

Poster #1

Complications after Spinal Fusion in Patients with Baclofen Pumps: A Controlled Study

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Purpose: To compare complication rates after spine fusion and instrumentation in patients with pre-existing baclofen pumps versus patients with spastic quadriparetic cerebral palsy (CP) without baclofen pumps.

Methods: Ten patients with indwelling baclofen pumps underwent spinal fusion and instrumentation at one institution in a 6 year period. Complication rates and types were compared with those from the 20 patients with spastic quadriparetic cerebral palsy who underwent spinal fusion and instrumentation at the same institution during the same period.

Results: Three patients in the baclofen pump group had pump related complications requiring reoperation (one catheter breakage, one catheter withdrew from the intrathecal space and became infected after revision, and one pump became positional). The deep infection rate in the pump group was 3/10 (30%) vs. 2/20 (10%) in the CP patients without pumps. Major complications were encountered in 5/10 (50%) of the pump patients (4/10 with major complications not directly related to the pumps) (7 total major complications) and 4/20 (20%) of the patients without pumps (4 total major complications).

Conclusion: Patients with preexisting baclofen pumps appear more likely to encounter a major complication after spine fusion surgery than are spastic quadriparetic CP patients without pumps. Some but not all of this difference appears directly due to pump and catheter related issues.

Poster #2

"Superior Mesenteric Artery Syndrome Following Surgical Treatment of Scoliosis in Children and Adolescents"

Athanasios Tsirikos, MD, FRCS (Hospital for Children); Lindsay Jeans

Study Design: We performed a retrospective review of 165 consecutive pediatric patients who underwent spine deformity surgery.

Objective: To investigate the prevalence of superior mesenteric artery (SMA) syndrome.

Summary of Background Data: Obstruction of the third part of the duodenum by the SMA is associated with spinal manipulation in the surgical or conservative management of scoliosis.

Methods: The study group comprised 85 patients with idiopathic scoliosis, 20 patients with neuromuscular and 18 patients with miscellaneous or syndromic scoliosis, and 42 patients with congenital spine deformities. The medical records and imaging tests were reviewed.

Results: Posterior spine arthrodesis was performed in 94 patients, combined anterior/posterior in 60 patients, and anterior spinal fusion in 11 patients. We identified 4 patients who developed SMA syndrome postoperatively. These were all markedly underweight, adolescent females; 2 patients had adolescent idiopathic scoliosis, one had neuromuscular, and one congenital scoliosis. Third generation instrumentation systems with derotational effect were used in 3 patients. The spine arthrodesis in the patient with neuromuscular scoliosis was performed using bone graft followed by application of a spinal jacket. The symptoms developed at a mean of 3.7 days post-surgery and included nausea, vomiting, increased nasogastric aspirates, abdominal pain and distension. Conservative management with prolonged nasojejunal feedings achieved resolution of the symptoms in all but one patient, who required derotation of the duodenum and jejunum. There was no evidence of recurrence of the condition in any patient.

Conclusions: The prevalence of SMA syndrome in our series was 2.4%. This draws attention to the significance of prevention of the condition by recognizing patients who are at a higher risk. An early diagnosis of the syndrome will allow for application of conservative methods and will increase the chances for a successful outcome.

TABLE 1. Presentation of our study population and the type of surgery that was performed.

Diagnosis	No. of patients	PSF with instrumentation	PSF without instrumentation	A/PSF with instrumentation	A/PSF without instrumentation	ASF with instrumentation
Idiopathic scoliosis	85	44	0	31 (two-stage)	0	10
Neuromuscular scoliosis	20	13	0	5 (two-stage)	1 (two-stage)	1
Congenital spine deformity	42	8	17	3 (two-stage: 2, one-stage: 1)	14 (one-stage)	0
Miscellaneous /syndromic scoliosis	18	12	0	6 (two-stage)	0	0

PSF: posterior spinal fusion, A/PSF: anterior/posterior spinal fusion, ASF: anterior spinal fusion

Poster #3

A Nonsynonymous WNT3A Mutation in a Patient with Congenital Scoliosis

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Prior investigations have not identified a major locus for congenital vertebral malformations, providing evidence that there is clinical and genetic heterogeneity for this condition. WNT3A has recently been identified as a negative regulator of Notch signaling and somitogenesis. Mice with mutations in Wnt3a develop caudal vertebral malformations and accessory neural tubes. Because congenital vertebral malformations represent a sporadic occurrence, linkage approaches to identify genes associated with human vertebral development are not feasible. Based on the observations in the mouse, we hypothesized that WNT3A mutations might account for a subset of human congenital scoliosis. We therefore performed DNA sequence analysis of the WNT3A gene in 50 patients with congenital vertebral malformations spanning the entire vertebral column. A female patient with a T12-L1 hemivertebrae was found to be heterozygous for a GCC -->ACC missense mutation resulting in the substitution of alanine by threonine at codon 134 in exon 3 (UCSC position ch1:224,545,178 May 2004 assembly) of the WNT3A gene. This entire exon is highly conserved. The father of the patient who is clinically asymptomatic was also heterozygous for the missense mutation. The mutation was not found in a control population of 85 anonymized individuals (81 Caucasians, 2 Hispanics and 2 Asians). Since this mutation was not observed in a control population, and leads to a non-conservative amino acid change, we conclude that this mutation is likely to be clinically significant. Several established mechanisms can explain the existence of the mutation in both the patient and her asymptomatic father. Documenting the absence of the mutation in a larger control population or documenting a functional difference in WNT3A function would provide further evidence supporting its pathogenicity.

Poster #4

Posterolateral Corpectomy of Thoracolumbar Fractures: Results of 100 Cases

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Aim Of the Study: This prospective study aims to evaluate an alternative technique for management of unstable thoracolumbar fractures.

Material and Method: From May 2003 to May 2005, posterolateral corpectomy, grafting and transpedicular screws fixation were done in 100 cases presented with thoracolumbar fractures in Assiut Trauma Unit- Assiut University Hospital. Average age was 32 years old (range 18-62). Fractures were classified according to Mageral et al., comprehensive classification system. Preoperative, postoperative and follow-up X-ray and CT-scan were done for all cases. Load-sharing and neurological status were the guide for preoperative planning. According to Frankel Scoring system, 92 cases presented with variable neurological deficit and 8 were neurologically-free. The surgical technique entailed posterolateral access through hemilaminectomy-facetectomy after transpedicular screws insertion. After efficient spinal decompression and corpectomy, the anterior spinal column was reconstructed with strut tricortical iliac bone graft. Operative time, operative blood loss, intra-operative complications, hospital stay, and postoperative complications were recorded according to Clavien Grading system.

Results: The average follow-up period was 28 months (range 24-36 months). Posterolateral corpectomy of D9 is done once, D10 (4 cases), D11 (13 cases), D12 (21 cases), L1 (44 cases), L2 (7 cases), L3 (5 cases), L4 (3 cases), and L5 (2 cases). The total operative time was 150 minutes in average (range 100-240 min.) the op. Blood loss was 1300cc in average (range 900- 2100 cc. Injury of the neural elements due to fracture was found in 43 cases, in 12 of them the injury was irreparable. Sudden intraoperative death occurred once. No serious post-operative complications were recorded apart from injury of L1 nerve root in two cases. Solid Fusion occurred in 87cases. Neurological improvement rate was 73%.

Conclusions: This modified method of posterolateral corpectomy is a safe, efficient and less morbid technique for treatment of unstable thoracolumbar fractures.

Poster #5

Responsiveness of the Spinal Appearance Questionnaire (SAQ) compared to the SRS instrument in Adolescent Idiopathic Scoliosis

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Medtronic

Background: Because appearance is a major issue in adolescent idiopathic scoliosis, the spinal appearance questionnaire (SAQ) was designed to assess various aspects of spinal deformity appearance. The SAQ has not previously been compared with the standard outcome tool for idiopathic scoliosis, the SRS instrument.

Methods: The SAQ and SRS instruments were both completed by 83 adolescent idiopathic patients preoperatively and 1 year postoperatively. Preoperative and postoperative scores were compared using paired t-tests for statistical significance. The effect size and standardized response mean were determined with values >0.8 considered large. The relative efficiency of the SAQ compared to the most responsive SRS domain was determined using the two sample Z-statistic.

Results: Both instruments had statistically significant improvement in all of their domains except of the SAQ Comparison and the SRS Activity scales. The effect sizes, standardized response means, Z-statistics, and relative efficiencies are shown in the table. The responsiveness of the SRS instrument was largely determined by the appearance domain (effect size 1.4). The relative efficiency of the SAQ domains to the SRS appearance domain was greater in 5, equivalent in 1, and less in 3 domains.

Conclusions: The appearance of the spine in adolescent idiopathic scoliosis shows the most responsiveness of any measured domain. The SAQ demonstrates markedly improved efficiency over the SRS instrument in this domain. We recommend use of the SAQ when spinal appearance is an important outcome for scoliosis.

Precis: The SRS and spinal appearance questionnaires (SAQ) were compared preoperatively and one year postoperatively in patients with idiopathic scoliosis. The appearance of the spine in adolescent idiopathic scoliosis shows the most responsiveness of any measured domain. The SAQ demonstrates markedly improved efficiency over the SRS instrument in this domain.

(Poster #5 Attachment)

Scale	P Value	Effect Size	Standardized Response Mean	Z-Statistic	Relative Efficiency*
SAQ Trunk	<0.0001	1.9	1.8	14.00	2.50
SAQ Leg Length	<0.0001	1.0	0.9	6.64	0.56
SAQ Ribs	<0.0001	1.9	1.8	12.84	2.10
SAQ Flank Prominence	<0.0001	1.2	1.2	9.52	1.16
SAQ Chest	<0.0001	1.3	1.2	8.70	0.97
SAQ Shoulders	<0.0001	1.9	1.8	13.87	2.46
SAQ General	<0.0001	1.4	1.3	9.39	1.13
SAQ Comparison	0.4673	0.1	0.1	0.63	0.01
SAQ Self-Image	<0.0001	0.5	0.5	3.41	0.15
SRS Pain	0.0020	0.4	0.3		
SRS Appearance	<0.0001	1.4	1.2	8.85	
SRS Activity	0.9848	0.0	0.0		
SRS Mental	0.0037	0.4	0.3		
SRS Subscore	<0.0001	0.8	0.8		
SRS Satisfaction	<0.0001	0.9	0.8		
SRS Total	<0.0001	0.9	1.0		

*Relative Efficiency is the square of the ratio of the specified SAQ subscale Z-Statistic and the SRS Appearance (the most responsive SRS scale) Z-Statistic.

Poster #6

Prevalence of Systemic and Intraspinal Anomalies in Congenital Deformity of the Spine

James T. Guille, MD (Shriners Hospital for Children); Anthony Riccio; Hamid Redjal; Linda P. D'Andrea, MD

We reviewed 266 patients with congenital deformity of the spine and found 162 patients who had adequate clinical documentation and had a MRI study of the entire spine. Eleven had kyphosis, 12 kyphoscoliosis, 20 Klippel-Feil syndrome, 119 scoliosis. The type and level of anomalous vertebra(e) were recorded. Deformity from other than an isolated hemivertebra was termed complex. Associated syndromes, intraspinal anomalies, renal anomalies, and limb anomalies were recorded. We hoped to determine which patients with congenital spine deformity required MRI of the spine to identify intraspinal anomalies. MRI revealed 72 patients (44%) with an intraspinal anomaly. Isolated hemivertebra was seen in 15 (21%) of these patients, and complex multi-level involvement in 57 patients (79%). Intraspinal anomalies were seen in 9/11 (82%) with kyphosis, 8/12 (67%) with kyphoscoliosis, 11/20 (55%) with Klippel-Feil syndrome, and 44/119 (37%) with scoliosis. Twenty of the 72 patients (28%) required neurosurgical intervention. Only 11/72 (15%) patients had abnormal neurologic findings on exam. An associated syndrome was found in 24/162 patients (15%), and 13/24 (56%) had an intraspinal anomaly. Renal anomalies were seen in 41/162 (25%), and 23/41 (56%) had an intraspinal anomaly. Limb anomalies were seen in 21/162 patients (13%), and 16/21 (76%) had an intraspinal anomaly. Higher prevalences of intraspinal anomalies were seen in patients with complex patterns of vertebral involvement (79%), congenital kyphosis (82%) and kyphoscoliosis (67%), and associated syndrome (54%), renal anomaly (56%), and limb anomaly ((76%). Unfortunately, physical findings alone were inadequate in their predictive capacity (15%).

Poster #7

Characterize Pedicle and Neurocentral Synchronosis Development in Young Normal Patients Using Magnetic Resonance Imaging

Hong Zhang, MD (Texas Scottish Rite Hospital); Daniel J. Sucato, MD, MS; Pamela Nurenberg; Anna McClung

Purpose: It has been hypothesized that asymmetric growth of the vertebral neurocentral synchondrosis (NCS) could lead to the development of spinal deformity. However, there are no studies which have analyzed the NCS of the normal spine to serve as a baseline for future study of spinal deformity. The objective of this study was to analyze the NCS development and pedicle using magnetic resonance imaging (MRI) in young patients (< 8 years) who have a normal straight spine.

Methods: Transverse MRI images of 25 patients who had a normal straight spine were analyzed from T1 to L5. NCS length and thickness, pedicle length and width, and percent left/right vertebral body area (%VBA) of the total vertebral body area were measured using a computer workstation at each level. The extent of symmetry in the vertebrae was determined and compared at each level using statistical methods.

Results: There were 19 females and 6 males with an average age of 4.3 years (0.8 to 7.8). The average NCS length and thickness were 7.9 mm x 1.2 mm on the left and 8 mm x 1.3 mm on the right. The pedicle length and width was 16.9 mm and 3.7 mm for the left and 16.7 mm and 3.4 mm for the right. The %VBA was 28.6% for the right and 27.7% for the left. No significant differences were found between the left and right at each level when compared the NCS, pedicle, and %VBA, respectively. Analysis of the pedicle in different regions of the spine correlated with age (Table).

Discussion: The pedicle size of the normal vertebrae for the infantile and juvenile spine is described. Developmental symmetry of the NCS was seen in the normal straight spine and may play an important role for maintaining normal spine alignment.

Pedicle Measurement Analysis In Different Region Correlated With Different Age

	6 - 8 Years		4 - 5 Years		< 3 Years	
	Length (mm)	Width (mm)	Length (mm)	Width (mm)	Length (mm)	Width (mm)
Upper Thoracic (T1 - T5)	16.9 ± 1.7	3.1 ± 1.4**	16.7 ± 2.1	3 ± 1.1	14.5 ± 2.5*	2.6 ± 1.3
Mid / Lower Thoracic (T6 - T12)	17.7 ± 1.8	3 ± 1.4	18 ± 2.1	3.1 ± 1.2	15 ± 2.5*	2.8 ± 1.3
Lumbar (L1 - L5)	20.2 ± 1.7	4.3 ± 1.4	19 ± 2.1	4.7 ± 1.2	15.8 ± 2.5*	4 ± 1.3

* Significant difference (p < 0.05) compared with 4 - 5 years and 6 - 8 years group in length

** Significant difference (p < 0.05) compared with 4 - 5 years and < 3 years group in width

Poster #8

Abnormal spread of junctional acetylcholine receptor of paravertebral muscles in scoliosis associated with syringomyelia

Yong Qiu; Bangping Qian

Background: The mechanism by which scoliosis develops secondary to syringomyelia is yet to be determined.

Study Design: All the patients were divided into three groups and the results of AchR staining were compared.

Patient Sample: 25 patients with scoliosis associated with syringomyelia, 16 adolescents with idiopathic scoliosis, and 10 cases without scoliosis were enrolled

Outcome Measures: Acetylcholinesterase staining defined the limits of the NMJs, and AChR staining that appeared outside of these limits indicated an abnormal distribution of AchR, which meant the patient was judged positive.

Methods: All the enrolled patients were divided into three groups: SS(scoliosis associated with syringomyelia) group consisted of 25 patients with scoliosis associated with syringomyelia, AIS(adolescent idiopathic scoliosis) group included 16 adolescents with idiopathic scoliosis, and NS(non-scoliosis) group was 10 cases without scoliosis. Histological evaluation of paraspinal muscles used a double-stain immunofluorescence technique for AchR and acetylcholinesterase. Wherein acetylcholinesterase staining defined the limits of the NMJs, and AChR staining that appeared outside of these limits indicated an abnormal distribution of AchR, which meant the patient was judged positive.

Results: Histological analysis showed that none of the patients both in AIS group and in NS group was judged positive, but 14 of 25 patients in SS group scored positive for the presence of AchR outside of the NMJs. The positive rate was 44% on the convex side of the curve, and 28% on the concave side.

Conclusions: The denervation of paraspinal muscles is present in some patients with scoliosis associated with syringomyelia, suggesting that scoliosis be caused by the strength imbalance of paraspinal muscles in these patients.

Poster #9

Radiologic presentations in relation to curve severity in scoliosis associated with syringomyelia

Yong Qiu; Bangping Qian

Purpose: To further explore the radiologic presentations in relation to curve severity in scoliosis associated with syringomyelia.

Study Design/ Setting: The patients were divided into three groups and the radiologic characteristics were explored.

Patient Sample: 87 patients with scoliosis associated with Chiari malformation and syringomyelia were enrolled.

Outcome Measures: Curves were classified into typical and atypical patterns in coronal plane, and the sagittal profile was evaluated. Cerebellar tonsillar descent or syrinx patterns in relation to curve severity and the frequency of atypical curves were also investigated.

Methods: 87 patients were divided into three groups according to Cobb angle: Group I (10-30 degrees), Group II (30-60 degrees), and Group III (Cobb angle > 60 degrees). Curves were classified into typical and atypical patterns in coronal plane, and the sagittal profile was measured. Cerebellar tonsillar descent or syrinx patterns in relation to curve severity and the frequency of atypical curves were also investigated.

Results: The frequency of atypical curve patterns from Group I to III was 46.2%, 45.2%, and 40.7% respectively. 65.3% patients with typical curve patterns had atypical features in all of the three groups. There was a significant difference of kyphotic angle among the three groups. Both the degree of cerebellar tonsillar descent and syrinx patterns had no correlation with the curve severity or the frequency of atypical curves.

Conclusions: These results show that radiographic presentations including typical curve patterns, atypical features in typical curve patterns, and a normal to hyperkyphotic thoracic spine may suggest the need for preoperative MRI. Kyphosis may be indicative of progressive scoliosis. There is no evidence to suggest that the degree of cerebellar tonsillar descent and syrinx patterns have an effect on the progress of scoliosis and the frequency of atypical curves.

Poster #10

Early Rebalancing Following Selective Lumbar Fusions in Adolescent Idiopathic Scoliosis

Michael W. Peelle, MD (Hospital for Special Surgery); Oheneba Boachie-Adjei, MD; Gina Charles; Yamuna Kanazawa

Methods: Retrospective radiographic review of 25 consecutive AIS patients who underwent anterior-only, selective lumbar fusion and instrumentation. Proximal levels T9(1), T10(3), T11(17) and T12(4) and distal levels were L2(3), L3(20), and L4(2). Lenke curve types included 5C-(2), 5C+(2), 5CN(19), 6CN(1), 6C+(1). Instrumentation included single or dual rod titanium constructs; interbody materials included femoral head allograft or titanium mesh cages and autograft. Radiographic measurements included the preoperative, 1 week, 1 month, 3 months, 1 year and latest follow-up X-rays.

Results: (See Table) Coronal decompensation increased 28% (p=0.03) at the 1 week period; however, spontaneous correction occurred between 1 week and 3 month follow-up such that correction at 3 months (56%, p=0.006) and 1 year (64%, p<0.001) were not statistically different (p=0.09). No significant improvement in T1 tilt or proximal thoracic curve Cobb magnitude at any time period were found. Shoulder balance, measured by clavicular tilt, worsened 36% (p=0.02) at 1 week but improved continually until achieving 46% correction (p=0.01) at 1 year. Main thoracic spontaneous correction averaged 31% (p<0.001) at 1 week and remained similar (39%, p<0.001) through latest follow-up (p=0.45). Apical thoracic translation increased at 1 week but then continually diminished at subsequent time intervals. Lumbar curve Cobb correction at 1 week (75%) was similar to 1 year postop (73%)(p=0.84). Mean kyphosis and lordosis remained similar at all time periods, although sagittal balance varied widely from 1 week (range -6.5 to +9.5cm, std dev. 3.8) through 1 year (range -7 to +2cm, std dev. 2.0).

Discussion: Early decompensation following selective lumbar fusion typically corrects within 3 months postoperatively. The thoracic curve exemplifies early Cobb correction followed by subsequent improvements in apical translation. Shoulder balance, also initially worsened after surgery, continues to improve through 1 year follow-up. The lumbar curve and EIV tilt remain unchanged from immediate post-op through 1 year follow-up.

	Pre-op	1 week	1 month	3 month	1 year	Latest
C7-CSVL (cm)	2.5	3.2*	2.1	1.1*	0.9*	1.1*
C7-TAT (cm)	1.9	2.7*	2.3	1.8	1.6	1.3
CSVL-LAT (cm)	4.8	1.9*	1.7*	1.4*	1.5*	1.3*
Prox Thor. Cobb (°)	10.6	11.7	10.5	9.1	8.9	8.8
Main Thor. Cobb (°)	31.1	21.5*	19.2*	17.4*	19.0*	19.4*
Lumbar Cobb (°)	52.4	13.0*	13.2*	12.6*	14.4*	15.4*
T1 tilt (°)	2.9	3.4	3.3	2.1	2.2	1.7
Clavicle tilt (°)	2.8	3.8*	3.3	2.1	1.5*	1.4*
EIV tilt (°)	28.4	5.3*	3.8*	3.7*	6.2*	4.2*
Kyphosis (°)	32.5	33.0	35.8	35.1	33.6	32.7
Lordosis (°)	56.7	55.5	52.8	59.1	59.7	60.6
Sagittal Balance (cm)	-1.2	0.1	-0.5	-1.4	-1.6	-1.5

* denotes p-value <0.05 (compared to preoperative measurement)
 Legend: C7=coronal plumbline; CSVL= center-sacral-vertebral-line; TAT= thoracic apical translation; LAT= lumbar apical translation; EIV= end-instrumented-vertebra

Poster #11

Scheuermann Kyphosis. Single Posterior Approach Or Anterior Release And Posterior Instrumentation ?

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Introduction: There is still debate regarding the optimal operative technique for the Scheuermann-kyphosis. A retrospective review of patients with a postoperative follow-up of at least 3 years was performed. The two study groups were: 1. Posterior instrumentation, 2. Anterior release and posterior instrumentation.

Material/Methods: 55 patients (11 females, 44 males; mean age 27 y). 14 had single posterior approach, 41 had preceding anterior release and posterior instrumentation.

Results: Group 1: Mean follow-up 6.3 years (5 – 9). Mean preop kyphosis was 73 (62 -110), postop corrected to a mean of 37 (30 -65).

Group 2: Mean follow-up 5.2 years (3 – 7) The mean preoperative kyphosis was of 78 (72 – 110) and was corrected to a mean of 32 (20 – 50).

The patients belonging to group 1 had a loss of correction of mean 4 after one year follow-up and fo 6 after the third year while in the second group there was a loss of correction of 2 after one year and no further loss of correction was seen in the three years follow-up. Complications: Group 1: 1 temporary neurologic deficit, 2 implant failures and 2 proximal junctional kyphosis. Group2: 1 proximal junctional kyphosis. Three patients of the first group underwent revision surgery.

The stationary treatment required in the second group 5 days longer, including one day in intensive care unit.

Conclusion: The combined approach showed an accurate segmental correction through restoration of the anterior vertebral height and a better correction of the kyphosis. In this group there were no neurologic complications and no pseudoarthrosis.

The patients who were treated using a single posterior approach showed also a good correction of the kyphosis but a poor segmental correction in the apex. The stationary treatment was shorter but the loss of correction and the complication rate was higher when compared to the other group.

Poster #12

Classification of congenitally fused cervical patterns in Klippel-Feil patients: epidemiology and role in the development of cervical spine-related symptoms

Dino Samartzis, BS; Jean Herman, MD; John P. Lubicky, MD; Francis H. Shen, MD (University of Virginia)

Objectives: To determine the role of cervical spine fusion patterns, age- and time-dependent factors associated with the development of cervical spine-related symptoms in patients with Klippel-Feil Syndrome (KFS).

Methods: A radiographic and clinical review of KFS patients. Radiographically, Type I patients exhibited a single congenitally fused cervical segment. Type II patients demonstrated multiple non-contiguous, congenitally fused segments, and Type III patients had multiple contiguous, congenitally fused cervical segments. Clinical records were reviewed for patient history, demographics, and the presence of cervical symptoms (axial, radiculopathy, and myelopathy). Radiculopathy and myelopathy were considered clinically significant symptoms.

Results: Twelve males and 16 females were reviewed for clinical follow-up (mean, 8.5 years) and radiographic assessment (mean, 8.0 years). The mean age of onset of cervical spine-related symptoms was 11.9 years. Clinically, 64.3% were asymptomatic. Radiographically, 25%, 50%, and 25% were Type I, Type II, and Type III, respectively. On final clinical follow-up, two patients were myelopathic (Types II & III) and two were radiculopathic (Types II & III). Axial symptoms were predominantly associated with Type I patients. Myelopathic patients developed initial cervical spine-related symptoms earlier (mean age, 10.6 years) than patients with predominant axial (mean age, 13.0 years) or radiculopathic symptoms (mean age, 18.6 years) ($p>0.05$). Patients with radiculopathy or myelopathy were diagnosed at a mean age of 17.9 years. Type I patients were predominantly females, whereas Type III patients were mainly males. Surgery entailed 10.7% of patients (2 Type II, 1 Type III).

Conclusions: 35.7% of patients were symptomatic, the majority of which were axial and associated with Type I patients. Radicular and myelopathic symptoms occurred in Types II & III patients. Type I patients had an earlier onset of axial symptoms. Myelopathic patients were diagnosed later in adolescence, but presented with initial cervical symptoms at an earlier age. Fusion patterns may be associated with sex-type.

Poster #13

Does The Direction Of Pedicle Screw Rotation Affect The Biomechanics Of Direct Transverse Plane Vertebral Derotation?

Stefan Parent, MD, PhD (Hopital St-Justine, Orthopaedics); Tim Odell; Michelle Wedemeyer; Andrew T. Mahar, MS; Peter O. Newton, MD

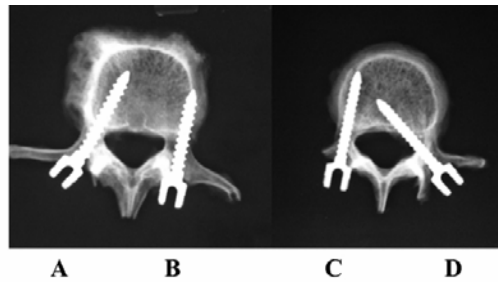
a - DePuy Spine
e – Depuy Spine

Introduction: Thoracic pedicle screws are thought to have better vertebral rotation control and segmental scoliosis correction compared to hook and wires. This study evaluated the biomechanical differences in transverse plane vertebral body derotation maneuvers of pedicle screws in medial and lateral directions.

Methods: Vertebral bodies (T4-L5) from twelve cadavers were instrumented with appropriate length pedicle screws while measuring insertion torque. Bodies were anchored for independent loading in medial or lateral directions. Screws were rotated around a rod using a constant length lever arm (30.5cm) fixed to the screw head simulating posterior vertebral derotation. Yield torque (Nm) was analyzed using a one-way ANOVA ($p < 0.05$).

Results: Yield torques for both directions were significantly related to screw insertion torque (both p

Discussion: While yield torque was not significantly different between medial and lateral directions, the failure modes provide interesting clinical information. Medial tests rotating the shank towards the spinal canal produced bone failure in half of the specimens while 2/3 of lateral tests resulted in lateral body fracture. From these data, a surgeon performing a direct vertebral derotation using a 30cm lever would need to apply roughly 40N (18lbs) to cause a failure. Adolescent patients would likely tolerate a greater force without failure due to greater bone density, yet, extreme caution is still recommended to prevent screw rotation into the spinal canal or laterally into the chest.



Poster #14

Degenerative Lumbar Scoliosis: Revision Rates After Decompression Alone or Decompression and Limited Fusion

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Background: Degenerative lumbar scoliosis treatment is tailored to the specific symptomatology of the patient. Surgical management consists of either decompression, correction, stabilization and fusion procedures or a combination of all these.

Objective: To compare the rates of revision surgery after decompression alone or decompression and limited fusion for treatment of radicular symptoms in patients with degenerative lumbar scoliosis.

Methods: 38 consecutive patients with degenerative scoliosis and radiculopathy treated surgically by one surgeon at one institution with minimum followup of 24 months were studied. Protocol for treatment included decompression for radiculopathy, and the addition of fusion for cases of instability. Instability was defined by degenerative spondylolisthesis and/or lateral listhesis of more than 3 mm.

Results: 21 patients (11 males, average age 70) in the group underwent decompression alone. The average curve pre and post-operatively were 16 and 18 respectively. The average followup was 31 months. Eight patients (38%) underwent revision surgery at an average of 29 months after index procedure. The main reason for surgery was revision decompression at the site of the original surgery.

17 patients (3 males, average age 71) in the group underwent decompression and limited fusion (9 spondylolisthesis, 8 lateral listhesis). The average curve pre and post-operatively were 21 and 19 degrees respectively. The average followup was 39 months. Six patients (36%) underwent revision surgery at an average of 32 months after index procedure. The main reason for surgery was decompression at stenotic site adjacent to index fusion site.

Conclusion: The rates of revision surgery after decompression alone or decompression and limited fusion for treatment of radicular symptoms in patients with degenerative lumbar scoliosis are similar. The reason for revision surgery in the former group is revision decompression and for the latter group is decompression of adjacent segment stenosis.

Poster #15

Influence of Previous Surgery on Outcome in IDE ProDisc-L Study

Jeffrey A. Goldstein, MD (NYU - Hospital for Joint Diseases); Alok Sharan

b - Synthes

Introduction: It has been reported previously that prior surgery negatively influences the success of subsequent surgeries at the same level.

Purpose: The objective of this study was to compare patients that had any previous surgical treatment at the operative level prior to being enrolled in the IDE study to patients with no previous surgery for both treatment arms.

Study Design: A multi-center prospective, randomized clinical trial was completed to assess the safety and efficacy of the ProDisc-L prosthesis (Synthes Spine, L.P.) compared to circumferential fusion at one level from L3-S1.

Patient Sample: There was a total of 286 patients in the IDE trial.

Outcome Measures: SF-36, VAS, Oswestry Disability Index (ODI), neurologic status, radiographic ROM.

Methods: All patients were assessed pre-operatively and post-operatively at 6 weeks, 3, 6, 12, 18, and 24 months. Patients all met the inclusion/exclusion criteria to be included in the ProDisc 1-level clinical study. Patients with any prior surgery were compared to no previous surgery. Prior surgeries were then divided into discectomy, IDET, laminectomy, laminotomy, or other. Patients may have been included in one or more subgroup.

Results: All demographical measurements were the same between the three comparison groups. Those that had prior surgery was not statistically different in the randomized portion of the trial (ProDisc-L-R: 35.4%; Fusion: 30.7%) but was statistically higher in the training cases (ProDisc-L-NR: 48%). VAS and ODI results at all time points show patients with no previous surgery and patients with previous surgery were statistically better than pre-op. Within treatment groups, no statistical differences could be found for any of the primary endpoints between those with and without prior surgery.

Conclusion: This study reports Class I data. At 2 years follow-up, it does not appear that prior surgery limited to those described above negatively effects the overall success of the patient.

Poster #16

Does Correction of Preoperative Coronal Imbalance Make a Difference In Outcomes of Adult Deformity Patients?

Michael D. Daubs, MD (Washington University School of Medicine); Lawrence G. Lenke, MD; Yongjung J. Kim; Gene Cheh, MD; Georgia Stobbs; Keith H. Bridwell, MD

Background: There are few studies evaluating the treatment or affect of coronal imbalance on adult deformity patient outcomes. Prior studies have suggested that the severity of coronal imbalance postoperatively was insignificant.

Purpose: To evaluate the clinical outcomes and radiographic results of deformity surgery on patients with greater than 4cm of coronal imbalance.

Methods: 36 patients, mean age 51 years(range 18-77) with at least 4cm of preoperative coronal imbalance who underwent a thoracic/lumbar fusion for deformity correction were evaluated with a mean follow-up of 49 months(range 24-124). Radiographs were measured pre-operatively, post-operatively, and at last follow-up. Outcomes were measured using the Oswestry Disability Index(ODI).

Results: The average pre-op coronal imbalance was 61mm(range 40-142), and corrected post-op to an average of 35mm(range 0-84)($p < 0.0001$) for an average correction of 43%. 89%(32/36) of patients had postoperative improvement of their coronal imbalance. Oswestry scores improved by a mean of 15 points, 45 to 30($p < 0.0001$). The patients were divided into three groups based on the coronal C7 plumb line measurements at last follow-up: 0-2cm($n=9$); 2-4cm($n=14$), and >4cm(13) of coronal imbalance. There were no significant differences in the 3 groups in regard to the severity of the pre-op coronal imbalance, or their pre-op and post-op ODI scores. All three groups had significant improvement in ODI scores($p < 0.05$).

Conclusion: There was significant improvement in clinical outcomes following surgical treatment of patients with > 4cm of coronal imbalance. There was no significant difference in outcomes based on the severity of the residual imbalance whether it was greater or less than 4cm. However, 89%(32/36) had significant postoperative improvement in their coronal imbalance($p < 0.001$). This data suggests that the absolute amount of residual postoperative coronal imbalance may not be as important a factor in patient outcomes as is the fact that there was significant postoperative improvement in their coronal balance.

Poster #17

The Associated Effects of Untreated Unilateral Hip Dislocation in Cerebral Palsy Scoliosis

Suken A. Shah, MD (Alfred I DuPont Hospital for Children); Hakan Senaran; Kirk W. Dabney, MD; Freeman Miller, MD

Introduction: The presence of a unilateral hip dislocation (UHD) in children with cerebral palsy (CP) may cause problems with sitting imbalance, pressure ulcers and hip pain. There is a dynamic interplay between hip dislocation, pelvic obliquity and scoliosis, but this is not well defined in the literature. The purpose of this study is to investigate the effect of UHD on pelvic obliquity and the rate of curve progression in children with CP.

Methods: Patients with spastic quadriplegic CP who had adequate spine radiographs were evaluated. Twenty-three children with spastic CP who had an untreated UHD and scoliosis constituted the study group. The control group consisted of 83 quadriplegic CP patients with scoliosis and well located hips. The rate of curve progression, incidence of pelvic obliquity and the rate of pelvic obliquity progression at follow up were compared between the two groups.

Results: The mean age of patients with a UHD and with located hips at initial radiograph were 10.4 and 10.5 years, respectively. The mean follow-up was 3.5 years. The mean rate of scoliosis curve progression in patients with a UHD was 12.9 degrees/year. In the control group, the mean progression was 12.2 degrees/year. The incidence of pelvic obliquity at follow up was 74% in scoliotic patients with a dislocation and 63% in scoliotic patients with normal hips. Using repeated-measures ANOVA, UHD was found to have no significant effect on scoliosis progression; however, progression of pelvic obliquity was significantly increased in the hip dislocation group ($p < 0.05$). Pelvic obliquity was corrected after posterior spinal fusion to the sacrum with pelvic fixation, without reducing the hip(s) at the same surgery.

Conclusion: Unilateral hip dislocation causes a significant increase in pelvic obliquity, but does not have an effect on the rate of scoliosis progression.

Poster #18

Scoliosis in Cerebral Palsy: Natural History and Risk Factors for Progression

Suken A. Shah, MD (Alfred I DuPont Hospital for Children); Hakan Senaran; Joseph Glutting, PhD; Kirk W. Dabney, MD; Freeman Miller, MD

Purposes: To define the natural history of scoliosis, risk factors for progression and the effect of the adolescent growth spurt on the progression of scoliosis in children with spastic quadriplegic CP.

Patients and Methods: A retrospective review of medical records and radiographs was performed of 135 CP patients who had a scoliotic curve of at least 25°, with adequate radiographs of the spine at initial presentation and minimum two year follow up. The effects of curve type, adolescent growth spurt, functional capacity of the patient and surgically treated previous hip subluxation on the rate of curve progression and pelvic obliquity were evaluated.

Results: The mean rate of curve progression was found to be 13.9 degrees/year. Scoliosis was diagnosed and treated at an earlier age in wheelchair bound patients compared to ambulatory patients. The rate of curve progression was greater in the most severely involved patients. Using an analysis of covariance, juvenile patients (<10 years old) had a significantly higher rate of curve progression than adolescent patients (>10 years old) ($p<0.05$). Previous hip subluxation, even if surgically treated, significantly increased the magnitude of pelvic obliquity. Curve type or gender had no effect on rate of curve progression. Lumbar curves were the most common.

Conclusions: The adolescent growth spurt has a significant worsening effect on the rate of curve progression, and most curves increased with growth, at an average of 13.9° per year. Patients with spastic quadriplegic CP who develop curves at less than 10 years of age and who are nonambulatory with previous or co-existing spastic hip disease should be monitored at frequent intervals and their caretakers counseled on the natural history of progressive scoliosis since they have the highest risk of curve progression.

Poster #19

Does osteoporosis contribute to clinical and radiographical outcomes of transforaminal lumbar interbody fusion for postmenopausal women with lumbar spinal disorders?

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Purpose: To evaluate the adverse effect of osteoporosis on clinical and radiographical outcomes of TLIF which was carried out in postmenopausal women with degenerative lumbar disorders.

Methods: Thirty-seven postmenopausal women who underwent one-level (L4-5) unilateral TLIF using two open box carbon cages (OCCs) were reviewed for a minimum 2-year follow-up. The patients were divided into following two groups according to BMD, which was measured by DEXA in the lumbar spine (L2-3): Osteoporotic group (Group-O: 18 patients, a mean age and BMD: 66.6 years, 0.686g/cm²); and non-osteoporotic group (Group-NO: 19 patients, 71.3 years, 0.946g/cm²). Radiographical assessment included percent of slippage (%slip), percent of anterior and posterior disc height (%ADH, %PDH), disc angle (DA), and fusion status. Clinical outcomes were evaluated by means of the scoring system of the Japanese Orthopedic Association (JOA score) for low back pain. Changes in these radiographic parameters and recovery rate of the JOA scores were compared between the two groups during follow-up period. Mann-Whitney U-test was used for statistical analysis.

Results: At the final follow-up, a mean correction loss of %slip, %ADH and DA in Group-O (2.1%, 20.5%, 2.4 degrees) was significantly greater than that in Group-NO (0.1%, 8.1%, and 0.5 degrees) ($p < 0.05$). Whereas, although the average correction loss of %PDH in Group-O (17.2%) was greater than that in Group-NO (7.0%), there was no significant difference. Radiographic fusion was successfully obtained in the both groups (94.7% in Group-O and 88.9% in Group-NO). There was no significant difference in the recovery rate of JOA score between Group-O (73.4%) and Group-NO (72.3%).

Conclusion: Osteoporosis significantly contributed to postoperative correction loss of the reconstructed spine by TLIF using OCCs in postmenopausal women. However, in one-level TLIF, osteoporosis did not exert the adverse effect on radiographic fusion and clinical outcomes.

Poster #20

Results of surgical experience using the VEPTR device for the treatment of Thoracic Insufficiency Syndrome. A multicenter study.

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Background: Between 1996 and 2003, 8 centers participated in the VEPTR IDE study. The VEPTR device was conceived for the treatment of thoracic insufficiency syndrome secondary to flail chest, hypoplastic thorax, congenital scoliosis with fused ribs, and progressive scoliosis. The purpose of this study is to review the initial surgical experience with implantation of the VEPTR device.

Methods: We conducted an IRB approved retrospective review of 214 patients enrolled in the VEPTR IDE multicenter study. Intraoperative parameters including operative time, estimated blood loss, length of hospitalization, perioperative complications were calculated for index surgeries, expansion surgeries, and replacement surgeries.

Results: There were 1265 total surgical procedures, (Initial implantation 214; Expansion 785; Replacement 141; Removal 16; Other 109). The mean operative times were initial implantation: 213 minutes; expansion of the device: 61 minutes; replacement of the device: 111 minutes; and other surgeries: 134 minutes. Estimated blood loss for index procedure averaged 82 cc; expansion 10 cc; replacement 37 cc; and other 61 cc. There were 10 intraoperative adverse events in 9 patients associated with the index procedure, including accidental injury (3), hypotension (1), cardiovascular disease (1), anemia (3), hypokinesia (1), transient spinal cord injury (1). There were 8 adverse events associated with expansion surgeries and 20 associated with replacement surgery. The average length of hospital stay for the index surgery was 14 days for the initial implantation (range 2-266 days).

Conclusions: Thoracic Insufficiency Syndrome develops in a small number of children with severe, complex deformities of the chest wall and spine. The use of expansion Thoracoplasty with chest wall expansion stabilized using the VEPTR device offers the only current treatment for TIS that addresses both the spine and chest wall deformity. This study demonstrates that the initial implantation of the VEPTR device is safe and associated with relatively low morbidity in this challenging population of patients.

Poster #21

Revision Surgery After Primary Spine Fusion For Idiopathic Scoliosis: Results From A Different Institution

Scott J. Luhmann, MD (Washington University School of Medicine); Lawrence G. Lenke, MD; Keith H. Bridwell, MD

Purpose: At the 2005 SRS annual meeting, re-operations after index spine fusion for idiopathic scoliosis were reported in 13.8% of patients at a single institution (n=1050). The purpose of this study was to review the overall prevalence of, and indications for, re-operations at our center with similar number of primary procedures performed over a similar period

Methods: A spinal deformity database search at our center identified all primary anterior (ASF), posterior (PSF) and circumferential (APSF) spinal fusions performed for idiopathic scoliosis (1985-2003). 1064 patients were identified (8-22 years) with minimum 2 year follow-up after index surgery. Study cohort consisted patients who underwent re-operation for any reason after index fusion procedure.

Results: Of the 1064 spinal fusions for idiopathic scoliosis, 41 (3.9%) underwent re-operation. Mean age at index procedure was 14.0 years (10-18). Primary surgeries were: 11 ASF, 25 PSF, and 5 APSF. Mean follow-up was 5.7 years (2 to 10.8). 47 additional procedures were performed at an average of 26 months after index procedure (1 week to 73 months). Of the 47 re-operations, 20 (43%) were revision spinal fusions (for pseudarthroses, curve progression or junctional kyphosis), 16 (34%) because of infections (5 acute, 11 chronic), 7 (15%) for implant removals due to pain a/o prominence (4 complete, 3 partial), 2 (4%) were revision of loosened implants, and 2 (4%) were elective thoracoplasties.

Conclusions: This study documented a 3.9% overall re-operation rate at our medical center, a three-fold lower re-operation rate than the previously reported 13.8%. The most common re-operations were for infections (34%), pseudarthroses (26%), and postoperative curve progression of the adjacent unfused spine (17%).

Significance: Multiple patient, surgeon, and institutional factors are likely to account for marked differences in the re-operation rates after primary spinal fusion for idiopathic scoliosis at various medical centers (3.9% vs. 13.8%).

Poster #22

Multicenter Outcome and Cost Analysis of Circumferential vs. Posterior-only Fusions with Thoracic Pedicle Screw Constructs for Main Thoracic Idiopathic Curves between 70-100 Degrees

Scott J. Luhmann, MD (Washington University School of Medicine); Lawrence G. Lenke, MD

Purpose: The purpose of this study on a multicenter study group database was to assess the early outcome and treatment costs between circumferential spine fusion (APSF) and posterior fusion-only with thoracic pedicle screws (PSF-TPS) of main thoracic adolescent idiopathic scoliosis (AIS) curves between 70 and 100 degrees.

Methods: A database query identified 35 patients. Patient demographics, preoperative and postoperative curve measures, surgical data (surgical procedure, length of anesthesia, time in operating room, and spinal implants), and length of hospitalization was tabulated and analyzed for both groups. A previously reported cost/charge analysis model was applied to this data.

Results: Of the 35 patients identified in the SDSG database, 12 underwent APSF and 23 PSF-TPS. Mean age was 13.4 years (10 to 17 years). Preoperative thoracic curve size (APSF, 84.2; PSF-TPS, 78.6 degrees), flexibility (APSF, 36.5; PSF-TPS, 38.9 degrees), final curve correction % (APSF, 72.7%; PSF-TPS, 77.6%) and final curve measurements (APSF, 21.1; PSF-TPS, 17.0 degrees) were similar between the two groups ($p > 0.05$). Cost/charges analysis demonstrated APSF had higher surgeon procedural charges (\$21,867 vs. \$14,470), anesthesiologist charges (\$4327 vs. \$2967), and operating room charges (\$27,466 vs. \$17,826) ($p < 0.05$).

Conclusions: This multi-center, multi-surgeon study demonstrates PSF-TPS constructs to have equivalent curve correction (PSF-TPS, 77.6% vs. APSF, 72.7%) with lower overall treatment costs when compared to circumferential fusion. Anterior release for large, main thoracic curves between 70 and 100 degrees does not appear necessary with adequate spinal fixation with TPS constructs.

Significance: Concern about the costs of TPS constructs does not appear valid when a circumferential approach is avoided for thoracic AIS curves between 70 and 100 degrees.

Poster #23

The Impact of Curve Characteristics and Spine Fusion on Pulmonary Function in Adolescent Idiopathic Scoliosis

Scott J. Luhmann, MD (Washington University School of Medicine); Yongjung J. Kim, MD; Lawrence G. Lenke, MD; Keith H. Bridwell, MD

Purpose: The purpose of this study was to analyze the impact of main thoracic Lenke type 1-4 curve characteristics and their surgical correction on PFT values.

Methods: Our spinal deformity surgical database was queried to identify all patients with Lenke type 1-4 AIS who underwent posterior spinal fusion (PSF) between 1985 and 2003 (minimum 2-year f/u). Demographic, and preoperative and 2-year postoperative radiographs and PFTs were analyzed. 139 patients (113 females) were included in the analysis.

Results: Mean age at surgery was 14.7 years (10.8-21.6). Mean preoperative coronal Cobb was 60 degrees (40-91); sagittal T5-12, 21 degrees (-10 to 61). Mean preoperative %-predicted FVC was 78.8% (40.8-145) and FEV1 was 74.5% (36.8-131). Mean number of levels fused was 11.3 (7-15) with a mean postoperative coronal Cobb of 19.7 degrees (3-48) and sagittal T5-12 of 25.8 degrees (2-63). Overall % change in coronal Cobb was 57% and sagittal T5-12 was -10.4%. Preoperatively, coronal Cobb and curve flexibility had significant correlations with %-predicted preoperative FVC and FEV1 values ($p < 0.04$). Length of fusion and final postoperative sagittal T5-12 Cobb were significantly associated with postoperative %-predicted PFTs ($p < 0.03$). Postoperative %-predicted FEV1 and FVC values progressively declined with more proximal upper instrumented vertebral (UIV) levels (T5: 82.8%, 85.3%; T4: 76.6%, 84.9%; T3: 74.8%, 77.3%; T2: 72.8%, 75.1%, respectively).

Conclusion: In Lenke type 1-4 main thoracic curves, preoperative curve magnitude and flexibility and postoperative fusion length, UIV and sagittal Cobb all were significantly associated with PFTs. In main thoracic scoliosis curves the overall spinal flexibility or thoracic motion, or the lack thereof due to curve stiffness or fusion, appeared to influence PFTs in this series.

Significance: Pulmonary function is optimized in main thoracic scoliosis posterior spinal fusions by minimizing the proximal extent of the instrumented fusion and maintaining thoracic kyphosis to maintain chest mechanics.

Poster #24

An Evaluation of the Utility and Cost-Effectiveness of Kyphoplasty for the Treatment of Vertebral Fractures

Gary Fleischer, MD (University of California-San Francisco); Erin Boyd; Steven Garfin; Sigurd H. Berven, MD

Purpose: This study aims to define the cost-effectiveness of kyphoplasty for lumbar and thoracic vertebral fractures by comparing average cost to improvement in health status as measured by Quality Adjusted Life Years (QALYs).

Methods: 100 patients with 1-3 vertebral fractures treated with kyphoplasty completed SF-36 questionnaires pre-operatively and 2 years post-operatively. Changes in SF-36 sub-domains from pre-operative evaluation to 2 year follow-up were compared with age and sex-matched controls. Data were converted to Quality Adjusted Life Years (QALYs) using the Brazier method (Sheffield, UK). Cost data for kyphoplasty were utilized to compute the average cost/QALY for inpatient and outpatient kyphoplasty.

Results: 80% of patients had 1 level kyphoplasty, with 16% and 4% undergoing 2 and 3 level kyphoplasty respectively. Significant increases in SF-36 scores were observed after kyphoplasty in physical function, role physical, bodily pain, vitality, social function, emotional health, and mental health. Average change in health-related quality of life was .16 per year (range -.146 to .423), yielding an average gain of .32 QALYs for patients at 2 year follow-up. Cost/QALY was \$11,856 for outpatient kyphoplasty and \$23,292 for inpatient. No cost difference was observed for thoracic versus lumbar fractures.

Conclusions: Kyphoplasty effectively improves pain and function for patients 2 years post-operatively and is cost-effective even if health benefits only extend 2 years. Of note, the cost/QALY of outpatient kyphoplasty is only slightly greater than that of total hip arthroplasty, a well-established cost-effective procedure, estimated to be \$10,000/QALY, and it is much more cost-effective than CABG, estimated at more than \$100,000/QALY by several analyses. The cost/QALY decreases proportionally every year that improvement in health extends beyond 2 years. Therefore, these data represent the upper limit of cost/QALY. For each year that kyphoplasty benefits the patients' health beyond 2 years, the cost/QALY continues to decrease, continuing to improve cost-effectiveness.

Poster #25

A Retrospective Cohort Study of Pulmonary Function, Radiographic Measures and Quality of Life in Children with Congenital Scoliosis: An Evaluation of Patient Outcomes after Traditional Spine Surgery

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a - Synthes Spine

Purpose: The purpose of this study is to evaluate pulmonary function and quality of life (QOL) of children who were treated with growing rods and/or fusion for progressive congenital scoliosis and to compare them to those of healthy children. The relationships between radiographic measures, pulmonary function, and QOL in children with progressive congenital scoliosis will also be examined.

Methods: Twenty three patients (average 14 ± 5 years) with a primary diagnosis of congenital scoliosis who were treated with growing rod/fusion and subsequent fusion were evaluated using radiographs, pulmonary function testing and QOL surveys using Child Health Questionnaire Parent Form (CHQ). They were, on average, 6.5 years post definitive fusion. Average age at initial surgery was 6 years and average age at definitive fusion was 7 years.

Results: Forced vital capacity (FVC)($p < 0.0001$), forced expiratory volume in one second (FEV1) ($p < 0.0001$), total lung capacity ($p = 0.002$), and vital capacity ($p < 0.0001$) were significantly lower than those in healthy children. The average percent predicted FVC and FEV1 were 68.3% and 67.6% respectively. CHQ scores in our study patients were significantly lower than healthy children in physical function ($p = 0.001$), general health ($p = 0.001$), and physical summary ($p < 0.001$) and significantly higher in bodily pain ($p < 0.001$) and impact on parent time ($p = 0.036$).

Discussion: Compared with healthy peers, patients with congenital scoliosis treated with a growing rod technique and/or subsequent fusion have significantly worse pulmonary function and quality of life scores when assessed at an average of 7.5 years following initial surgery. Current efforts are underway to ascertain the relative effects of spinal deformity, characteristics of the growing rod technique and time of definitive fusion on QOL and pulmonary function in this population.

Poster #26

Temporary Internal (Dis)Traction as an Aid to Correction Of Severe Scoliosis

Paul D. Sponseller, MD (Johns Hopkins); Jacob Buchowski; David L. Skaggs, MD; Rishi Bhatnagar, MD

Purpose: Traction is a recognized adjunct to correction of severe scoliosis. This report describes situations in which traction may be contra-indicated. An internal alternative method of staged correction was developed.

Methods: Ten patients from two institutions with severe spinal curvature greater than 90 degrees were considered candidates for traction prior to their definitive correction. One patient had diastrophic dysplasia, four had cerebral palsy, one had myelomeningocele with Chiari, one had syndromic scoliosis and three had severe idiopathic scoliosis. Three had absolute contra-indications to halo traction: fixed cervical kyphosis, cervical instability or deformity. Five had relative contra-indications: distal deformity, movement disorders or hip flexion contractures. Mean curve size preoperatively was 105 degrees.

These patients underwent an initial posterior release of the rigid portion of the spine (five also anterior) and placement of a longitudinal internal distraction rod. Initial distraction intra-operatively was followed in seven cases by 1-2 additional interval distractions. Finally, posterior spinal fusion with definitive dual-rod fixation was performed. Minimum 2 year follow-up of all patients.

Results: Internal distraction produced improvement at each distraction. This facilitated safe, gradual soft tissues and skeletal deformity. Mean initial correction was 52%, at insertion of first distraction rod. This compares favorably with 30-41% reported in the literature after halo traction. Mean time between initial and final procedure was 3 weeks. Mean final curve correction was 76%. There were no neurologic deficits or infections.

Conclusions: Temporary internal (dis)traction is an alternative to halo-based traction. It may be preferred for patients who have contra-indications to halo traction such as cervical deformity or instability, or connective tissue laxity. It is also more effective for curves in the caudal end of the spine. It eliminates long hospital stays and enhances longer staging between procedures. It may be beneficial for some curve types considered for halo traction.

Poster #27

Coronal Cobb Correction with the VEPTR Device in Patients with Scoliosis and Chest Wall Abnormalities

James T. Guille, MD (Shriners Hospital for Children); Linda P. D'Andrea, MD; Randal R. Betz, MD; John T. Smith, MD; Robert M. Campbell, Jr., MD

Purpose: To evaluate the correction in coronal Cobb magnitude obtained with the VEPTR device in patients with scoliosis and chest wall abnormalities.

Methods: A query was done of a database containing information on 214 patients who had been treated with the VEPTR device for scoliosis and chest wall abnormalities. Eight patients had a flail chest, 75 rib fusion, 87 hypoplastic thorax, and 44 progressive scoliosis and constricted chest wall. The VEPTR had been used in all patients to treat thoracic insufficiency syndrome; the added benefit of scoliosis correction was secondary. The average age at the time of surgery was 6 years, and the average age at follow-up was 9 years. All patients had at least 2 years of follow-up.

Summary: The mean coronal Cobb magnitude prior to surgery was 51 degrees. Postoperatively, it had been decreased to a mean of 37 degrees. At a mean follow-up of 3.5 years, the mean Cobb angle was 39 degrees. This represented a mean change from the preoperative value of -11 degrees. The percent correction observed at follow-up was 36% in the flail chest group, 21% in the rib fusion group, 8% in the hypoplastic thorax group, and 28 % in the progressive scoliosis group. In every patient, the correction obtained at the time of initial surgery was maintained at last follow-up.

Significance: The VEPTR device is able to improve coronal Cobb measurements at the time of initial insertion. This correction was maintained in all four groups at the time of last follow-up. These data are important, as the use of the VEPTR as a growing spine device increases. The overall mean improvements in coronal Cobb magnitude do not appear to be as great as has been reported in the literature for growing rods. To confirm this finding, a prospective study will need to be done.

Poster #28

Loss of Lumbar Lordosis After Fusion and Instrumentation Using 5.5 Millimeter Rod Implants

Jerome L. Kolavo, MD (OAD Orthopaedics); Susan Reed

Twenty two cases were retrospectively reviewed after decompression and fusion was performed for spinal stenosis with degenerative spondylolisthesis and/or degenerative disc disease, with a minimum of 2 levels fused and a minimum follow up of 24 months (range 24-33 months). Average age at surgery was 63.6 years (range 45-85 years). all cases underwent posterior lateral fusion only with a multi-axial pedicle screw and 5.5 millimeter titanium rod system. Fused levels ranged from 2 to 6 (average 2.7). No cases were treated with interbody support. All patients were braced for at least 3 months with a rigid orthosis. There was no loss of fixation noted in any cases. Pre-operative standing x-rays were measured for total lordosis and surgical segment lordosis. Intra-operative films were measured for surgical segment lordosis after instrumentation was placed. Initial post-operative standing films were measured for surgical segment lordosis and total lordosis as were 2 year post-operative films. Loss of surgically established lordosis was seen at the first follow up averaging 6.3 degrees (range 0-19 degrees) as measured over fused levels. An additional 1.5 degree average loss was seen over the next 2 years (range 0-8 degrees). Loss of total lordosis was seen at the first post-operative visit when compared to pre-operative films in 14 cases averaging 8 degrees (maximum 20 degrees) with further loss of lordosis seen at 2 year follow up in 10 cases (maximum 18 degree loss). Loss of instrumented segment lordosis was compensated for by hyperlordosis at proximal adjacent segments in 6 cases with advanced collapse of adjacent discs in 2 others. No pseudoarthroses have been identified to date. Two patients are awaiting revision surgery. These implants appear to inadequately control lumbar lordosis without anterior column support.

Poster #29

Spinal Balance in Lenke 1A-C Curves

B. Stephens Richards, III, MD (Texas Scottish Rite Hospital); Daniel J. Sucato, MD, MS; Charles E. Johnston, II, MD; Lawrence G. Lenke, MD; Timothy R. Kuklo, MD, JD; David W. Polly, Jr., MD; James O. Sanders, MD

Purpose: To assess spinal balance before and after thoracic fusion in Lenke 1A-C idiopathic curves.

Methods: Using a multicenter database, preoperative and postoperative digital radiographic trunk balance measurements were compared in patients with Lenke 1A, 1B, and 1C curves. The percentage of patients whose imbalance (deviation away from the midline) exceeded magnitudes of 1 cm and 2 cm were recorded. Comparisons were made between the three subgroups.

Results: Preoperative: 88% of 137 patients with Lenke 1A curves had thoracic trunk shift >1 cm, compared to 88% of 32 patients with 1B curves, and 44% of 64 patients with 1C curves. The difference between 1A/1B curves and 1C curves was significant (p2 cm, compared to 31% for Lenke 1B curves, and 14% for Lenke 1C curves. All three groups were significantly different (p<.05).

Postoperative: 32% of 124 patients with Lenke 1A curves had thoracic trunk shift >1 cm, compared to 53% of 32 patients with 1B curves, and 62% of 58 patients with 1C curves. The difference between 1A and 1B was significant (p=.03), as was the difference between 1A and 1C (p1 cm was significantly lower than 1C (p2 cm, compared 16% for Lenke 1B curves, and 31% for Lenke 1C curves. The difference between group 1A and 1C was significant (p<.001).

Conclusions: Patients with Lenke 1A curves improve significantly in their trunk balance following surgery when compared to those with Lenke 1B and 1C curves. Patients with Lenke 1C curves have a compensatory flexible lumbar component which allows for better trunk balance preoperatively but leads to a greater measurable decompensation postoperatively.

Poster #30

Minimum 10 Year Radiographic Results after Selective Thoracic Fusion for AIS Patients with Lenke Type 1C Curves

Peter Metz-Stavenhagen, MD (Werner-Wicker Klinik); Luis Ferraris, MD; Stefan Krebs, MD; Axel Hempfing, MD

Introduction: Selective anterior thoracic fusion can be performed in adolescent idiopathic scoliosis (AIS) even with a widely deviated compensatory lumbar curve. Nevertheless, long-term outcome and whether treatment is better with fusion of both curves remains unclear.

Material and Methods: 15 patients with Lenke type 1C were operated between 1991 and 1994 (mean age 15.4 y, all patients had preop traction films). Radiographs were retrospectively evaluated with a minimum follow up of 10 years.

Results: Mean preop thoracic curve 57.1 ± 12.9 , lumbar curve 41.5 ± 8.8 . Mean thoracic curve at latest follow up 26.2 ± 12.1 , lumbar curve 22.1 ± 8.0 (mean of 55 % thoracic and 46 % spontaneous lumbar correction). No reoperations, no distal extension of the fusion.

Conclusion: Good radiographic results in type 1C curves can be achieved with a selective anterior thoracic fusion over a long-term period. Traction films help to carefully select the appropriate patients.

Poster #31

Avoiding Screw Fixation Failure during Osteotomy Closure with the use of a Central Hook/Rod Construct

Lawrence G. Lenke, MD (Washington University School of Medicine); Kota Watanabe; Michael D. Daubs, MD; Keith H. Bridwell, MD; Georgia Stobbs; Marsha Hensley, MD

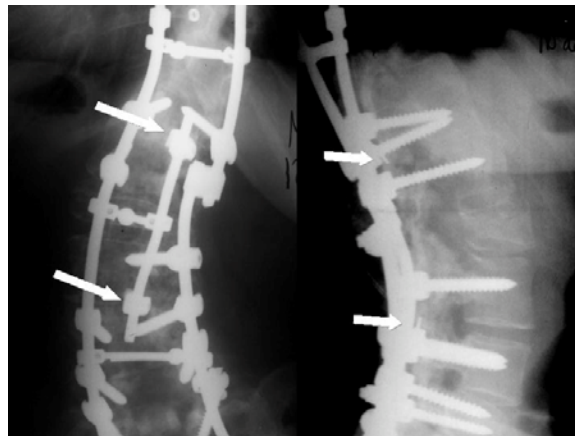
Medtronic Sofamor Danek

Purpose: There are various techniques used to close an osteotomy site, most of which involve patient positioning, rod cantilevering, or compression through points of pedicle fixation. All of these techniques place added stress on the spinal fixation points and may lead to loosening and eventual fixation failure. The purpose was to evaluate the effectiveness of a central hook/rod construct utilized as a closing device following spinal osteotomy(ies).

Methods: 31 consecutive patients in whom fixed sagittal imbalance (FSI) was treated with a lumbar pedicle subtraction osteotomy (PSO) or multilevel Smith-Petersen Osteotomies (SPO) utilizing a central compression hook/rod construct for osteotomy closure were analyzed. Compression hooks were inserted into the fusion mass above and below the osteotomy and centrally attached to a short rod. Compression forces were applied to securely close the osteotomy site. The mean age was 49.2 years (range 27-76). Diagnoses included: two ankylosing spondylitis, 25 scolioses, and four degenerative spondylolistheses of which all but two cases were revisions. 22 patients had a PSO, and nine multilevel SPOs. A radiographic and clinical analysis was performed to evaluate the efficacy and possible complications of this technique. (See Figure)

Results: Overall, lumbar lordosis increased an average of 31.0° (range 11-68°) and local lordosis through the osteotomy site increased by an average of was 26.3 (range 11-47°). The C7 sagittal plumbline improved with an average of 8.6cm (range 3-237cm). There were no failures of the hook/rod construct and no neurological complications due to this method for osteotomy closure.

Conclusions: A central hook/rod construct is a safe, quick, controlled, and effective method for spinal osteotomy site closure. It adds strength to the overall construct and avoids the placement of undue stress across the main points of pedicle fixation that can lead to screw loosening and ultimately to fixation failure.



Poster #32

Cross-Cultural Comparison of the SRS Outcomes Instrument between American and Japanese Scoliosis Patients: Are there Differences?

Kei Watanabe, MD (Niigata University); Lawrence G. Lenke, MD; Keith H. Bridwell, MD; Kazuhiro Hasegawa, MD; Toru Hirano; Naoto Endo; Gene Cheh, MD; Yongjung J. Kim, MD; Georgia Stobbs; Marsha Hensley, MD

Purpose: To report a preliminary evaluation of the SRS-24 Outcomes Instrument and determine whether any differences of baseline scores exist between American and Japanese patients with idiopathic scoliosis. The SRS-24 was primarily introduced for the Western population so the baseline scores of the SRS-24 in the non-Western population might differ from that of the Western population.

Methods: We analyzed two comparable groups of 100 preoperative idiopathic scoliosis patients, which were separated into American (Group A) and Japanese (Group J) populations prior to spinal fusion. There were no statistically significant differences between the groups for: gender (A: 9 male, 91 female vs. J: 13 male, 87 female), age (A: 15.0 ± 2.4 vs. J: 14.9 ± 3.8), main curve location, main curve Cobb angle, and thoracic kyphosis ($p > 0.05$ for all comparisons). The patients were evaluated using the first section (15 questions) of the SRS-24, which was divided into four domains: total pain, general self-image, general function, and activity. Statistical comparison was performed using the Mann Whitney U test.

Results: See Table) Group A had significantly lower scores in pain ($p < 0.0001$, A: 3.7 ± 0.8 vs. J: 4.3 ± 0.4), function ($p < 0.01$, A: 3.9 ± 0.6 vs. J: 4.2 ± 0.5) and activity ($p < 0.0001$, A: 4.5 ± 0.8 vs. J: 4.9 ± 0.3) domains compared to Group J. Group J had significantly lower scores in the self-image ($p < 0.0001$, A: 4.0 ± 0.7 vs. J: 3.5 ± 0.5) domain. With regard to individual questions, there were significant differences in the scores for all questions except for question five and 13 between the two groups.

Conclusion: There were significant differences in all four domains between American and Japanese scoliosis patients. Japanese patients had less pain, a more negative self-image with higher general function and daily activity. It is highly probable that different culturally related perceptions of the patient affect the SRS-24 scores so a cross-cultural comparison of the SRS-instrument is necessary.

(Poster #33 Attachment)

Comparison of the SRS-24 Individual Domain and Question

(n=100)	Domain and Question		American (n=100)	Japanese
	p-value		Mean Score (S.D.)	Mean
		Total Pain Domain	3.7 (±0.8)	4.3
(±0.4)	p<0.0001*			
		General Self-Image Domain	4.0 (±0.7)	3.5
(±0.5)	p<0.0001*			
		General Function Domain	3.9 (±0.6)	4.2
(±0.5)	p<0.005*			
		Activity Domain	4.5 (±0.8)	
4.9 (±0.3)	p<0.0001*			
1.		The degree of pain you experience regularly.	3.8 (±1.3)	4.6
(±0.7)	p<0.0001*			
2.		The most severe degree of pain over the last month.	3.6 (±1.4)	4.5
(±0.9)	p<0.0001*			
3.		How would you feel about spending the rest of your life?	2.2 (±1.2)	2.5
(±0.8)	p<0.005*			
4.		What is your current level of leisurely activity?	4.5 (±0.7)	4.9
(±0.5)	p<0.0005*			
5.		How do you look in clothes?	3.6 (±1.0)	3.5
(±1.2)	p=0.4842			
6.		Do you experience back pain at rest?	3.6 (±1.3)	4.6
(±0.7)	p<0.0001*			
7.		What is your current level of work/school activity?	4.5 (±0.9)	
4.8 (±0.5)	p<0.001*			
8.		What medications are you currently taking for your back?	4.7 (±0.5)	4.99
(±0.1)	p<0.001*			
9.		Does your back limit your ability around the house?	4.3 (±1.3)	4.9
(±0.4)	p<0.0001*			
10.		Have you taken any sick time from work/school?	4.5 (±1.1)	4.9
(±0.4)	p<0.0001*			
11.		Does your condition negatively affect your personal relationships?	4.5 (±1.1)	4.8
(±1.0)	p<0.01*			
12.		Are you or your family experiencing financial difficulties?	4.7 (±0.7)	4.8
(±0.7)	p<0.05*			
13.		Do you get out more or less than your friends?	2.8 (±0.9)	3.0
(±1.0)	p=0.0657			
14.		Do you feel attractive?	3.6 (±1.0)	
2.7 (±0.9)	p<0.0001*			
15.		How would you rate your self-image?	3.7 (±1.2)	2.9
(±0.8)	p<0.0001*			

*statistical difference (p<0.05)

Poster #33

How Accurately do Inexperienced Surgeons Place Thoracic Pedicle Screws with the Free Hand Technique?

Richard M. Schwend, MD (Carrie Tingley Hospital); Ryan Bergeson; Selina Silva; Tracy Delucia

Purpose: To evaluate with real time direct observation what are the common errors made and whether these errors are recognized while they are occurring when inexperienced surgeons learn to place thoracic pedicle screws.

Methods: Three orthopaedic resident surgeons inexperienced in the straight ahead freehand technique received an introductory teaching session and utilized published visual charts (Lenke 2004). Six adult spines were used to harvest intact vertebral body specimens with rib heads removed. Each vertebral body was mounted on a clear plexiglass frame with only the posterior surface anatomy visible to the surgeon. The resident surgeon verbalized all perceived anatomical violations. An observer recorded in real time the accuracy of gearshift probe, flexible probe, tap and screw placement. A critically perforated screw was defined as greater than 2.0 mm outside the confines of the pedicle wall.

Results: 137 pedicles in 68 intact vertebral body specimens were instrumented with either a 4.2 or 5.2 mm screw selected based on the perceived pedicle diameter. 61/137 (45%) screws were not fully within the pedicle, most commonly due to a narrow pedicle diameter and were typically a noncritical perforation (48/61 (77%) vs 14/61 (23%) critical perforation). There were 13/61 (22%) perforations that were not perceived by the surgeon to be outside the pedicle. A total of 4/137 (3%) screws were felt to be placed safely but were critically perforated medially (average 3.8mm). Several screws were simultaneously outside pedicle wall both medial and lateral.

Conclusion: Inexperienced surgeons utilizing anatomic straight ahead insertion of thoracic pedicle screws generally were able to have perforations less than 2mm. Screws most commonly were perforated due to narrow pedicle diameter, not poor starting point or technique. Most perforations were recognized immediately by the operator during probing and did not lead to major screw misdirection.

*** The FDA has not cleared a drug and/or medical device described in this presentation (i.e., the drug or medical device is being discussed in an (off-label use.) For full information refer to page 5.*

Poster #34

CT Vacuum Disk Sign: A Highly Specific Predictor of Lumbar Nonunion

Charles C. Edwards II, MD; Spiro B. Antoniadis, MD; Lisa Ford; Eric Crabster

Summary: 61 patients with a prior lumbar fusion were evaluated with a CT scan prior to undergoing surgical fusion exploration. Of the 17 previously fused levels with a vacuum disk sign on preoperative CT, all 17 were subsequently found to have a surgical nonunion (100 % specificity).

Purpose: To determine the validity of the vacuum disk sign on CT scan as an indicator of lumbar nonunion.

Methods: 61 patients at a single institution with prior lumbar fusion underwent CT imaging. A single spine surgeon assessed the presence or absence of a vacuum disk sign at previously fused levels in a blinded fashion. The presence of a vacuum disk sign on CT images was compared to the presence of surgically confirmed union status (n=143 levels).

Results: 61 patients (mean age: 58.0 years) had a CT scan of the lumbar spine an average of 4.7 years after their index lumbar spine fusion procedure. Of the previously 'fused' levels, vacuum disk signs were detected at 17 levels in 15 patients. When present, the vacuum disk sign was consistently visualized in each imaging plane (axial, sagittal, coronal). Of the 17 levels with vacuum disk signs, 14 had prior posterior only fusion, and 3 circumferential fusion. Surgical exploration confirmed the presence of a nonunion at 51 of 143 levels in 33 patients. A vacuum disk sign was present at 17 of 51 surgically confirmed nonunion levels (specificity: 100%, sensitivity: 33.3%, positive predictive value: 100%).

Conclusion: A vacuum disk sign on CT, when present, is an extremely strong predictor for the presence of a lumbar nonunion.

Poster #35

** Louis A. Goldstein Award Nominee

Degenerative Spondylolisthesis of the Cervical Spine. A Long Term Follow-up Study

Clayton L. Dean, MD (University Hospitals of Cleveland); Jose Gabriel, MD; Michael Bolesta, MD; Ezequiel Cassinelli, MD; Henry Bohlman, MD

Introduction: Degenerative spondylolisthesis has been well described as a disorder of the lumbar spine. Few authors have suggested that a similar disorder occurs in the cervical spine. The purpose of the current study was to establish degenerative spondylolisthesis of the cervical spine as a distinct entity, and to report on a series of patients with long-term follow-up.

Methods: We reviewed the records of fifty-eight patients treated for degenerative cervical spondylolisthesis from 1974 to 2001. Fifty patients were followed for at least two years. Forty-five required operative treatment, while five were managed nonoperatively. The average follow-up was six years (range, two to twenty-four years). Thirty-eight patients presented with neck or occipital pain, eighteen with radiculopathy, and twenty were myelopathic. Patients presenting with myelopathy were classified according to the Nurick grading system. Seventy-one cervical levels demonstrated spondylolisthesis, with the mean degree being 4.03 mm (range, 2.0 to 7.0 mm). The most frequent level of involvement was between the fourth and fifth cervical vertebrae. In all cases there was radiographic evidence of facet degeneration, including joint erosion, remodeling and subluxation.

Results: Forty-two of forty-five patients achieved osseous fusion. All thirty-eight patients with neck pain reported improvement. At final follow-up, no patient had worsened neurologically. All twenty patients with myelopathy demonstrated improvement, with an average recovery of 1.5 Nurick grades. There was one reoperation for increased symptomatic spondylolisthesis at the cervicothoracic junction below a three-level fusion. Two additional patients required a second anterior procedure for symptomatic nonunion.

Conclusions: Degenerative spondylolisthesis of the cervical spine is a distinct entity. Neck pain, radiculopathy, and myelopathy are common presentations. Patients with mild symptoms can be successfully managed with conservative measures. In patients with more severe symptoms and/or evidence of neurological compression, anterior or posterior cervical decompression and arthrodesis appear to be effective ways to achieve neurological improvement and spinal stabilization.