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ORIGINAL ARTICLE

Preoperative SRS pain score is the primary predictor of postoperative pain after surgery for adolescent idiopathic scoliosis: an observational retrospective study of pain outcomes from a registry of 1744 patients with a mean follow-up of 3.4 years

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Abstract

Background Traditionally, adolescent idiopathic scoliosis (AIS) has not been associated with back pain, but the increasing literature has linked varying factors between pain and AIS and suggested that it is likely underreported.

Purpose Our objective was to investigate factors associated with post-op pain in AIS.

Methods A prospectively collected multicenter registry was retrospectively queried. Pediatric patients with AIS having undergone a fusion with at least 2 years of follow-up were divided into two groups: (1) patients with a postoperative SRS pain score ≤ 3 or patients having a reported complication specifically of pain, and (2) patients with no pain. Patients with other complications associated with pain were excluded.

Results Of 1744 patients, 215 (12%) experienced back pain after postoperative recovery. A total of 1529 patients (88%) had no complaints of pain, and 171 patients (10%) had pain as a complication, with 44 (2%) having an SRS pain score ≤ 3. The mean time from date of surgery to the first complaint of back pain was 25.6 ± 21.6 months. In multivariate analysis, curve type (16% of Lenke 1 and 2 curves vs. 10% of Lenke 5 and 6, $p = 0.002$) and a low preoperative SRS pain score (no pain 4.15 ± 0.67 vs. pain 3.75 ± 0.79, $p < 0.001$) were significant. When comparing T2–4 as the upper instrumented vertebrae in a subgroup of Lenke 1 and 2 curves, 9% of patients had pain when fused to T2, 13% when fused to T3, and 18% when fused to T4 ($p = 0.002$).

Conclusion 12% of all AIS patients who underwent fusion had back pain after postoperative recovery. The most consistent predictive factor of increased postoperative pain across all curve types was a low preoperative SRS pain score.

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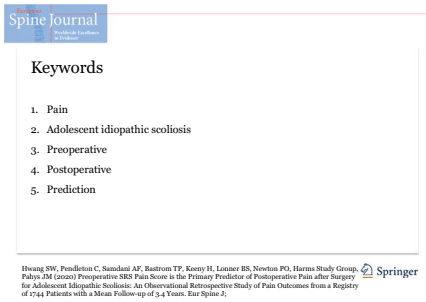
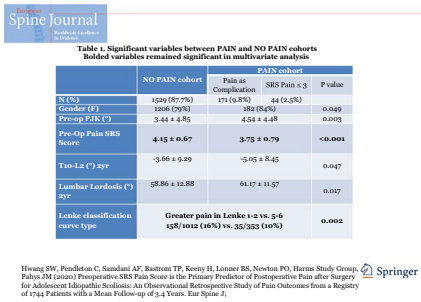
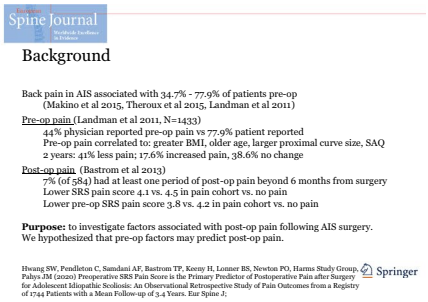
Extended author information available on the last page of the article

Graphic abstract

These slides can be retrieved under Electronic Supplementary Material.







Keywords Pain · Adolescent idiopathic scoliosis · Preoperative · Postoperative · Prediction

Introduction

Back pain has been recognized as increasingly common in patients with AIS, both preoperatively and postoperatively. Historically, preoperative pain in patients with AIS has been underestimated and underreported by patients, families, and physicians [1]. In a study published 20 years ago, 23% of patients with AIS reported pain at the time of diagnosis [2], whereas more recent studies suggest that nearly half (47.3%) of patients experience back pain [3]. Preoperative pain has also been associated with increased body mass index (BMI), larger Cobb angles, and older age [1, 3–5], with an incidence of preoperative pain ranging from 34.7 to 77.9%. In a recent study [6], pain was the greatest perioperative concern of patients and families.

Studies assessing postoperative pain outcomes based on SRS-22 scores have demonstrated an increase in postoperative pain scores between 2- and 5-year follow-up visits but documented overall unchanged levels of patient satisfaction over the same interval [7].

Patient reporting of postoperative pain is well correlated with lower scores on the SRS-22 questionnaire both pre- and postoperatively, suggesting that it is a reliable gauge of subjective pain [8]. However, cultural variations may affect patient concerns and hence influence responses to the SRS-22 questionnaire [9, 10].

Overall, identification of pain associated with AIS has improved; however, a better understanding of factors influencing postoperative pain is necessary to provide appropriate counseling to patients and families in the perioperative setting.

Methods

A prospectively collected multicenter database of patients with AIS and a minimum 2-year follow-up was retrospectively reviewed. Institutional review board (IRB) approval for this study was obtained from each of the contributing centers prior to the study initiation. Consecutive pediatric patients (between 10 and 18 years of age) with (1) adolescent idiopathic scoliosis and (2) operative intervention to correct spinal deformity were included in this study. All surgeries were performed at one of 12 hospitals throughout North America specializing in the treatment of pediatric spinal deformity. At a minimum, patients within this registry were evaluated postoperatively at 6 weeks, 6 months, 12 months, and 24 months postoperatively. Some patients returned for a 5-year follow-up visit. A minimum follow-up of 24 months was required for all patients, but the 2-year data point could span up to 4.5 years.

Patient demographics as well as clinical and radiographic data were prospectively collected, but all analyses were performed retrospectively. Any patient with a concurrent complication (e.g., pseudarthrosis, implant failure, prominence, infection, neurological injury) that was associated with pain was excluded. Patients were divided into two groups: (1) those with SRS pain scores ≤ 3 postoperatively or with a recorded complication of back pain occurring beyond 6 months of surgery (pain), and (2) all others (no pain). The number of patients with an SRS pain score ≤ 3 was too small to evaluate independently, and therefore, they were grouped together with those who had pain as a complication for analyses. A selective thoracic fusion was defined as the lowest instrumented vertebra (LIV) at least 2 vertebrae rostral to the apex of the lumbar curve.

Statistical analysis

A retrospective analysis of our registry was performed. Univariate analysis was then used to compare demographic, pre- and postoperative radiographic, and operative variables between both groups. Variables meeting a p value of 0.05 were then entered into a multivariate regression model. The analysis was performed for the entire group, and then the analysis was repeated for subgroups based on curve pattern and patients were divided into the groups of Lenke 1 and 2, Lenke 3 and 4, or Lenke 5 and 6. The Lenke 1 and 2 groups were further subdivided to try to elucidate if the upper instrumented vertebra (UIV) was associated with unfused upper thoracic curves. Criteria for remaining within the final regression models were $p < 0.05$. All analyses were carried out with SPSS v.24 (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY.)

Results

All patients

Of all patients with AIS who met the inclusion criteria, there were 1388 female and 356 male patients with a mean follow-up of 3.4 ± 1.9 years. Within this group, 1529 patients (88%) had no complaints of pain, and of the remaining patients, 171 (10%) had pain reported as a complication per the registry protocol, with 44 (2%) having an SRS pain score ≤ 3. Within the "pain reported as a complication" subgroup, 15 patients (9% of pain group) had recurrent reported complications of pain, with one patient having two recurrent episodes. Of the 187 discrete episodes of pain complication, 130 (69.5%) were for back pain, 23 (12.3%) for shoulder/scapular pain, 12 (6.4%) for chest wall pain, and 22 (11.8%) for other/not described. The mean time from date of surgery to first complaint of back pain was 25.6 ± 21.6 months (range 5.9–139.8 months) with a median of 19 months. For the entire group, SRS-22 pain scores improved from 4.1 ± 0.7 preoperative to 4.5 ± 0.6 at 2 years postoperative ($p \leq 0.001$). The no pain group improved from 4.2 ± 0.7 preoperative to 4.5 ± 0.5 at 2 years postoperative ($p \leq 0.001$), and the pain group improved from 3.7 ± 0.8 preoperative to 3.9 ± 0.8 at 2 years postoperative ($p = 0.02$).

When comparing both pain and no pain groups, statistically significant variables included preoperative SRS pain score ($p < 0.001$), preoperative degree of junctional kyphosis ($p = 0.003$), female gender ($p = 0.049$), 2-year T10–L2 angulation ($p = 0.047$), and 2-year lumbar lordosis ($p = 0.017$) (Table 1). In a multivariate analysis of all patients, curve type (16% of Lenke 1 and 2 curves vs. 10% of Lenke 5 and 6, $p = 0.002$) and preoperative SRS pain score (no pain 4.15 ± 0.67 vs. pain 3.75 ± 0.79, $p < 0.001$, meeting the minimal clinically important difference [MCID] of 0.2) remained significant.

Patients were then grouped into Lenke 1–2, Lenke 3–4, and Lenke 5–6 subgroups for further analysis. In patients with Lenke 1–2 curves, having undergone a selective thoracic fusion was not associated with pain ($p = 0.095$). In all groups, curve magnitude (primary, upper thoracic, or lumbar), percent correction, BMI, and curve flexibility, along with other recorded radiographic and clinical variables, were not statistically significant.

Lenke 1–2 curves

The Lenke 1–2 subgroup included 1170 patients, with 1012 (86.5%) having no pain and 158 (13.5%) having pain. In the pain group, 131 (11.2%) had pain as a complication, and 27 (2.3%) had SRS pain scores ≤ 3. Of these patients, 921 (78.7%) were female and 249 (2.1%) were male; selective fusion was performed in 750 (64.1%) patients, while non-selective fusion was performed in 420 (35.9%). Significant variables are indicated in Table 2. Only female gender ($p = 0.044$), less rostral upper instrumented vertebra (UIV) ($p = 0.002$), and lower preoperative SRS scores ($p < 0.001$)

Table 1 Significant variables between pain and no pain groups

	No pain group	Pain group		
		Pain as complication	SRS pain ≤ 3	p value
N (%)	1529 (87.7%)	171 (9.8%)	44 (2.5%)	
Gender (F)	1206 (79%)	182 (84%)		0.049
Pre-op PJK (°)	3.44 ± 4.85	4.54 ± 4.48		0.003
Pre-op pain SRS score	**4.15 ± 0.67**	**3.75 ± 0.79**		**< 0.001**
T10–L2 (°) 2 yr	− 3.66 ± 9.29	− 5.05 ± 8.45		0.047
Lumbar lordosis (°) 2 yr	58.86 ± 12.88	61.17 ± 11.57		0.017
Lenke classification curve type	**Greater pain in Lenke 1–2 versus 5–6 158/1012 (16%) versus 35/353 (10%)**			**0.002**

Bolded variables remained significant in multivariate analysis

PJK proximal junctional kyphosis

Table 2 Subgroup analysis of Lenke 1 and 2 curve patterns

	No pain	Pain	*p* value
Gender (F)	**787 (78%)**	**134 (85%)**	**0.044**
UIV (T2–4)	**897 (88%)**	**136 (86%)**	**0.002**
T2	32%	20%	
T3	29%	27%	
T4	28%	40%	
LIV groups (L3–5)	80%	20%	0.012
Selective fusion	88.5%	11.5%	0.006
Non-selective	82.9%	17.1%	
Pre-op variables			
SRS pain score	**4.17 ± 0.66**	**3.78 ± 0.82**	**< 0.001**
Cobb angle (°)	54.4 ± 10.8	52.8 ± 11.0	0.093
EIV (°)	15.9 ± 13.1	12.8 ± 15.2	0.010
EIV disk angulation (°)	4.08 ± 4.17	3.32 ± 4.74	0.047
T2–5 kyphosis (°)	8.13 ± 6.47	9.25 ± 6.00	0.049
PJK (°)	3.33 ± 4.87	4.86 ± 4.54	< 0.001
DJK (°)	− 8.03 ± 8.60	− 9.63 ± 9.71	0.041
2-year post-op variables			
SRS pain score	4.54 ± 0.47	3.98 ± 0.79	< 0.001
Cobb angle (°)	19.8 ± 7.7	19.1 ± 3.2	0.273
T2–12 kyphosis (°)	29.32 ± 10.30	31.90 ± 10.70	0.005
T2–5 kyphosis (°)	9.40 ± 6.40	10.90 ± 6.09	0.008
T10–L2 (°)	− 1.85 ± 9.40	− 3.68 ± 8.53	0.030
Lumbar lordosis (°)	57.71 ± 12.69	60.52 ± 11.99	0.019
DJK (°)	− 5.90 ± 9.66	− 8.13 ± 10.60	0.011

Bolded variables remained significant in multivariate analysis

DJK distal junctional kyphosis

remained significant in multivariate analysis. A higher percentage of patients instrumented to T4 were represented in the pain group vs. T2. When comparing T2–4 as the UIV, 9% had pain when fused to T2, 13% when the UIV was T3, and 18% when fused to T4 ($p = 0.002$). Upper thoracic curve magnitude, percent correction, LIV, number of levels fused, and C7 to center sacral vertical line (CSVL) translation were not significant. When subdividing patients into Lenke 1 or Lenke 2 type curves, there was no significant difference in incidence of pain by UIV in Lenke 1 patterns, but in Lenke 2 type curves, patients with a UIV of T3 more often had pain (20%) than T1 (9.9%) or T4 (9.7%).

Lenke 3–4

The Lenke 3–4 subgroup included 186 patients; 164 (88.2%) had no pain, 16 (8.6%) had complication-related pain, and 6 (3%) had an SRS pain score ≤ 3. Statistically significant variables included preoperative SRS pain score ($p = 0.018$), preoperative end instrumented vertebra (EIV) disk angulation ($p = 0.018$), 2-year SRS pain score ($p < 0.001$), 2-year T10–L2 angle ($p = 0.003$), and 2-year Cobb angle ($p = 0.007$). However, only preoperative EIV disk angulation remained significant on multivariate analysis (Table 3).

Lenke 5–6

The Lenke 5–6 subgroup included 388 patients; 353 (91%) had no pain, 24 (6.2%) had complication-related pain, and 11 (2.8%) had an SRS pain score ≤ 3. Statistically significant variables included pre- and postoperative SRS pain scores, but only preoperative SRS pain score remained significant in multivariate analysis ($p < 0.001$) (Table 4). Selection of UIV ($p = 0.953$) and LIV ($p = 0.449$) and selective fusion ($p = 0.732$) were not correlated with pain in this group.

Discussion

As healthcare providers continue to try to optimize patient outcomes, increasing efforts are placed on minimizing pain. Bastrom et al. [8] noted that 7% of patients had an episode of pain reported as a complication after AIS surgery. Upasani et al. [7] reported that SRS pain scores decrease from 2 to 5 years after surgery (4.2 ± 0.6 to 3.9 ± 0.9), indicating that patients have increasing pain with time. Landman et al. [1] found that 41% of patients reported less pain after surgery, but 17.6% had more pain. Furthermore, Chan et al.

Table 3 Subgroup analysis of Lenke 3 and 4 curve patterns

	No pain	Pain	*p* value
Pre-op variables			
SRS pain score	4.07 ± 0.68	3.69 ± 0.75	0.018
Cobb angle (°)	66.07 ± 15.89	72.18 ± 17.61	0.097
EIV disk angulation (°)	**3.11 ± 5.60**	**0.09 ± 5.30**	**0.018**
2-year variables			
SRS pain score	4.49 ± 0.48	3.78 ± 0.87	< 0.001
T10–L2 (°)	− 5.51 ± 8.39	− 11.27 ± 7.67	0.003
Cobb angle (°)	21.57	27.05	0.007

Bolded variables remained significant in multivariate analysis

Table 4 Subgroup analysis of Lenke 5 and 6 curve patterns

	No pain	Pain	*p* value
Pre-op variables			
Pain SRS	**4.52 ± 0.47**	**3.74 ± 0.90**	**< 0.001**
Cobb (°)	51.98 ± 10.19	52.29 ± 0.12	0.863
2-year variables			
Pain SRS	4.13 ± 0.68	3.61 ± 0.72	< 0.001
Cobb (°)	19.43 ± 8.38	17.38 ± 9.37	0.179

Bolded variables remained significant in multivariate analysis

[6] surveyed AIS patients and families and noted that the predominant concern among them was perioperative pain.

In our series, we noted an overall 12% incidence of pain. We defined our group as having a low SRS pain score (≤ 3) or a complication of pain requiring treatment. Our incidence is likely higher than that of Bastrom et al. [8], even though there is overlap from the same registry, since we included low SRS scores in our group. Similarly, we may have a lower incidence than that of Landman et al. [1] since we excluded any known complications that may be associated with pain (pseudarthrosis, neurological injury, etc.). Nonetheless, the finding that approximately 1 in 10 patients may have a worsened outcome due to postoperative pain is concerning and warrants further investigation.

Several other studies have attempted to investigate factors associated with postoperative pain with conflicting results. Crawford et al. [11] reported a lower SRS pain score (3.92) in patients undergoing a non-selective fusion as defined by an LIV of L3 or below when compared to those fused to an LIV of L1 or above (4.13). Similarly, Bartie et al. [12] reported a higher incidence of pain in patients fused to L4 with greater than 10 years of follow-up. In contrast, Danielsson and Nachemson [13] published a series of 142 patients treated with Harrington rods at 23 years of follow-up and noted a higher incidence of lumbar pain (65% vs. 47%) in the nonoperative scoliotic control group. They did not note a correlation with LIV selection, curve magnitude, BMI, or smoking but did find a greater incidence of back pain in patients where the UIV was fused to T5 or lower.

Selective fusions did not correlate with pain in the multivariate analysis. Our definition of selective fusion also varied from that of Crawford et al. [11] but should not have significantly impacted the findings. In the Crawford study [11], preoperative SRS scores were not detailed, which may account for a difference from our findings as well. Similar to the findings from Danielsson and Nachemson [13], we noted a higher incidence of pain associated with more caudal UIV in the Lenke 1–2 subgroup, but variables such as shoulder balance and T1 tilt were not correlated in our patients. This may be counterintuitive, as one might hypothesize that more pain may occur with more muscle dissection, longer fusions, or larger proximal curves (as reported by Landman et al. [1]). However, we also noted a higher incidence of pain (16%) in Lenke 1–2 curve patterns as opposed to the Lenke 5–6 groups (10%) where more lumbar muscle dissection was likely required. It is possible that pain from patients self-adjusting to gain balance after surgery may contribute to the increased incidence, but our results are unable to draw any conclusions to explain this finding.

Although several radiographic measures were statistically significant, these findings may carry little clinical impact given the subtle differences in magnitude and the wide range in standard deviations. Aside from radiographic parameters, the only other variables that remained significant on multivariate analysis were female gender and a low preoperative SRS pain score. Gender may be partially reflected by the disproportionate prevalence of AIS in young girls. The only variable consistently predicting postoperative pain across all groups in univariate analysis was a low preoperative SRS pain score, which remained significant in the subgroup analysis of Lenke 1–2 and the Lenke 5–6 groups. The Lenke 3–4 subgroup's smaller size may have contributed to why preoperative SRS pain was not significant in multivariate analysis.

Although the data are limited from a retrospective analysis and our inability to further answer questions outside of data fields already collected, the large group size and multicenter nature of this study help us extrapolate these conclusions to a wider population of patients. The 5-year follow-up of our registry at the time of publication was 53%, and therefore, our incidence of pain may underestimate the true incidence given patients lost to follow-up. Often, patients may be less inclined to return for follow-up when doing well, but this is offset by other factors as patients grow older. Given the impact of preoperative pain on postoperative pain, further research is required to better understand what factors influence preoperative pain.

Conclusion

In conclusion, 12% of AIS patients had back pain after postoperative recovery and excluding known complications. For Lenke 1 and 2 curves, generally the incidence decreases with more proximal instrumentation; however, within the subgroup of Lenke 2 curves, patients with an UIV of T3 more often had pain. Overall, the most consistent predictive factor across curve types was a low preoperative SRS pain score, signifying greater preoperative pain.

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Compliance with ethical standards

Conflict of interest S.W. Hwang has received consultancy fees and stock options from Auctus; consultancy fees and speaker honorarium from NuVasive; and speaker honorarium from Zimmer Biomet. A.F. Samdani has received consultancy fees from DePuy Synthes Spine; consultancy fees from Ethicon; consultancy fees from Globus Medical; consultancy fees and royalties from NuVasive; consultancy fees from Stryker; and consultancy fees and royalties from Zimmer Biomet. B.S. Lonner has received consultancy fees from ApiFix; consultancy fees, royalties, and speaker honorarium from DePuy Synthes Spine; consultancy fees Ethicon; research support from the John and Marcella Fox Fund; speaker honorarium from K2M; research support from OREF; stock/options from Paradigm Spine; stock/options from Spine Search; consultancy fees from Unyq Align; consultancy fees and royalties from Zimmer Biomet. P.O. Newton has received research support from Alphatec Spine; research support from DePuy Synthes Spine via the Setting Scoliosis Straight Foundation; royalties from DePuy Synthes Spine; stock/options from Electrocore; consultancy fees and research support from EOS Imaging; consultancy fees and royalties from K2M; research support from K2M via the Setting Scoliosis Straight Foundation; research support from MAZOR Surgical Technologies; research support from Medtronic via the Setting Scoliosis Straight Foundation; research support from NuVasive; research support from NuVasive via the Setting Scoliosis Straight Foundation; research support Orthopediatrics; research support Zimmer Biomet. Harms Study Group: Research grants to the Setting Scoliosis Straight Foundation in support of Harms Study Group research from DePuy Synthes Spine, EOS Imaging, K2M, Medtronic, NuVasive, and Zimmer Biomet. J.M. Pahys has received consultancy fees from DePuy Synthes Spine; consultancy fees from NuVasive; and consultancy fees from Zimmer Biomet. The other authors (C. Pendleton, T.P. Bastrom, H. Keeny) report no conflicts of interest.

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