Session 11 | Neuromuscular & Miscellaneous Abstracts

Papers are listed in presentation order

Paper #164. Hemivertebra Resection in Children Below 3-Years-Of-Age: Safety Profile, Clinical and Radiographic Outcomes

Bing Wui Ng, MD; Altug Yucekul, MD; Nuri Demirci; Yilmaz Kilic, MD; Feyzi Kilic, MD; Aynur Kaval; Elif Gizem Carus, MS; Tais Zulemyan, MSc; Caglar Yilgor, MD; *Ahmet Alanay, MD*

Hypothesis
Hemivertebra resection before age 3 is safe and efficient

Design
Retrospective chart review

Introduction
Controversy exists regarding the most suitable age for hemivertebrae resection. Yet, the consensus would be to treat this congenital defect before compensatory scoliosis sets in, which ultimately results in a fixed deformity. Main concerns with early surgery include the unknown neurotoxic effects of anesthetics on the developing brain, difficulties in neuromonitoring, small sized fragile pedicles, less secure fixation and extensive bleeding. This study evaluates the safety, clinical and radiological outcomes of patients with hemivertebra operated on before age 3 with a minimum 2-years of follow-up.

Methods
Demographic and radiographic data were retrospectively analyzed. Coronal and sagittal curve magnitudes and balance were measured. Correction rates, complications, intraoperative blood loss, duration of surgery and length of hospital stay were collected. Descriptive analyses were performed. Surgical technique included type-3 hemivertebra resection, use of navigation for pedicle screws and multi-rod (3-4) constructs performed by a specialized pediatric neuro-ortho surgical team.

Results
14 patients who had undergone 18 hemivertebrectomies with minimum 2-years follow-up were included. Mean age at surgery was 29 (11-35) months. Mean follow-up was 64.6 (24-121) months. Mean preoperative segmental Cobb angle of the hemivertebra and C7PL-CSVL distance was 31.2°±7.4° and 11.4mm±8.9mm, respectively. Mean postoperative segmental Cobb angle was 4.0°±3.3°. Mean segmental Cobb angle at the latest follow-up was 5.1°±6.1°, resulting in an average correction rate of 85.1%±15.2%. Mean C7PL-CSVL at the latest follow-up was 16.4mm±12.8mm. Median intraoperative estimated blood loss was 175 (75-600) and operative time was 250 (180-480) mins per hemivertebra; and length of hospital stay was 4 (3-6) days. There was one patient with recurrent wound dehiscence necessitating implant removal 2 years after surgery, and one patient had superficial wound infection. None of the patients had implant failure and all multi-rod instrumented patients used only brace as external support.

Conclusion
Hemivertebra resection in patients under age 3 results in low complication rates and provides favorable outcomes. Use of navigation, multi-rod constructs and specialized teams contribute to the procedure's safety in this age group.

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Paper #165. Trends in Blood Loss and Transfusion in Patients with Cerebral Palsy Undergoing Posterior Spinal Fusion for Neuromuscular Scoliosis

Terrence G. Ishmael, MBBS; Steven W. Hwang, MD; Joshua M. Pahys, MD; Suken A. Shah, MD; Paul D. Sponseller, MD, MBA; Peter O. Newton, MD; Nicholas D. Fletcher, MD; Amer F. Samdani, MD; Harms Study Group

Hypothesis
EBVL and transfusion of RBCs and cell saver blood in PSF for patients with CP has decreased from 2008-2020.

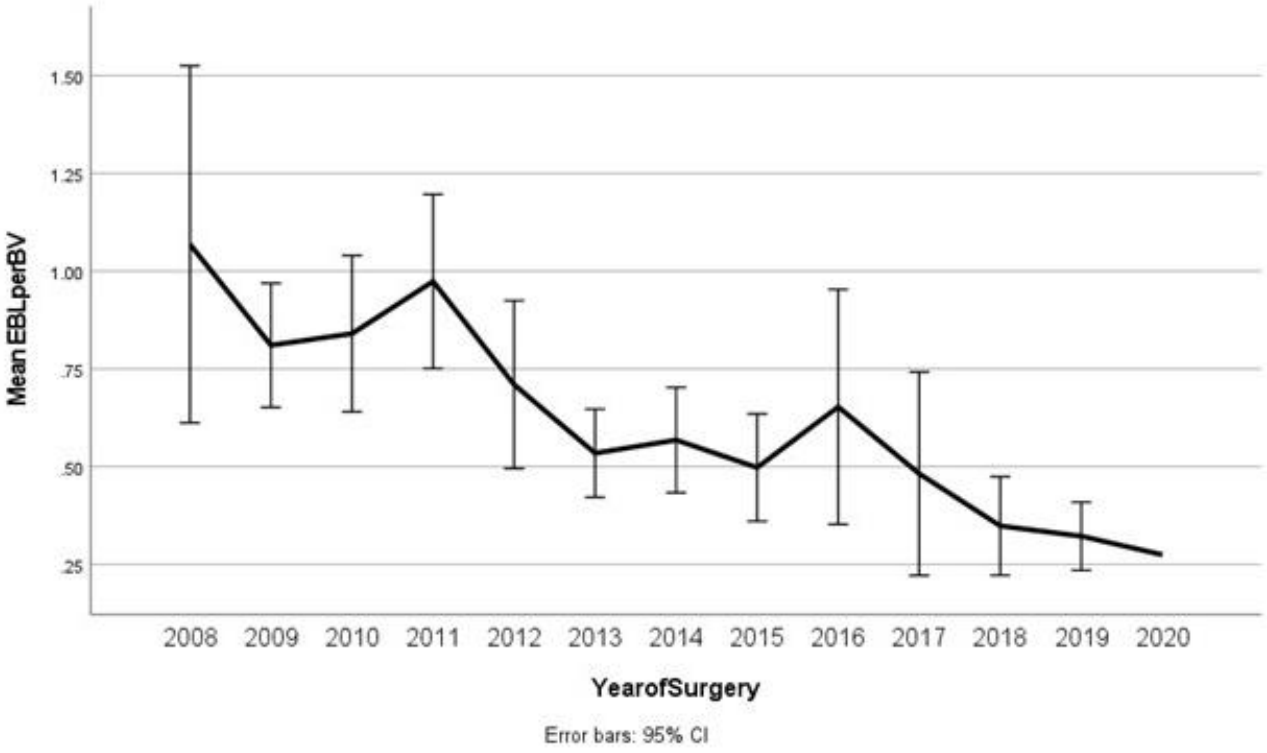
Design
Retrospective review of prospective multicenter registry of patients with CP undergoing PSF.

Introduction
Spinal deformity is common in patients with cerebral palsy (CP). These patients undergo long surgical procedures with a high complication rate, such as bleeding requiring transfusion. Changes in surgical and anesthesia techniques have reduced blood loss in recent years, and we aimed to evaluate recent trends.

Methods
We performed a retrospective review of a prospective multicenter registry of patients with CP (GMFCS IV & V only) who had posterior spinal fusion (PSF) and a minimum 2-year follow-up. Baseline characteristics (demographics, functional status, and deformity measures) were evaluated. Operative approach and outcomes evaluated included estimated blood volume loss (EBVL), allogenic blood transfusion, cell saver transfusion, and use of tranexamic acid (TXA).

Results
333 patients (23% GMFCS IV and 77% GMFCS V) met inclusion criteria. Between 2008-2020, there was an overall decrease in EBVL with Spearman's rho value of -0.444 ($p<0.001$). CART analysis divided patients into two groups: 2008-2012 (n=157) and 2013-2020 (n=176). There were no significant differences in curve characteristics and patient demographics except that there were 82% GMFCS V in Group 1 vs. 73% in Group 2 ($p=0.037$). There was no difference in curve magnitude between the groups ($p=0.776$), percent correction ($p=0.662$), surgical time ($p=0.565$) or the rate of fusion to the pelvis ($p=0.182$). There was a decrease in cell saver transfusion (431cc vs. 319cc, $p=0.004$), decrease in transfusion of RBCs (1012cc vs. 599cc, $p<0.001$) and an increase in the use of TXA ($p<0.001$). There were also fewer anterior releases performed ($p=0.003$), fewer days spent intubated ($p<0.001$), and no difference in length of stay ($p=0.107$) or occurrence of infections ($p=0.735$).

Conclusion
Between 2008–2020, there was a decrease in EBVL and transfusion of cell saver blood and allogenic blood after PSF for patients with CP. There was also an increase in the use of TXA, decrease in the use of anterior releases, and fewer days spent intubated. The overall decrease in EBVL over time may be associated with routine use of TXA, decrease in anterior releases, and practice changes in anesthesia.



rs -0.444 p<0.001

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Paper #166. Trends in Readmission Rates After Spinal Fusion for Neuromuscular Scoliosis: A 12-Year Retrospective Analysis

Aladine A. Elsamadicy, MD; James Cross; Joshua M. Pahys, MD; Amer F. Samdani, MD; Paul D. Sponseller, MD, MBA; Suken A. Shah, MD; Peter O. Newton, MD; Firoz Miyanji, MD; Harms Study Group; *Steven W. Hwang, MD*

Hypothesis
Length of stay, estimated blood loss, and and readmission rates have improved for CP patients undergoing fusions over time.

Design
Retrospective review of a prospectively collected multicenter database

Introduction
The aim of this study was to investigate the longitudinal trend in hospital readmission rates for patients with CP undergoing spinal fusion.

Methods
We queried a database for CP patients who underwent a fusion (2008-2019) from 19 centers. Patients were categorized in 4-year increments: 2008-2011; 2012-2015; 2016-2019. Readmission rates were categorized as: 0-30 vs. 31-90 vs. >90 day readmissions (with a 5.5-year cut-off post discharge to limit excessive weighting of the earlier years). Length of hospital stay (LOS) after index case and hospital readmission rates were the primary outcomes of this study.

Results
There were 453 patients included in the study, with n=166 in 2008-2011, n=165 in 2012-2015, and n=122 in 2016-2019. There were no significant differences in age at time of surgery (p=0.825). Majority of patients were GMFCS Level V (78.1% vs. 63.6% vs. 72.9%, p=0.024). There was no significant difference in the use of intra-op halo traction (p=0.669). There was a significant decrease in mean EBL in the later years (1983 mL vs. 1313 mL vs. 972 mL, p<0.001), with a decreasing trend in average operative times over the years (410 min vs. 413 min vs. 374 min, p=0.063). The mean LOS was not significantly different over time, respectively (11.6 days vs. 11.7 days vs. 9.6 days, p=0.164). Readmission rates within 30 days, 31-90 days, and >90 days have been similar over the years (2008-2011: 6.6%, 4.2%, 11.4% vs. 2012-2015: 7.3%, 1.8%, 6.7% vs. 2016-2019: 9.0%, 4.9%, 9.8%; p=0.741, p=0.311, p=0.315, respectively). There were no significant differences in the driver of readmissions (p=0.76), with the most common being surgical site/incision, gastrointestinal, and instrumentation complications (2008-2011: 7.2%%, 3.0%, 1.8% vs. 2012-2015: 5.5%, 3.0%, 1.2% vs. 2016-2019: 8.2%, 3.3%, 4.1%, respectively).

Conclusion
Our study suggests there have been improvements in the care of CP patients undergoing surgical intervention over time (EBL and OR time). However, readmission rates and the drivers of readmission have not improved. Further studies are necessary to better understand and identify risk factors for early and late readmissions to begin reducing these rates.

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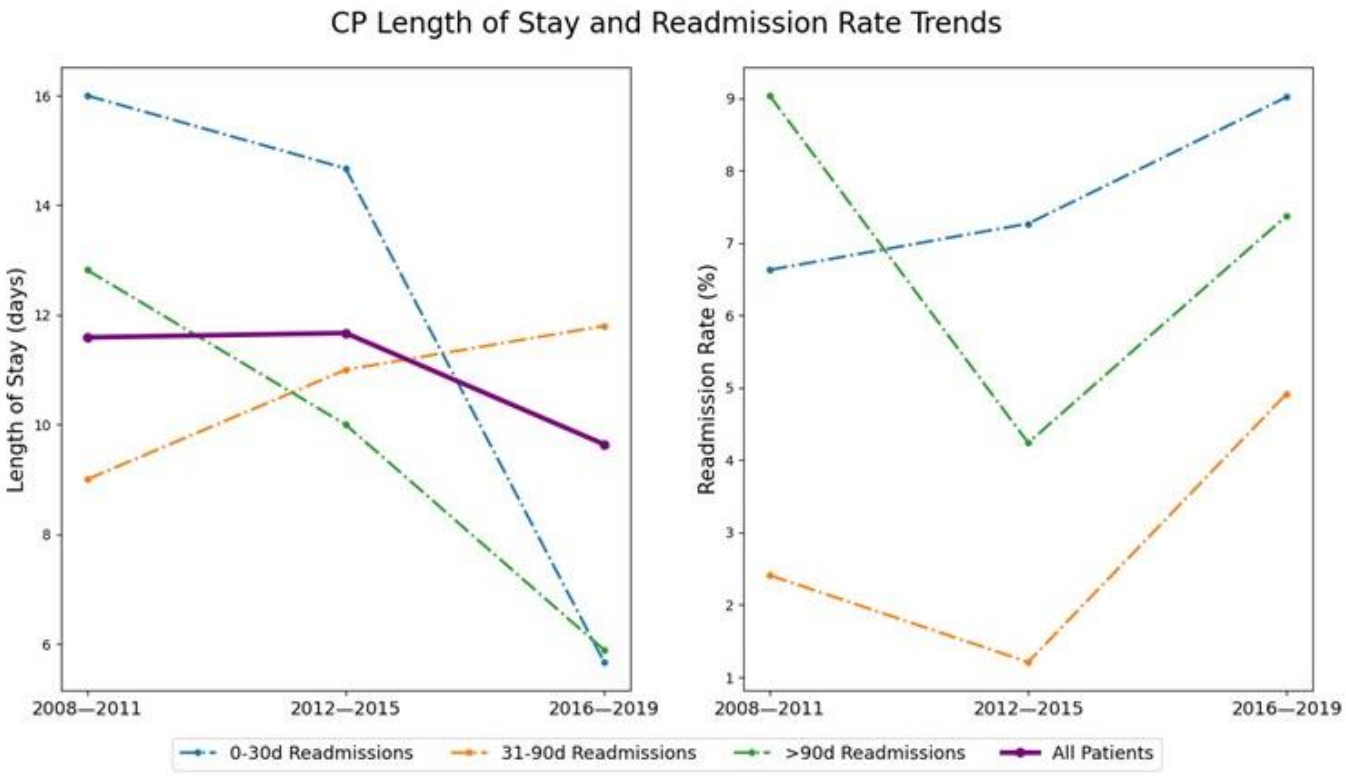

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Paper #167. Multicenter Assessment of Closure Technique for Reducing Short-Term Wound Complications in Pediatric Neuromuscular Scoliosis

Jason Z. Amaral, BS; McKenna C. Noe, BS; Rebecca Schultz, BS; Tristen N. Taylor, BS; Kennedy Morey, BS, ATC; John T. Anderson, MD; Richard Schwend, MD; *Brian G. Smith, MD*

Hypothesis
We hypothesized that plastic closure would decrease the rate of short-term complications after spinal fusion with pelvic fixation in pediatric neuromuscular scoliosis.

Design
Retrospective Comparative

Introduction
This study evaluates plastic multilayered closure (PMC) for preventing infections and improving wound healing in children with neuromuscular scoliosis (NMS) undergoing spinal fusion and pelvic fixation. It compares the rates of surgical site infection (SSI), wound complications, and unplanned reoperations between PMC and orthopedic closure (OC) techniques.

Methods
This study analyzed NMS patients undergoing spinal fusion and pelvic fixation from 2018-2023 at two institutions using distinct closure techniques: PMC and OC. It examined demographics, surgical details, reoperation rates, and complications between the groups. SSI was defined as deep infection within 90 days post-operation, following CDC guidelines. Exclusions were patients over 18 years, those undergoing revision surgeries, and those with growth constructs. The minimum follow-up was 90 days.

Results
Of 156 patients (average age 13.5 years, 57% female), 79 underwent OC and 77 PMC. No significant differences in age, sex, blood loss, or transfusion rates were observed between groups ($P>0.05$). The average BMI was higher in the PMC group (19.1 vs. 17.6, $P=0.008$). OC procedures were shorter on average, taking 5.7 hours compared to 7.6 hours for PMC ($P<0.001$). Drains were placed in all PMC cases (vs. 28% of OC, $P<0.001$), with 25% of PMC patients discharged with a drain. SSI incidence did not significantly differ between PMC at 2.6% and OC at 8.9% ($P=0.17$). Similarly, there was no significant difference in the rate of wound dehiscence (11.7% vs. 3.8%, $P=0.064$). The 90-day rate of unplanned reoperation was 5.2% in PMC compared to 13.9% in OC ($P=0.064$). While 30-day readmission rates were similar (PMC at 7.8% vs. OC at 12.7%, $P=0.32$), PMC patients had longer average hospital stays (11.8 vs. 8.3 days, $P<0.001$). The median follow-up period was 1.1 years (range: 0.3-5.3 years).

Conclusion
PMC and OC techniques demonstrated similar short-term complications. PMC, however, had longer operative times, hospital stays, and increased drain use. These observations underline the need for larger prospective studies to clarify PMC's role in this patient population considering these drawbacks.

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168. What Happens if You Wait? Larger Curves Require More Resources for Less Correction in Neuromuscular Scoliosis

Brandon Yoshida, MD; Jacquelyn Valenzuela-Moss, BS; Tyler Tetreault, MD; Tishya Wren, PhD; Nico Silverman-Lloyd, BS; Tiffany N. Phan, BA; Lindsay M. Andras, MD; *Michael J. Heffernan, MD*

Hypothesis
Larger preoperative curve magnitude is associated with increased resource utilization in neuromuscular scoliosis.

Design
Retrospective study

Introduction
Despite previous attempts to assess the impact of curve magnitude on outcomes after posterior spinal fusion (PSF) in neuromuscular scoliosis (NMS), equipoise remains regarding optimal surgical timing. This study assessed the impact of curve magnitude on the complexity of surgery, resources utilized, and outcomes during surgical management of NMS.

Methods
Consecutive patients aged 7-21 years with NMS and fusion to the pelvis were reviewed at a single tertiary pediatric hospital from 2004-2021. Patient demographics, surgical parameters, complications, and radiographic measurements were collected. Clinical and radiographic outcomes were compared between patients with preoperative curves ≥80° and <80°.

Results
337 patients met inclusion criteria with a mean curve of 83.1°±26.5°. Patients with curves ≥80° had greater blood loss (994±607 vs 764±535 ml, p=0.0003), increased transfusion requirement (795±647 vs 478±482 ml, p<0.0001), longer surgical time (418±117 vs 338±117 min, p<0.0001) anesthesia time (552±123 vs 472±122 min, p<0.0001), and ICU stay (3±2 vs 2±1 day, p=0.009) compared to patients with curves <80°. Need for continued intubation was 2.4 times more likely (OR 2.4; 95% CI [1.5, 3.9]; p=0.0002) and the odds of utilizing adjunctive surgical techniques (i.e. intraoperative halo traction, temporary rods, and/or staged procedures) were 4 times more likely for patients with curves ≥80° (OR 4.1; 95% CI [2.5, 6.6]; p<0.0001). The use of spinal osteotomies was more likely among patients with larger curves (OR 4.6; 95% CI [2.8, 7.2]; p<0.0001). 75% of unplanned staging occurred in the ≥80° group. Residual curve magnitude (44.7±20.5 vs 22.6±13.6, p<0.0001) and pelvic obliquity (10.2±12.6 vs 4.8±8.7, p<0.0001) were higher in the ≥80° group. Complications were similar between groups (p=0.81).

Conclusion
Curve magnitude ≥80° was associated with larger residual curves despite increased surgical complexity and greater resource utilization in the management of NMS, which parents and providers should consider when deciding on timing of surgical intervention.

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Variable	Curve ≥ 80° at Surgery (N=179)	Curve < 80° at Surgery (N=158)	P value
Estimated Blood Loss (cc)	994 ± 607	763.9 ± 535.4	0.0003
Transfusion Units Utilized (cc)	796 ± 647	478.8 ± 482.4	<0.0001
Length of Surgery (minutes)	418 ± 117	338.8 ± 117.4	<0.0001
Length Under Anesthesia (minutes)	552 ± 123	472.2 ± 121.6	<0.0001
ICU Stay (days)	3 ± 2	2 ± 2	0.002
Length of Hospital Stay (days) - median	7.0 (6.0)	7.0 (4.0)	0.03

Variables are presented as mean ± standard deviation or median (interquartile range). Significance defined as a p-value less than 0.05.

Table 1: Resource Utilization in Patients with Curves ≥80° vs <80°

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Paper #169. Does Spine Fusion Limit Ambulatory Status in Spina Bifida Patients with Severe Spine Deformity?

Ambika Paulson, MD; Ryan Seltzer, MD; Kyle Graham, MPH; Douglass Clayton, MD; Jeffrey E. Martus, MD; *Gregory A. Mencio, MD*; Craig R. Louer, MD

Hypothesis
Spina Bifida (SB) patients undergoing posterior spine fusion (PSF) for severe spinal deformities do not have significant changes in ambulatory status compared to patients treated with observation (OBS).

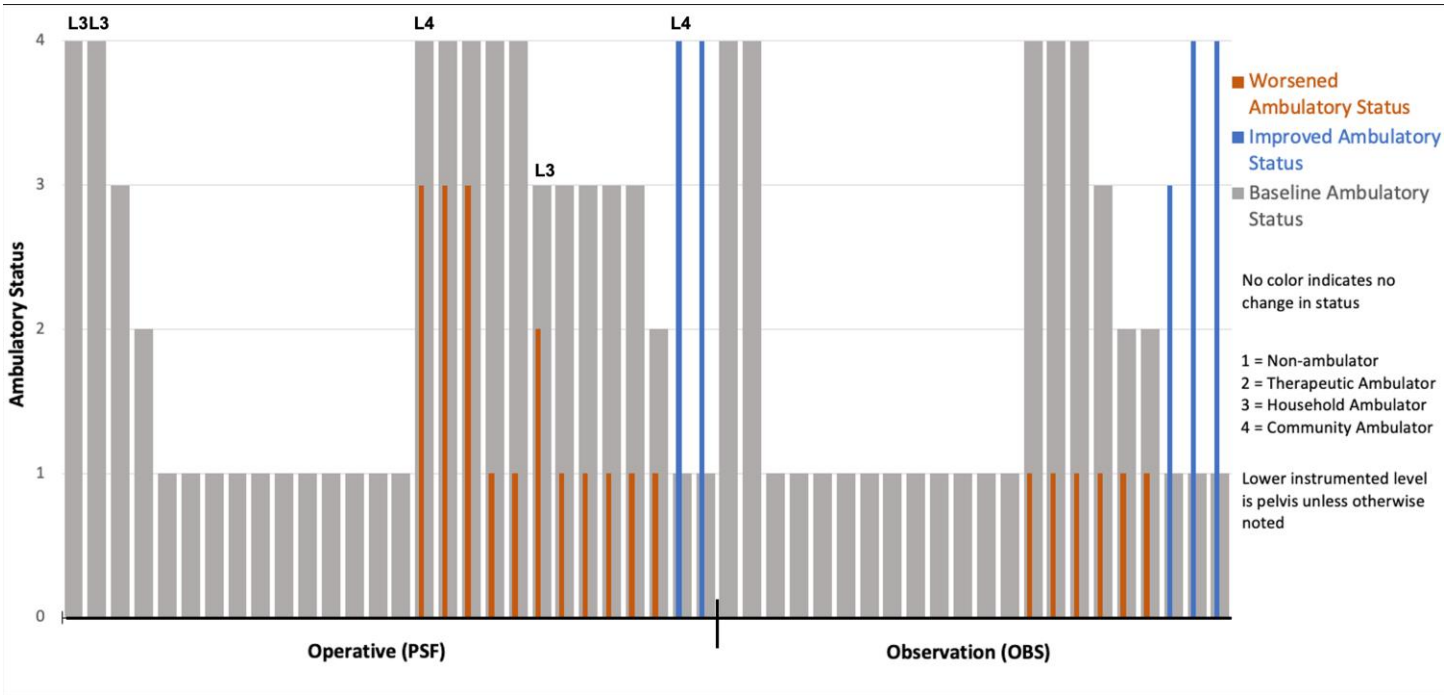
Design
Retrospective Cohort

Introduction
The functional impact of PSF in SB patients with severe spinal deformities is under-explored. This study sought to compare how PSF impacts functional capacity in SB patients relative to treatment with OBS.

Methods
A single-institution SB registry was queried for patients with severe coronal or sagittal deformity >50°, including gibbus deformity. Prospectively collected National Spina Bifida Patient Registry (NSBPR) questionnaire data was used for longitudinal functional assessment. Patients excluded if <2 years of radiographic or NSPBR data. Primary outcomes were ambulatory level and unassisted wheelchair (WC) transfer. Hoffer criteria was used to define ambulatory status (AS) based on four categories: community, household, therapeutic, and non-ambulatory. PSF and OBS groups were compared at baseline and final follow-up, including pairwise analysis of each patient over time.

Results
52 patients met inclusion criteria (30 PSF, 22 OBS). 7 PSF patients without pre-operative NSBPR outcomes were excluded from initial visit and within groups analysis. Length of follow-up was similar between groups (7.1 vs 5.2yrs, p=0.20). At study inclusion, PSF was similar to OBS in age (6.8 vs 7.5yrs, p=0.19), coronal deformity (57.1° vs 50.6°, p=0.26), AS (community ambulators: 26% vs 23%, p=0.19), and unassisted WC transfer rate (50% vs 69%, p=0.35). Major coronal deformity at last follow-up was decreased in PSF cohort (38.0° vs 66.7°, p<0.001). Neither treatment resulted in significant change in AS over time (p=0.11 and p=0.55; Figure 1). Of the 9 patients in each group who performed unassisted WC transfers at initial visit, 6 (66.7%) per group maintained the ability to perform unassisted transfers at last visit.

Conclusion
SB patients with severe spinal deformities undergoing PSF did not show a significant decline in mobility or functional capacity relative to OBS. These findings indicate that while some functional decline may be expected as the natural progression of SB, PSF does not significantly impact this trajectory. This affirms its utility in managing severe spinal deformities and can be used to counsel SB patients considering treatment with PSF.



Initial and final ambulatory status

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Paper #170. Adult Consequences of Neurofibromatosis Type1 Patients Who Had Spinal Deformity Surgeries

Arihiko Tsukamoto, MD; Koki Uno, MD, PhD; Teppei Suzuki, MD, PhD; Masaaki Ito, MD, PhD; Keita Nakashima, MD

Hypothesis

Postoperative scoliosis patients treated with neurofibromatosis type1 have poorer outcomes than postoperative idiopathic scoliosis patients and are less likely to have a satisfactory social life.

Design

Retrospective study

Introduction

Spinal deformity associated with neurofibromatosis type1(NF-1)is known to be intractable, and it's surgical outcome is known to be poorer than that of idiopathic scoliosis. However, it is not clear whether or not patients are able to lead a healthy social life as adults, and we investigated the surgical outcomes of patients who had reached adulthood after surgery.

Methods

Thirty-eight patients(16 males, 22 females) who had undergone spinal deformity surgery and had reached the age of 18 years at last follow up were included. X-rays, surgery, complications, survival rate, employment status, and married rate were evaluated. HR-QOL(SRS-22, ODI) was compared with those of adolescent idiopathic scoliosis(AIS) operated in our hospital.

Results

The mean age at the initial surgery was 14.6 [4~49] years, and the mean age at the last observation was 29.4 [18~56] years. Anterior and posterior fusion were performed in 18 patients, posterior fixation was performed in 20 patients. Five patients (13.2%) died (3: malignant schwannoma, 1:brain tumor, 1:unknown), with a mean age of 27 [18~35] years at the time of death and 12.2 [3~21] years after the last surgery. Two patients over 40 years of age were treated for vascular system disorders, and 1 patient for a brain tumor. All survivors were ambulators except 1 case of non-ambulator due to neoplastic destruction of the hip joint. The working status was light work in 13 patients, desk work in 7, unemployed in 4, students in 8. Three patients (7.9%) were married. SRS-22 and ODI in the NF-1 group were lower than in AIS, and significant differences were observed especially in Function (3.89/4.41), Pain (4.45/4.72) and Self-image (3.66/4.07).

Conclusion

At an average follow-up of 14.8 years after surgery, 5 of 38 patients had died, 29 patients (76.3%) were able to lead a healthy social life. However, HR-QOL was lower than that of AIS. Patients undergoing NF-1 scoliosis surgery require careful long-term follow-up, taking into account the possibility of reoperation due to osteolysis, malignant changes in the tumor, and vascular problems due to vascular fragility.

		NF-1	AIS	P value
SRS-22	Function	3.89(±0.53)	4.41(±0.36)	<0.05
SRS-22	Pain	4.45(±0.50)	4.72(±0.39)	<0.05
SRS-22	Self Image	3.66(±0.56)	4.07(±0.52)	<0.05
SRS-22	Mental	4.33(±0.46)	4.48(±0.46)	0.08
SRS-22	Satisfaction	4.10(±0.66)	4.06(±0.72)	0.91
ODI		6.68(0.09)%	5.34(0.07)%	0.93

SRS22 function, Pain, and Self image were lower in NF-1 than in idiopathic scoliosis

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Paper #171. A Changing EOS Phenotype in SMA: Nusinersen Use is Associated with Increased Curve Magnitude and Kyphosis at the Time of Index Surgery

John S. Vorhies, MD; Nicole S. Pham, MPH; Xochitl M. Bryson, BA; Marleni Albarran, BS; Majella Vaughan, MPH; Amy L. McIntosh, MD; Brandon A. Ramo, MD; Daniel Bouton, MD; Brian D. Snyder, MD, PhD; Michael G. Vitale, MD, MPH; John T. Smith, MD; Benjamin D. Roye, MD, MPH; Patrick J. Cahill, MD; Ian Hollyer, MD; Jaysson T. Brooks, MD; Ron El-Hawary, MD; Pediatric Spine Study Group

Hypothesis
Nusinersen administration affects preoperative curve characteristics and flexibility among patients with spinal muscular atrophy (SMA) and early onset scoliosis (EOS).

Design
Retrospective review of a multicenter database

Introduction
Nusinersen provides functional benefits to SMA patients but does not affect the prevalence or progression of scoliosis. The effect of nusinersen on curve characteristics in SMA has not been described. Here we investigate curve characteristics associated with nusinersen use in a SMA patient population undergoing initial surgical treatment for EOS.

Methods
A multicenter international pediatric spinal deformity database was queried for SMA patients undergoing initial surgical treatment (index growing construct implantation or definitive fusion) for scoliosis. Patients were stratified by exposure to nusinersen preoperatively. Preoperative clinical and radiographic characteristics and first erect postoperative radiographic parameters were compared between the two groups.

Results
225 patients were identified, 187 of which were controls (nusinersen naïve) and 38 who were treated with nusinersen preoperatively. Patients in the nusinersen group were treated for a median of 1.9 years(range: 0.02 - 5.9) prior to surgery. Mean age at surgery in the nusinersen group was lower than controls 6.4 vs 7.7yrs (p=0.002). The nusinersen group was more likely to be treated with MCGR 87% vs 45% (p<0.001). 80% of patients were instrumented to the pelvis and this did not differ between the two groups. Mean preoperative major curve and kyphosis were higher among the nusinersen group vs controls 83°vs 74° (p=0.023) and 77° vs 66° (p=0.021) respectively. Mean percent coronal correction was 46% and mean change in kyphosis was 25° and did not differ between the groups. Mean preoperative pelvic obliquity was 20°, was corrected an average of 47% and did not differ between the groups.

Conclusion
Nusinersen use was associated with larger more kyphotic curves and younger age at intervention among SMA patients undergoing initial surgical treatment for EOS. Percent correction of the curves was similar suggesting similar curve flexibility. Further study is needed to understand if Nusinersen directly affects curve characteristics or rather improves function in more severely affected patients allowing them to become surgical candidates.

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	No Nusinersin Use (n = 187)		Nusinersin Use (n = 38)		
	Mean	SD	Mean	SD	p-value
Age (years)	7.7	2.7	6.4	2.0	0.002*
BMI	16.7	4.3	16.2	3.0	0.430
Preop Major Curve (degrees)	74	22	83	20	0.023*
Postop Major Curve (degrees)	39	16	45	19	0.094
Percent correction	-45.6%	22.2%	-46.1%	16.4%	0.854
Preop T2-T12 Kyphosis (degrees)	66	29	77	24	0.021*
Postop T2-T12 Kyphosis (degrees)	43	17	49	16	0.035*
Change in Kyphosis (degrees)	-25	25	-27	27	0.552
Preop Pelvic Obliquity (degrees)	20	13	23	13	0.150
Postop Pelvic Obliquity (degrees)	7	6	9	6	0.272
Percent Correction	-46.6%	82.3%	-35.9%	77.7%	0.504
	N	%	N	%	p-value
Surgery Type					
MCGR	84	45%	33	87%	
VEPTR/TGR	79	42%	2	5%	< 0.001*
Other	24	13%	3	8%	
Superior Anchors					
Rib	70	43%	19	54%	
Spine	88	54%	15	43%	0.405
Both	5	3%	1	3%	
Inferior Anchors					
Pelvis	67	41%	15	43%	
Spine	32	20%	6	17%	0.976
Spine and Pelvis	63	39%	14	40%	
Rib and Pelvis	1	1%	0	0%	

Table 1: Summary Data *p<0.05

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Paper #172. Spine MRI in Patients with Arthrogryposis is Compulsory Due to High Rates of Tethered Cord/Low-Lying Conus Medullaris and Scoliosis

Hans K. Nugraha, MD; *Arun R. Hariharan, MD*; Aaron Huser, DO; Kaveh Asadi, MD; David S. Feldman, MD

Hypothesis
Children with arthrogryposis have a high incidence of tethered cord and low lying conus medullaris

Design
Retrospective case series

Introduction
Arthrogryposis is defined by contractures of the multiple joints and is found in conditions such as AMC. These conditions are also associated with scoliosis and neural axis malformations. There have been no studies examining the prevalence of tethered cord in this population. The aim of the study was to determine the incidence of tethered cord (TC), characterized by a low-lying conus medullaris (LLCM), and secondarily, scoliosis, in children with arthrogryposis.

Methods
Patients less than 18 years old with a diagnosis of arthrogryposis and a spine MRI were identified. LLCM is defined by a conus at or below mid-L2 level of the vertebral body indicative of a TC. The MRI were independently reviewed by a pediatric neurosurgeon and a pediatric orthopedic surgeon. Clinical charts and Xrays were also reviewed. Descriptive statistics reported.

Results
39 of 102 patients (38%) had a LLCM, while 37 patients (36%) had spinal deformities, mainly scoliosis (92%). Of the 39, 21 (54%) had scoliosis with a mean Cobb angle of 52o (SD 28). Compared to the typical population, the distribution of conus termination is skewed to the caudal end of the neural axis. Mean age at MRI is 5.6 years old (SD 4.60). Nineteen patients elected to undergo detethering through filum terminale sectioning, with 13 patients having neurologic deficits in addition to their arthrogryposis such as bowel bladder dysfunction and decreased sensation in lower extremities.

Conclusion
There is a high prevalence of TC in children with arthrogryposis due to a LLCM. Nearly 40% of patients had a LLCM/TC, 54% of whom had scoliosis. This highlights the importance of a screening MRI in children with arthrogryposis, particularly with pre-surgical planning, in addition to routine exam and Xrays for scoliosis. More extensive, multicenter prospective research are needed to deepen understanding of this condition and its clinical ramifications in patients with arthrogryposis.

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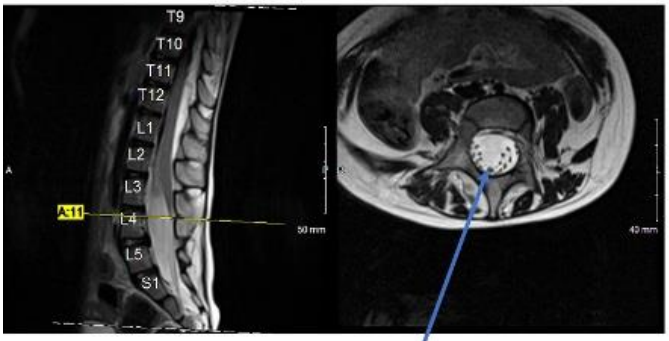
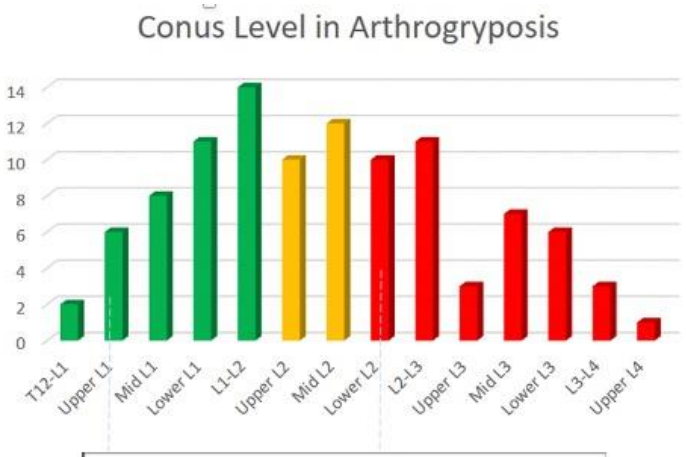
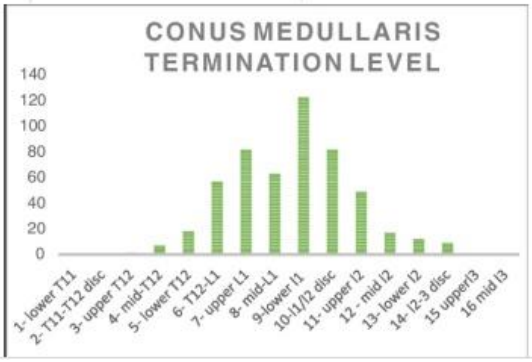


Filum terminale extending to L4



Conus Level in Normal Pediatric Population

Blaaza M, Figueira CFC, Ramali MR, McNamara C, et al. Assessment of the levels of termination of the conus medullaris and thecal sac in the pediatric population. Neuroradiology. 2023 Apr;65(4):835-843



MRI illustrating LLCM/TC and distribution of conus level in Arthrogryposis compared to normal pediatric population

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Paper #173. Redefining Physiological Whole-Body Alignment According to Pelvic Incidence: Normative Values and Prediction Models

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Hypothesis
Global alignment parameters must be interpreted according to subject's pelvic incidence.

Design
Multicentric retrospective

Introduction
This study aimed at providing normative values for commonly used parameters in whole-body alignment analysis based on pelvic incidence (PI), and prediction formulas for pelvic tilt (PT), T1 pelvic angle (TPA), spino-sacral angle (SSA), maximum lumbar lordosis (LLmax) and sacro-femoral angle (SFA).

Methods
This study included healthy volunteers with full-body biplanar radiograph in free-standing position. All radiographic data were collected from 3D reconstructions: Sagittal vertical axis (SVA), T1 pelvic angle (TPA), spino-sacral angle (SSA), T1 spino-pelvic inclination (T1SPi), sagittal odontoid-hip axis angle (ODHA), pelvic parameters, sacro-femoral angle (SFA), knee flexion angle (KFA), ankle flexion angle (AA), Pelvic shift (PSh), LLmax, segmental lumbar lordoses, thoracic kyphosis (TK) and cervical lordosis (CL). Population was divided into five groups according to PI.

Results
790 subjects were included. Mean age was 33±17.7 years (range: 4-90). Mean PI in the cohort was 48±9.8°(range: 21-87). LL, PT, SFA, SSA and TPA correlated with PI and age. ODHA and the other lower limb parameters were not associated with PI. Cervical lordosis and thoracic kyphosis lost significant relationship with PI after taking age into account. SSA, SFA, TPA, segmental lumbar lordoses, LL and PT significantly increased in every PI subset. All normative values across PI groups are provided, with predictive formulas: PT=-13+0.4*PI+0.1*Age (R2: 0.46, std error: 5.2°), TPA=-17+0.4*PI+0.1*Age (R2: 0.45, std error: 5.1°), SSA=110+0.6*PI-0.2*Age (R2: 0.45, std error: 6.4°), LLmax=-32-0.65*PI+0.15*Age (R2: 0.34, std error: 8.8°), and SFA=173+0.4*PI+0.1*Age (R2: 0.34, std error: 6.3°).

Conclusion
SSA, PT, TPA and SFA must be assessed according to patient's PI. This study provides normative values for each PI group, and predictive formulas taking age and PI into account. These results are relevant to define correction goals in adult spinal deformity surgery, but also for short fusions in degenerative surgery and traumatology cases. PI cannot be used to define thoracic and cervical curvatures.

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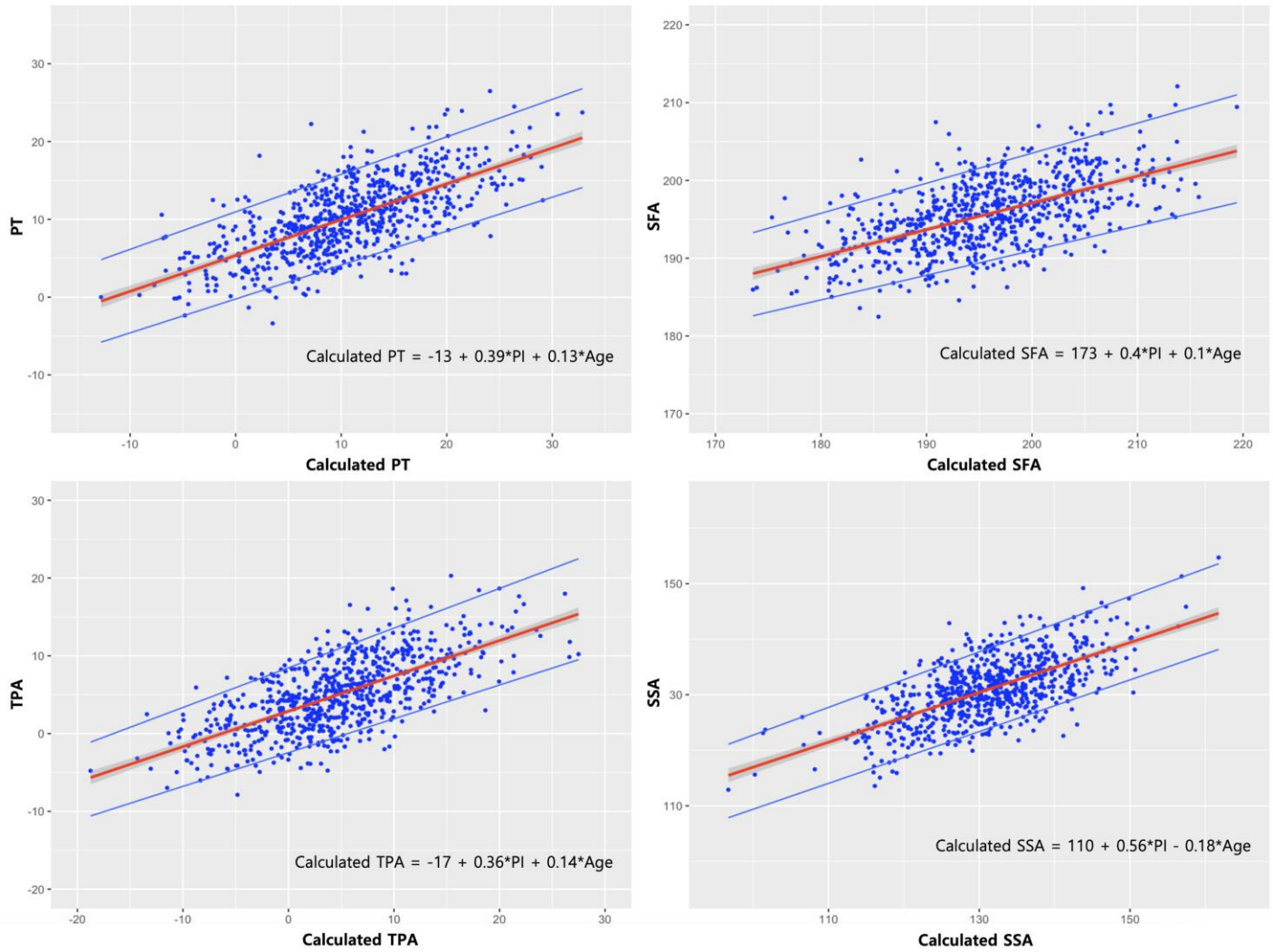

Accuracy of prediction formulas for PT, SSA, TPA and SFA, with 95% confidence intervals (blue lines)

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Paper #174. Not All Are Created Equal: Lumbosacral Anatomy is Different in Pediatric Spondylolysis

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Hypothesis
Differences in novel lumbosacral anatomic parameters will exist between patients with and without L5 spondylolysis.

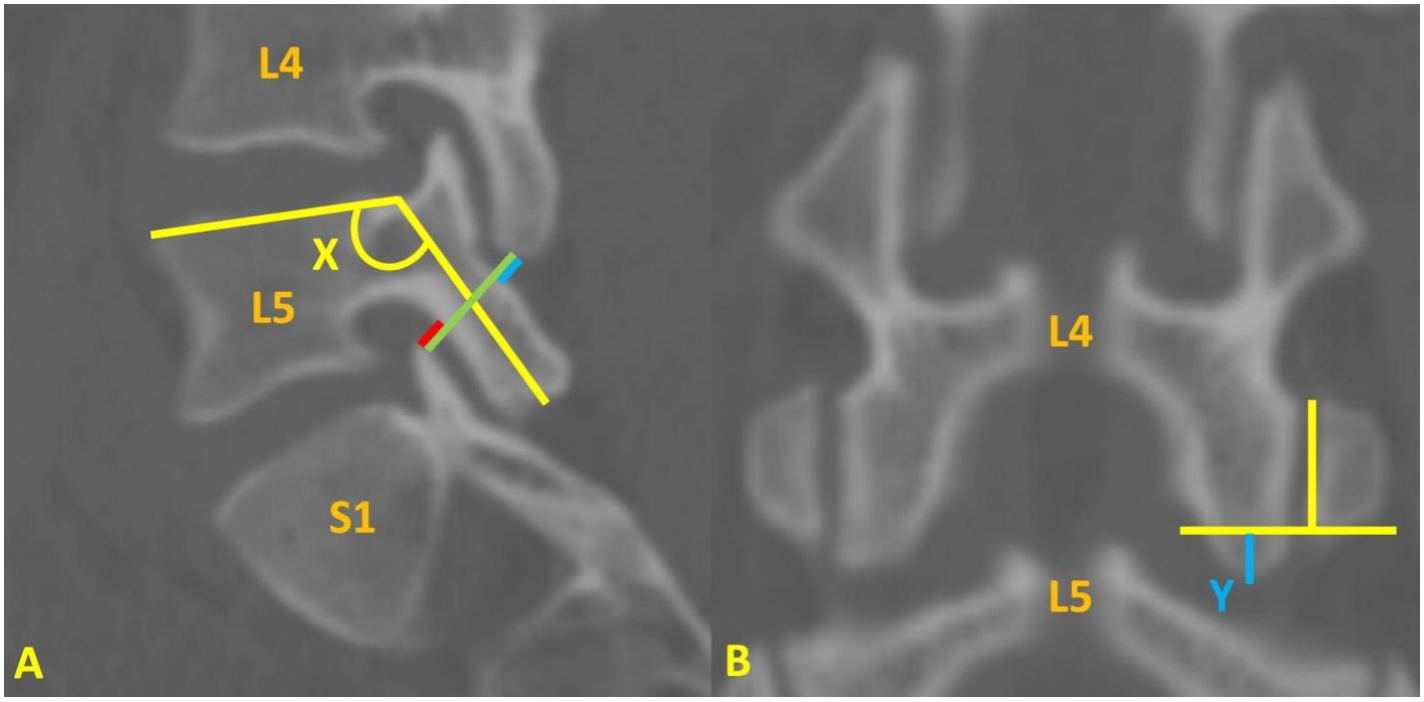
Design
Retrospective Cohort

Introduction
Pediatric spondylolysis is a known source of low back pain. With its low incidence, there is a lack of large, single-center data describing how geometric parameters of the lumbosacral anatomy contribute to its development. This study compares novel parameters on computed tomography (CT) scans of pediatric patients with and without spondylolysis at L5.

Methods
CT-scans of pediatric patients at a single-center (2005-2022) were reviewed. Patients with isolated L5 spondylolysis were identified and matched 1:4 (age, sex, BMI) to patients without spondylolysis. Sagittal parameters were assessed: sacral slope angle, sacral table angle, L4-S1 and L5-S1 Cobb angles, the horizontal angle of the L5 pars interarticularis, and the distances between the L4 inferior articular process (IAP) and the S1 superior articular process (SAP) and their respective individual distances to the L5 pars. On coronal view, the percent subluxation of L4 IAP below the facet joint was assessed. Statistical analyses included two-tailed t-tests for each parameter and Pearson correlation analysis with significance at 0.05.

Results
The incidence of L5 spondylolysis was 3% (32/1084). Spondylolysis patients (mean age 15±2.3, 46.9% female) were compared to 122 patients without spondylolysis. The horizontal angle of the L5 pars was greater in spondylolysis patients (153.1±13.8 vs. 133.5±10.0, $p<.001$). There was less distance (mm) between L4 IAP and S1 SAP (11.3±3.9 vs. 14.7±2.9, $p<.001$) in the spondylolysis group. There was less distance (mm) from both L4 IAP (2.6±1.7 vs. 5.4±2.2, $p<.001$) and S1 SAP (0.7±0.4 vs. 1.5±0.7, $p<.001$), respectively, to the L5 pars. Spondylolysis patients had greater subluxation of L4 IAP beneath the facet joint (29.0±20.1 vs. 13.2±11.4, $p<.001$). There was no difference in sacral slope, sacral table, or Cobb angles. Pearson's analyses revealed that a larger horizontal angle of the L5 pars is strongly associated with spondylolysis (0.59).

Conclusion
Pediatric patients with L5 spondylolysis are more likely to have a horizontal L5 pars situated closer to both the L4 IAP and S1 SAP, therefore causing increased impingement on lumbar extension.



A) Horizontal angle of the L5 pars (x) and distances between L4 IAP, L5 pars, and S1 SAP; and B) Subluxation of L4 IAP below facet joint (y).

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Paper #175. Spondylolisthesis in Children Younger than 10 Years: Who Will Progress to a High Grade Slip?

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Hypothesis
It is possible to determine predictors of slip progression in children under 10 years of age with spondylolisthesis.

Design
Retrospective analysis of prospectively collected data.

Introduction
The risk of progression for patients younger than 10 years with spondylolisthesis remains largely unknown, such that there are no guidelines on the follow-up needs for these individuals. We aim to document the progression of spondylolisthesis in children younger than 10 years and identify predictors of progression.

Methods
We reviewed the radiographs of patients younger than 10 years presenting with a spondylolisthesis at our institution, and who attended at least 1 follow-up visit. The percentage of slip, sacral slope, pelvic tilt, and pelvic incidence were measured.

Results
There were 58 girls and 36 boys aged 8.5±1.8 years at initial presentation and 13.7±3.4 years at last follow-up. The mean of follow up was 5.1± 3.2 years. There were 91 patients with low-grade spondylolisthesis mean 19.1± 10.7 % slip and 3 patients with high-grade spondylolisthesis 80.1±8.5 % slip at the initial presentation. 22 patients (24%) showed a slip progression greater than 10% during follow-up. A significant association was found between the slip % at the initial presentation vs. last follow-up. No associations were found between pelvic parameters and slip progression. At the end of follow-up, 5 children had a slip greater than 50 % at the age of 12.7±5.7 years (4 were low grade spondylolisthesis and 1 high grade at the initial presentation). The mean slip percentage at the beginning was 46%(29%-73%). All these patients were girls. There were 2 girls who required surgery before the age of 10 years due to high grade spondylolisthesis.

Conclusion
The slip % at initial presentation is the most important predictor of further progression, particularly when it is 40% or greater at initial presentation. Furthermore, all subjects with a high-grade spondylolisthesis were girls. There was no association between slip progression and sagittal morphology/balance. Despite the challenge in predicting progression in children under 10 years, vigilance until skeletal maturity is prudent, particularly for girls and those presenting with a slip percentage of 40% or greater at initial presentation.

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Paper #176. Social Determinants of Health Predict Patient Reported Outcomes 2-Years Following Surgery for Grade 2 Spondylolisthesis: A QOD Study

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Hypothesis
Certain social determinants of health such as race, education, and socioeconomic status may negatively affect outcomes following surgery for Grade 2 spondylolisthesis. Patients with these identities may benefit from extra support pre-, peri-, and post-operatively.

Design
Retrospective analysis of a prospective multi-center registry

Introduction
We aim to identify which social determinants of health (SDOH) affect patient reported outcomes (PROs) 2 years after surgery for Meyerding grade 2 spondylolisthesis.

Methods
Patients with grade 2 spondylolisthesis who were prospectively enrolled at the 12-highest enrolling Quality Outcomes Database (QOD) sites were identified. Separate multivariate linear regression models were trained to identify predictors of 2-year postoperative PROs, including numerical rating scale (NRS) leg pain (NRS-LP), back pain (NRS-BP), EQ5D (quality of life), and Oswerty Disability Index (ODI). Each model was trained using the following SDOH: race (white, black, Asian, Native American/Alaskan Native, Native Hawaiian/Pacific islander), insurance payor, education level (at least college degree vs no college degree), and preoperative employment status. Each model controlled for age, gender, (American Society of Anesthesiologists) ASA grade, BMI, and preoperative value of the studied PRO.

Results
In total, 400 patients with grade 2 spondylolisthesis were identified. The follow up rate was 80% 2 years. Protective SDOH: At least a college degree versus no college degree independently predicted improvements in NRS-LP (β-coefficient:-1.02, p=0.04), NRS-BP (β-coefficient:-0.87,p=0.01), EQ5D (β-coefficient:0.05, p=0.03), and ODI (β-coefficient:-4.2, p<0.001). Employment preoperatively predicted improvements in NRS-LP (β-coefficient:-0.85, p=0.04) and NRS-BP (β-coefficient:-0.89,p=0.03). SDOH Risk Factors: Usage of Medicaid versus private insurance was an independent predictor of worse PROs, including NRS-LP (β-coefficient:2.5, p=0.006), NRS-BP (β-coefficient:2.2, p=0.02), EQ5D (β-coefficient:-0.14,p=0.02), and ODI (β-coefficient:6.0, p=0.03).

Conclusion
Many indicators of lower socioeconomic status, such as Medicaid insurance, education level, and employment status were correlated with worse patient reported outcomes after surgery for Grade 2 Spondylolisthesis. These results may help indicate patients for whom more targeted interventions could improve outcomes.

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Paper #177. Incidental Dural Tears During Pediatric Posterior Spinal Fusions

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Hypothesis
N/A

Design
Retrospective cohort

Introduction
Incidental dural tears are a known complication of spinal surgery. When they occur, several studies advocate for immediate repair if identified intra-operatively and for return to the operating room for surgical repair if identified post-operatively. In the adult population, immediate suture repair has demonstrated resolution of neurological symptoms and equivalent outcomes compared to patients without tears. In pediatric spinal deformity patients, the etiology and management of dural tears is not well documented with the largest prior study only including 6 patients. The purpose of this study is to characterize the cause, treatment modality, and outcomes of incidental dural tears in pediatric patients undergoing posterior spinal fusion (PSF).

Methods
A retrospective review of all pediatric patients who underwent a posterior spinal fusion (PSF) between 2004-2019 at a tertiary children's hospital was conducted. Electronic medical records were reviewed for patient demographics, intra-operative data, presence of an incidental dural tear, repair method, and patient outcomes. Symptoms of CSF leaks, such as headaches, nausea, vomiting, dizziness, and lightheadedness were noted.

Results
3,043 PSFS were reviewed, with 104 dural tears identified in 99 patients (3.4% overall incidence). Mean follow-up was 32.3 months (range 0.1-142.5). When the cause of the dural tear was specified, 84% occurred during exposure, 5% during pedicle screw placement, 4% during osteotomy, 2% during removal of implants, and 2% during intra-thecal injection of morphine. The rate of dural tears during primary PSF was significantly lower than during revision PSF procedures (2.8% vs. 6.2%, $p<0.05$). 85.6% of dural tears were repaired and/or sealed intraoperatively, while 14.4% had spontaneous resolution. Postoperative headaches developed in 13.5% of patients and resolved at a mean of 7.6 days. There was no difference in the incidence of headaches in patients that were ordered bedrest vs. no bedrest ($p>0.99$). Postoperative infections occurred in 9.5% of patients and 24.1% patients were identified to have undergone a revision surgery.

Conclusion
Incidence of intra-operative dural tears in pediatric spine surgery is 3.4%. Although complications associated with the dural tear occur, most resolve over time and there were no long-term sequelae in patients with 2 years of follow up.

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Paper #178. Hydrogen Peroxide Fogging Reduces Spinal Surgical Site Infections: A QSVI Project

Lorena Floccari, MD; Matthew Holloway, MD; Richard Steiner, PhD; Todd F. Ritzman, MD; Michael Bigham, MD

Hypothesis

Hydrogen peroxide fogging in the operating rooms is feasible and significantly reduces spinal surgical site infection (SSI)

Design

Longitudinal QI study with retrospective comparative analysis

Introduction

Environmental exposure is a contributor to hospital acquired infections. Decontamination with hydrogen peroxide fogging has been shown to reduce bacterial detection and bioburden in the hospital setting. We sought to 1) implement and test feasibility of an operating room-based hydrogen peroxide fogging program and 2) assess the impact of hydrogen peroxide fogging on scoliosis surgical site infections.

Methods

A hydrogen peroxide fogging program was implemented for high-risk surgical patient populations at a freestanding children's hospital in September 2022. The spine operating suite received fogging every two weeks using a third-party vendor. The feasibility assessment was designed to identify safety events related to fogging or interruptions in care/access to operating rooms due to fogging. The time series outcomes were bioburden and bacterial cultures. The primary outcome measure was the incidence of early (90-day) SSI for scoliosis fusion surgeries with comparison Pre- to Post-fogging.

Results

The feasibility assessment identified no harm events, delays or interruptions in operating room utilization related to fogging. The time series evaluation indicated return to baseline bacterial bioburden at 3-4 weeks post-fogging. 221 spinal fusions were performed, including 130 Pre- and 91 Post-fogging. There were similar patient characteristics including age, scoliosis classification, and Cobb angle ($p>0.1$). In the Pre-fogging group, early SSI occurred in 10/130 (7.7%, 95% CI: 4.23%, 13.58%). Following implementation of the hydrogen peroxide fogging program, early SSI was 87% less likely to occur (Odds Ratio 0.13) with incidence decreasing to 1/91 (1.1%, 95% CI: 0.19%, 5.96%)($p=0.015$). This is represented by a center-line shift on the P Chart (Fig 1).

Conclusion

The risk of SSI following spinal fusion can be mitigated by implementing hydrogen peroxide fogging in operating rooms. Hydrogen peroxide fogging is feasible and significantly reduces spinal surgical site infection from 7.7% to 1.1% ($p=0.015$).

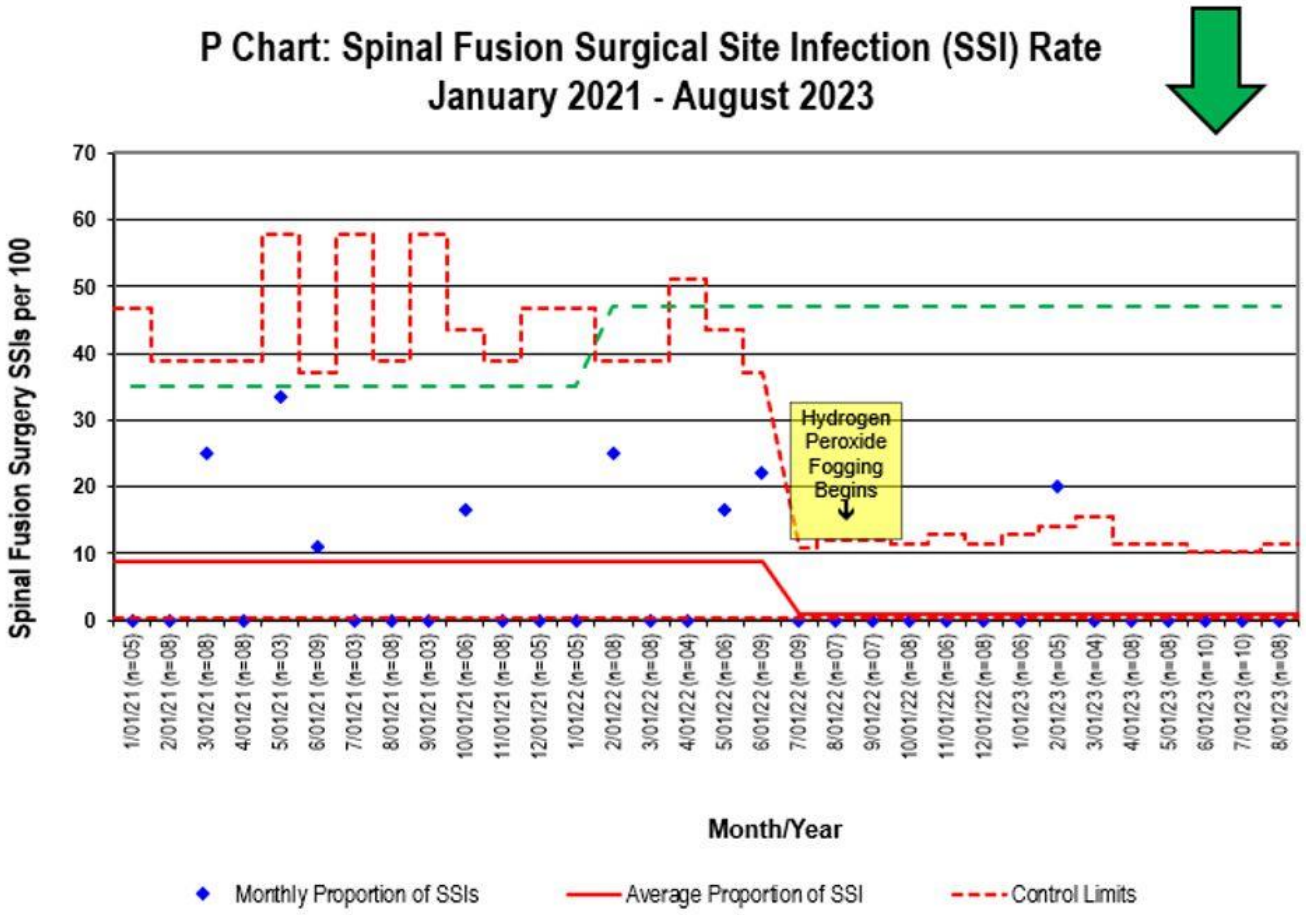

Figure 1: Statistical process control chart showing SSI over time with control limits (3 SDs).