertebra, flexibility of the lumbar curve, and percent thoracic curve correction achieved.

SIGNIFICANCE: These findings suggest that the observed phenomenon of spontaneous lumbar curve correction after selective thoracic fusion in AIS is independent of surgical approach and can be achieved equally with either technique.



Comparison of Lowest Instrumented Vertebra (LIV) Selection in Lenke 1 Main Thoracic Adolescent Idiopathic Scoliosis Curves by the Surgical Approach: A minimum 5-year Follow-up Study

Larry Lenke, MD; Kathy Blanke, RN; Randal Betz, MD; Peter Newton, MD; Alvin Crawford, MD; Thomas Lowe, MD; David Clements, MD; Harms Study Group

INTRODUCTION: The debate as to whether distal fusion levels are “saved” and correction is maintained when treating Lenke type 1 main thoracic (MT) AIS curves by an anterior approach (ASF) vs a posterior approach (PSF) continues. The purpose of this study was to critically compare the selected LIV with respect to the lower end vertebra (LEV) of the major curve in Lenke type 1 MT AIS via the surgical approach (ASF vs PSF) and followed to a minimum 5-years post-op (PO) to quantify whether correction was maintained.

METHODS: Pre-op, early PO, 2-year and a minimum 5-year PO radiographic evaluation of the MT Cobb, LIV angulation, disc angle and LIV translation (AVT) in 131 patients (91 ASF, 40 PSF) was performed. The LIV to LEV distance (LIV-LEV) was used as a comparison of distal fusion level selection in these patients to score each case (e.g. LIV-L2, LEV-L1=+1). Thus, the LIV-LEV score was a positive number when the LIV was more caudal than the LEV and negative when the LIV was cephalad to the LEV.

RESULTS: (See table). For the ASF patients, 77/91 (85%) had a 0 or -1 LIV-LEV score, as compared to only 7/40 (18%) of the PSF procedures ($p<0.05$). The majority of PSF procedures (33/40, 82%) were treated to an LIV-LEV score of +1 or greater. For ASF procedures, the pre-op, early PO, 2-year PO and 5-year PO MT Cobb measures were: 51, 18, 23, and 25 degrees, respectively ($p<0.0001$ for early: 2-year PO; $p=0.005$ for 2-year: 5-year PO comparison). A similar statistically significant loss of correction over time was seen for the LIV-AVT parameter, but not for the LIV and disc angulation parameters. For PSF procedures, the corresponding Cobb values were: 52, 17, 21, and 21 degrees, respectively ($p<0.0001$ for early: 2-year PO; $p=0.478$ for 2-year: 5-year PO comparison). All 3 LIV parameters showed similar results with maintenance of correction between 2 and 5 years post-op.

CONCLUSION: Lenke type 1 MT patients treated with an ASF to an LIV-LEV score of 0 or -1 showed more loss of correction in the MT Cobb and specific radiographic LIV parameters up to 5 years post-op than corresponding PSF procedures fused primarily to an LIV-LEV score of +1 or greater. The ultimate clinical consequences of these radiographic changes are unknown.

SUMMARY: The debate as to whether distal fusion levels are “saved” and correction is maintained when treating Lenke type 1 main thoracic AIS curves by an ASF vs a PSF continues. ASF patients fused 1 or 2 levels short of the lower end vertebra will show more loss of correction in the MT Cobb and specific LIV parameters up to 5 years postoperative than corresponding PSF procedures that were fused principally to 1 or more levels below the LEV.

91 ASF	40 PSF	PREOP	1ST PO	2 YR PO	5 YR PO
MT	ASF	51	18 (0.000*)	23 (0.000+)	25 (0.005**) (0.000++)
COBB	PSF	52	17 (0.000*)	21 (0.000+)	21 (0.478**) (0.000++)
LIV	ASF	24	9 (0.000*)	7 (0.024+)	8 (0.697**) (0.137++)
ANGLE	PSF	13	5 (0.000*)	5 (1.000+)	4 (0.319**) (0.269++)
DISC	ASF	3	0 (0.000*)	-1 (0.057+)	-1 (0.206**) (0.001++)
ANGLE	PSF	6	3 (0.000*)	2 (0.084+)	1 (0.376**) (0.023++)
LIV	ASF	1.4	0.1 (0.000*)	0.9 (0.000+)	1.1 (0.002**) (0.000++)
AVT	PSF	0.3	-0.2 (0.097*)	0 (0.111+)	0 (0.714**) (0.421++)

* Preop to 1st PO; +1st PO to 2 yr PO; ** 2 yr PO to 5 yr PO; ++1st PO to 5 yr PO

Radiographic and Surgeon-Rationale for NOT Performing a Selective Thoracic Fusion in Lenke 1C Adolescent Idiopathic Scoliosis Curves

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INTRODUCTION: To investigate the percentage of Lenke 1C curves [structural main thoracic (MT) and nonstructural lumbar curves (LC)] treated with a selective thoracic (ST) vs. a nonselective (NS) fusion and evaluate why a ST fusion was NOT performed.

METHODS: A prospective multicenter database revealed 92 patients with Lenke 1C curves treated with an anterior (ASF) or posterior (PSF) spinal fusion. We considered a ST fusion if the lowest instrumented vertebra (LIV) was L1 or cephalad. A detailed survey was completed by the surgeons for each patient they treated with a NS fusion of a 1C curve pattern as to why a ST fusion was NOT performed.

RESULTS: 67 of 92 (73%) Lenke 1C curves underwent a ST fusion, while 25 (27%) underwent fusion of both MT and LC regions. 50 ST fusions were performed via an ASF and 17 via a PSF. The thoracic Cobb angle averaged 52 degrees in the ST and 53 degrees in the NS fusion group ($p>0.05$); corresponding TL/L Cobb angles averaged 41 degrees in the ST fusion and 44 degrees in the NS fusion group ($p>0.05$). Thoracic apical vertebral translation (AVT) averaged 3.9cm in the ST fusion and 3.8cm in the NS fusion group ($p>0.05$), but TL/L AVT averaged -2.7cm in the ST fusion and -3.2cm in the NS fusion group ($p<0.05$; Table). Thus, the main radiographic difference between the groups was an increased TL/L AVT in the NS fusion cases. Reasons provided by the surgeon for NS fusion were: surgeon, radiographic and clinical-related. The main surgeon reason was anticipation of an unacceptable residual lumbar curve; the main radiographic reason was nearly-equal preop MT and TL/L Cobb measurements; and the main clinical reason was nearly-equal T & L prominences/scoliometer readings.

CONCLUSIONS: The majority of Lenke 1C curves (73%) underwent a ST fusion as recommended by the Lenke classification system. The main radiographic difference between those patients undergoing ST fusion vs. NS fusion was increased TL/L AVT. The main surgeon rationale for a NS fusion was concern for an unacceptable post-op lumbar curve, and the main clinical reason was nearly equal preop thoracic and lumbar scoliometer measurements.

SUMMARY: A prospective multicenter database revealed 92 patients with Lenke 1C curves treated with an ASF or PSF. ST fusion was considered if the LIV was L1 or cephalad. 73% underwent a ST fusion as recommended by the classification. The main radiographic difference between patients undergoing ST fusion versus NS fusion was increased TL/L AVT. The main surgeon-rationale for a NS fusion was concern for an unacceptable post-op lumbar curve; the main clinical reason was nearly-equal preop T & L scoliometer measurements.

	ST = 67	(ALL PSF) NS = 25
Thoracic Cobb (range)	51.9 (35-80)	53.4 (42-81)
Thoracolumbar/Lumbar Cobb (range)	41.4 (26-61)	44.3 (31-57)
Thoracic AVT (range)	3.9 (0.2-6.4)	3.8 (2.1-5.5)
Thoracolumbar/Lumbar AVT (range)	-2.7 (-0.9-4.7)	-3.2 (-1.8-5.5)

ST: selective thoracic; NS: nonselective; PSF: posterior spinal fusion; AVT: apical vertebral translation

Effect of Selective Fusion on Trunk Flexibility for Lenke 5 Adolescent Idiopathic Scoliosis

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PURPOSE: This prospective, two-year a minimum follow-up, multicenter study of 48 patients with primary lumbar curves that had spine fusions with instrumentation, evaluated the effect fusion length on trunk range of motion

MATERIAL AND METHODS: From a prospective database of 1292 patients, subjects with Lenke 5 curves, and fusions crossing thoracic lumbar junction that ended at L3 or L4 were selected. Subjects were grouped by length and type of fusion, the Selective Anterior Fusion Group(SASF) (N=36) had 5 to 7 levels fused($x=5.6 \pm 0.6$), while the Non-Selective Posterior Fusion Group (NPSF) (N=12) had over 8 fused levels($x=12.5 \pm 1.9$). The sets were compared via clinical flexion and extension, right and left side bending, and SRS 24 domains scores. Pre-operatively the groups had alike Cobb's 46.5o(SASF) vs. 50.9o(NPSF), trunk flexibility ($p=0.371$ or higher see chart) and, SRS domain scores ($p=0.346$ and higher see chart).

RESULTS: Postoperatively both groups had a significant($p<0.001$) correction of the lumbar Cobb, there was no significant($p=0.876$) difference between SASF (14.2 ± 7.6) and NPSF 14.6 ± 9.2). Comparing postoperative trunk motion there was significantly less motion in NPSF's flexion($p=0.005$), right($p<0.004$) and, left($p=0.017$)compare to SASF, while both lost similar($p=0.275$) extension. Examining postoperative trunk motion as a percent of pre-op motion SASF keep 85.4% of flexion, 74.5% extension, 83.4% right bend, 91.5% left bend, 94.1%. NPSF keep 66.5% flexion, 87.5% extension 51.8% right bend, and 59.5% left bend. No difference is seen between groups for post-op SRS domains.(chart)

CONCLUSIONS: Selective anterior fusion had statistical significant better motion in flexion (19%), right bend (32%) and, left bend (32%) than the non-selective posterior fusions.

SIGNIFICANCE: Ideally all Lenke 5 curves should be treated with a selective fusion, but often a non-structural thoracic curve needs to be treated to manage its associated deformities. This paper demonstrates the effect of extending the fusion level on clinical trunk motion. The difference in residual motion may not be essential to patients as evident by the lack of distinction in SRS scores.

Can MRI Axial Rotation Measurements in Adolescent Idiopathic Scoliosis Correlate with CT?

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SUMMARY: Scoliosis patients frequently undergo a routine preoperative MRI to rule out intraspinal anomalies as well as a postoperative CT to assess thoracic pedicle screw position. However, no study exists correlating the accuracy of rotational measurements when using CT vs. MRI. Our results demonstrated a strong correlation of vertebral rotational measurement, Pearson correlation coefficient of $r=0.722$ ($p<0.01$), when utilizing MRI and CT. The establishment of a correlation between MRI and CT for assessing rotation facilitates future studies correction of rotational deformity.

INTRODUCTION: Scoliosis patients frequently undergo a routine preoperative MRI to rule out intraspinal anomalies as well as a post operative CT to assess thoracic pedicle screw position. If rotational measurements were comparable on MRI and CT than routine studies could be used to assess scoliosis correction after surgery. No study exists correlating the accuracy of rotational measurements when using MRI vs. CT. The purpose of this study is to determine the correlation between the rotation measurements of both the thoracic and lumbar vertebrae as assessed by MRI and CT.

METHODS: From a prospective database of 193 patients, we identified 11 patients with 17 structural curves with adequate preoperative MRI and CT exams. The average curve size was 56.6° (range: 41° - 77°). The average age was 13.2 years (range 11.6-16.7 years). The apical vertebra of the structural curve was determined using the AP radiographic view of the spine. The angle of rotation (RAsag) was measured by using the technique described by Aaro et al. (1988). Independent measurements were obtained by three reviewers. Pearson correlation coefficient (r) was used to assess the strength of correlation between the measurements of the individual observers with CT vs. MRI.

RESULTS: Comparison of the apical vertebral rotational measurement between the three observers demonstrated a CT RAsag= 22.5° and MRI RAsag= 21.8° ($r=0.722$, $p<0.001$, Table 1). Inter observer reliability demonstrated a correlation of $r=0.802$ ($p<0.01$) for CT, and $r=0.757$ ($p<0.01$) for MRI.

CONCLUSION: Assessment of vertebral rotation as measured by MRI correlates well with CT scan, demonstrating a Pearson correlation of $r=0.757$ ($p<0.001$).

SIGNIFICANCE: MRI assessment of vertebral rotation at the apical vertebrae can be reliable and have good correlation with CT as long as axial images are obtained parallel to the vertebral endplates. Therefore, routine pre operative MRI can be compared to post operative CT for analysis of rotation correction.

Table 1.

INDEPENDENT OBSERVER	1	2	3
CT RA _{sag}	$23.6^\circ \pm 4.6^\circ$	$22.3^\circ \pm 3.6^\circ$	$21.5^\circ \pm 3.9^\circ$
MRI RA _{sag}	$22.7^\circ \pm 3.9^\circ$	$21.8^\circ \pm 3.4^\circ$	$22.7^\circ \pm 2.8^\circ$
R	.747	.768	.728
P-value	<.001	<.001	<.001

CT inter-observer reliability was good with a correlation of $r = 0.802$ $p<0.01$

MRI inter-observer reliability was good with a correlation of $r = 0.757$ $p<0.01$

CT Evaluation of Rotation Correction in AIS: A Comparison of All Pedicle Screw Construct vs a Hook-Rod System

Jahangir Asghar, MD; Amer Samdani, MD; Joshua Pahys, MD; Linda D'Andrea, MD; James Guille, MD; David Clements, MD; Randal Betz, MD

SUMMARY: In 1988, Ecker et al. observed a 22 % derotation of the apical vertebra of the thoracic spine and 33% of the apical vertebra of the lumbar spine when using a hook and rod system (CD instrumentation). More recently Lee et al., in 2004, reported 42.5% derotation of the apical vertebra (both thoracic and lumbar) in a series of all pedicle screw constructs. Currently, there is no comparison series reported between the two groups of constructs. In this study measuring axial rotation of the apical vertebral bodies of patients with idiopathic scoliosis treated with an all pedicle screw construct versus hooks and rods using CT showed the pedicle screw group had a significantly greater percent apical vertebral body rotation correction (60%) as measured on CT scans than the hook-rod group (22%).

PURPOSE: Previous studies report derotation of apical vertebrae in scoliosis following spinal fusion using a hook-rod system, or all pedicle screw construct. However, there are no studies comparing results of the two different instrumentation systems. The purpose of this study is to measure axial rotation of the apical vertebral bodies of patients with AIS treated with an all pedicle screw construct versus hook and rods using CT.

METHODS: From a database of 193 patients with AIS and posterior spinal fusions, 21 patients were identified as having all pedicle screw constructs (APS), with pre- and post-op CT scans. This cohort of patients was compared to a historical published cohort of patients treated with all hook-rod constructs (HR) by Ecker and Betz (1988). Comparison of the groups showed no statistically significant differences for age and pre-op Cobb angle of the main curve ($p>0.05$); however, there was a statistically significant difference ($p<0.05$) in post-op correction values (Table 1). The apical vertebral rotation for the major curve was measured from the pre and postoperative axial CT using the methods described by Aaro and Dahlborn.

RESULTS: The average preoperative rotation was similar between the two groups (Thoracic HR-22.6, APS 21.3, $p=0.6$; Lumbar HR 19.4 APS 20.6, $p=0.7$). The post operative correction had a significant difference with a (Thoracic HR-16, APS 8.5, $p=0.015$; Lumbar HR 13.4 APS 20.6, $p=0.032$). The percent correction of the apical vertebrae showed a significant difference with 22% correction in HR group and to 60% in APS group ($P<0.001$, see table 1).

CONCLUSION: The pedicle screw group had a significantly larger percent apical vertebral body rotation correction (60%) as measured on CT scans than the hook-rod group (22%).

SIGNIFICANCE: While surgeons report coronal correction of non pedicle screw constructs similar to an all pedicle screw construct, our study found that axial rotation correction was significantly superior with an all pedicle screw construct.

Table 1.

	HOOKS + ROD	ALL SCREWS	P-VALUE
Age	14.0 ± 1.49	13.8 ± 1.72	0.668
Pre-operative curve (degrees)..... Thoracic.....	50.7 ± 8.45	56.9 ± 11.51	0.175
Lumbar.....	52.8 ± 7.16	53.6 ± 8.85	0.636
Post-operative curve (degrees)... Thoracic.....	15.8 ± 4.15	12.1 ± 5.23	0.015
Lumbar.....	20.8 ± 4.4	9.9 ± 4.55	<0.001
Cobb correction (%)..... Thoracic.....	69.4% ± 12.5	79.5% ± 7.96	0.002
Lumbar.....	60.8% ± 13.2	81.6% ± 7.25	<0.001
Pre-operative rotation..... Thoracic.....	22.6°	21.3°	0.639
Lumbar.....	19.4°	20.6°	0.721
Post-operative rotation..... Thoracic.....	16.0°	8.5°	0.015
Lumbar.....	13.3°	7.0°	0.032
Percent correction..... Thoracic.....	22.1%	60.2%	<0.001
Lumbar.....	33.2%	66.1%	<0.001

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Newton et al. Five-Year Follow-Up of AIS Patients Surgically Treated with T-Scope. Submitted to *JBJS* 10-07.

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PRESENTATIONS - ABSTRACTS

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115. Newton P, Faro F, Gaynor T, White K: Anterior fusion after thoracoscopic disc excision: analysis of 112 consecutive deformity cases. American Academy of Orthopaedic Surgeons. San Francisco, Ca, March 10-14, 2004.
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127. Rohmiller M, Newton P, Marks M, Gaynor T, Wenger D, Betz R, Lenke L, Lowe T, Clements D, Harms J, Letko I, Haheer T, Merola A, D'Andrea L, Crawford A, Sucato D: Does a Correlation Exist Between Instrumentation Type, Number of Fixation Points, and Cost in the Surgical Correction of Adolescent Idiopathic Scoliosis? 11th International Meeting for Advanced Spine Techniques, Southampton, Bermuda, July 1-3, 2004.
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