Adolescent idiopathic scoliosis: shoulder balance and SRS-22 patient-reported outcome

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Abstract

Background

This is a retrospective database review with the objective to review adolescent idiopathic scoliosis (AIS) surgery in terms of radiographic and patient-reported surgical outcome, assessing the relationship with shoulder balance.

Methods

Database search identified 97 AIS patients who underwent single-stage corrective fusion between 2011 and 2017, and had one year follow-up. The average age at surgery was 15.0 (10.9 – 20.7 ± 2.1) years. Preoperative and one-year radiographic analysis included Cobb angles, flexibility and correction indices. The curves were classified according to Lenke as 43 type 1, 14 type 2, 11 type 3, 12 type 4, 12 type 5 and five type 6. Shoulder balance was assessed by T1 tilt angle, clavicle angle and shoulder height. Pre- and postoperative Scoliosis Research Society (SRS)-22 patient-reported outcome measures (PROMs) were assessed in relation to the radiographic results.

Results

In Lenke 1–4, the preoperative Cobb angle was 64.4° (26–99 ± 15.69), with a flexibility index of 28% corrected to 22.8° (6–62 ± 11.4). Lenke 5–6 thoracolumbar (TL) was corrected from 56.8° (30–88 ± 143), with a flexibility index of 46% to 12.7° (0–34 ± 7.9). Overall SRS-22 postoperative satisfaction was high at 9.6 (6–10 ± 0.9), with improvement in self-image and mental health domains. While preoperative T1 tilt angle was associated, clavicle angle and shoulder height showed no difference in SRS-22 score.

Conclusion

Surgery improved SRS-22 PROMs overall, as well as self-image and mental health domains. Radiographic shoulder imbalance did not negatively affect the PROM.

Level of evidence: 4

Keywords: scoliosis, adolescent, surgery, PROMs, outcome, shoulder height, shoulder balance

Introduction

Adolescent idiopathic scoliosis (AIS) is a three-dimensional spine deformity without identifiable aetiology that affects 5.2% of children between 11 and 18 years.[1,2] It is described as any curve greater than or equal to 10° in the coronal plane.[3] Instrumented spinal fusion with pedicle screws and rods is the modern surgical technique used to correct the deformity.

Shoulder balance is one of the indicators of successful scoliosis surgery and may influence patient cosmesis and satisfaction.[4] Despite radiographic imbalance, patient perceptions may differ. This discrepancy between radiological and cosmetic shoulder balance was reported by Qiu et al.[5] Matamalas et al. showed no correlation between clinical/radiological shoulder balance and perceived shoulder balance.[6]

The Scoliosis Research Society (SRS)-22 is the most widely used validated tool to measure patient-reported outcomes in this setting. It provides a simple, practical, disease-specific, patient-based assessment in AIS. Surgery has shown improvement in SRS-22 domains of pain, self-image, mental health, and function in a two-year follow-up.[7]

We reviewed AIS surgical outcome in terms of radiographic and patient-reported outcome measures (PROMs), assessing the relationship with shoulder balance.

Methods

A retrospective study was performed on a single surgeon's (senior author) prospectively maintained database following institutional ethical approval (R039/2013). Between 2011 and 2017, 97 patients with single-stage corrective fusion for AIS were identified with one year follow-up available.

Demographic data (sex, age), Lenke curve type, and surgical approach with blood loss and duration were recorded. The estimated blood loss was calculated from the cell saver collection less the saline used for irrigation.

All radiographic images were accessed from the picture archiving and communication system (PACS). Preoperative

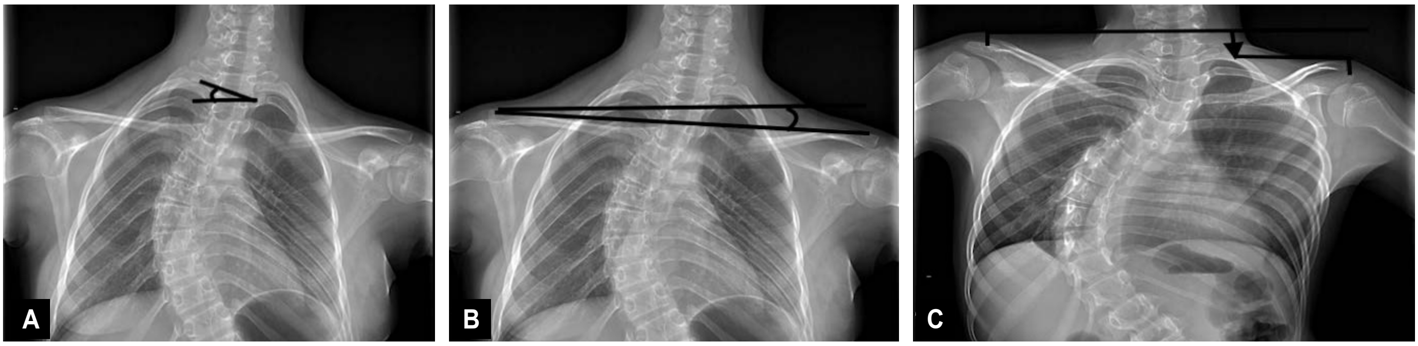

Figure 1. a) Tilt angle between proximal end plate of T1 and a horizontal line; b) clavicle angle: intersection line connecting the highest two points of each clavicle and a horizontal line; c) shoulder height difference between height of both acromioclavicular joints

radiographic assessment included whole spine erect anterior-posterior (AP) and lateral views, as well as supine bending views. Curves were measured using the Cobb method. The flexibility index was calculated (erect angle-bending angle/erect angle), and expressed as a percentage.[8] At one year following surgery, AP and lateral X-ray views were analysed, and residual Cobb's angle was measured on coronal views. The correction index was calculated (preoperative angle − postoperative angle)/ preoperative Cobb angle), expressed as a percentage.[9]

Further radiographic analysis included T1 tilt angle, clavicle angle and shoulder height (*Figure 1*). T1 tilt angle was defined as an angle between the proximal end plate of T1 and the horizontal.

Shoulder balance was determined from the clavicle angle, measured by the intersection of the line connecting the highest two points of each clavicle and the horizontal. Shoulder height was calculated by the difference of the acromioclavicular joints on both sides.[10]

All patients were asked to complete the SRS-22 questionnaire preoperatively and again at six months postoperatively. The 22 answers allow calculation of the five domains of pain, appearance, activity, mental health and satisfaction. Postoperatively, there is an additional satisfaction domain.

Descriptive and analytical statistical analysis was performed using Excel Microsoft software, with the Fisher's exact test used for categorical data and the t-test for continuous data.

Table I: Curve types (Lenke)

Lenke type	Frequency
1	43
2	14
3	11
4	12
5	12
6	5

Table II: Overall Scoliosis Research Society-22 (SRS-22) score

	Preop n = 51	Postop n = 48	p-value
Function	3.9 (2.2−4.6 ± 0.6)	4.0 (2.6−5.0 ± 0.6)	NS 0.511
Pain	4.1 (1.6−5.0 ± 0.9)	4.4 (2.2−5.0 ± 0.7)	NS 0.180
Self-image	3.3 (1.6−4.6 ± 0.7)	4.4 (3.0−5.0 ± 0.5)	S 0.0001
Mental health	3.8 (1.6−4.6 ± 0.7)	4.2 (2.8−5.0 ± 0.5)	S 0.0088
Total	15.2 (10.4−18.4 ± 1.8)	17.0 (10.6−19.0 ± 1.6)	S 0.0001

NS: not significant; S: significant

Results

Of the 97 AIS patients, 83 were female (86%) and 14 male (14%). The average age at surgery was 15 (10.9–20.7 ± 2.1) years.

The surgical approach was posterior in 79 and anterior in 18 patients, with thoracolumbar (TL) scoliosis the indication for the anterior retroperitoneal approach. The respective operating time was not statistically different at 162 (80–295 ± 39.9) and 155 (100–195 ± 297.9) minutes. However, there was a higher estimated blood loss with posterior surgery at 845.6 (200–3 000 ± 490.3) millilitres compared to 382.4 (100–1 000 ± 279.9) (p = 0.001).

Curve types were predominately Lenke 1 (43/97), with a relatively even spread of the rest (*Table I*). The curves were grouped into thoracic (Lenke 1–4) and TL (Lenke 5–6).

In Lenke 1–4, the average preoperative main thoracic Cobb's angle was 64.4° (26–99 ± 15.7), with flexibility index of 28% (03–0.9 ± 0.2). At one year follow-up, the average Cobb's angle was 22.8° (6–62 ± 11.4), with a correction index of 65% (0.1–0.9 ± 0.1).

The Lenke 5–6 TL average preoperative Cobb's angle was 56.8° (30–88 ± 13.9), with a flexibility index of 46% (0.2–1.0 ± 0.3). At one year follow-up, the average Cobb's angle was 12.7° (0–34 ± 7.9), with correction index of 78% (0.5–1.0 ± 0.1). The better anterior procedure correction index was significant (p = 0.002), with both procedure correction far better than predicted by the flexibility index (p = 0.0001).

SRS-22 scores were available in 51 preoperative and 48 postoperative patients. The self-image and mental health domains, as well as the total score, showed statistically significant improvement, as shown in *Table II*.

When comparing the Lenke 1–4 thoracic patients and Lenke 5–6 TL preoperative SRS-22 scores, patients with thoracic deformities had lower self-image score of 3.2 vs 3.7 (p < 0.04).

The shoulder parameters are illustrated in *Figures 2–4*. These groups were compared to their respective SRS-22 scores. A preoperative T1 tilt angle of more than 10° had a lower self-image score (2.7 vs 3.4) (p = 0.014). Patients with increased postoperative clavicle angle and shoulder height did not differ in any SRS-22 domain, even when shoulder height was more than 20 mm.

The overall postoperative satisfaction score was high at 9.6 (6–10 ± 0.9), and was no different despite shoulder imbalance.

Discussion

The goal of surgery in AIS is to correct the structural curves, stopping deformity progression and improving patient appearance.

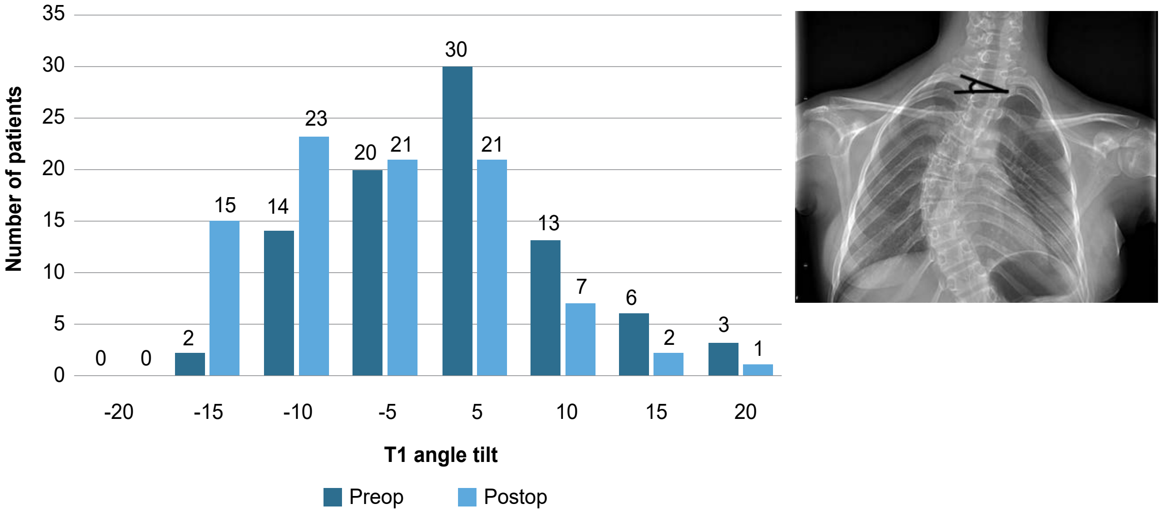

Figure 2. T1 tilt

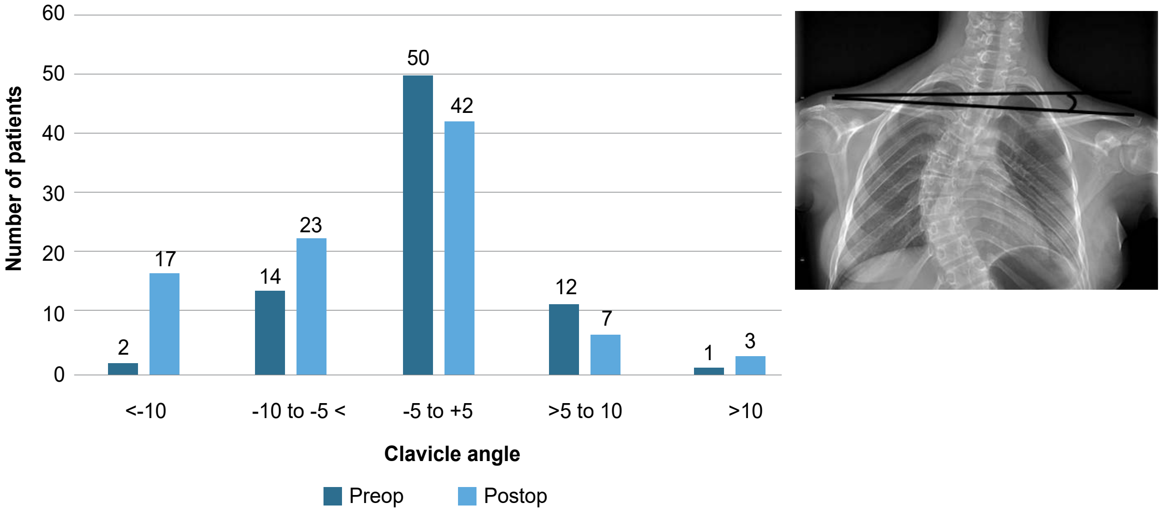

Figure 3. Clavicle angle

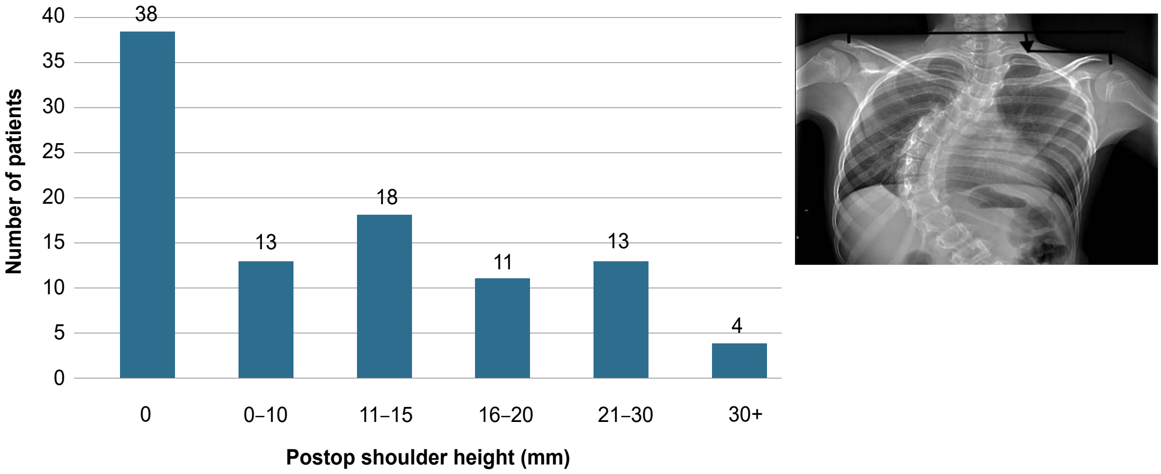

Figure 4. Shoulder height

The Lenke classification is a useful tool to assist surgeons classify curves and guide them in operative decisions.[11] Both the curve magnitude and flexibility index are determinants of full or near-full correction in AIS patients.[8] Our average 64% main thoracic and 78% TL curve correction is consistent with previously reported studies using pedicle screw constructs, ranging from 62 to 78%.[12-16] Our higher correction in TL curves is both due to the anterior technique of full discectomy/release as well as less costal resistance to correction.

The SRS instrument was developed in 1999 by Haher et al. and has developed with improved internal consistency, resulting in the SRS-22 score. It measures health-related quality of life outcomes in the five domains of function, pain, mental health, self-image and satisfaction.[17] We found improvement in the self-image, mental health domains and overall score with surgery. Gardner et al. supports this with self-image domain scores higher at six weeks postoperatively, and mental health scores improving over time, although the change was slow.[18]

Some studies have shown a correlation between SRS-22 outcome and radiographic parameters in AIS,[4] and that shoulder imbalance of (height of 2 cm) is a possible cause of patient dissatisfaction.[18] In our study, clavicle angle and shoulder height did not impact the SRS-22 score even when shoulder imbalance was > 2 cm. Our cohort had a unanimous and very high overall satisfaction score. This may indicate the gratitude these children felt having had the opportunity of the corrective procedure, with significant curve correction, which in our region is not readily available. This may explain tolerance of the shoulder imbalance.

Other authors have reported on a negative correlation of T1 tilt and the self-image domain, suggesting possible cultural and socioeconomic variation.[19,20]

Despite our attempts as surgeons to control shoulder balance in AIS patients, it remains common, with a reported incidence of 25%.[21] To the surgeon, it may be unacceptable but yet this does not always appear to be the case to the patient. Guler et al. support our findings in a similar study. They confirmed no significant correlation between shoulder imbalance and patient satisfaction with treatment evaluated by the SRS-22.[22]

This is an important concept as attempts to control the shoulders require increasing risk to the patient with prolonged surgery, increased invasiveness of release and density of instrumentation. This also has a cost implication.

Conclusion

Shoulder imbalance remains common postoperatively in AIS despite modern corrective techniques and diligent preoperative planning. However, patients remain highly satisfied with surgical correction when assessed by SRS-22 PROMs, improvement in self-image and mental health domains as well as overall score.

This radiographic shoulder imbalance does not negatively affect the patient's perception of improvement.

Despite a large cohort, only half had SRS-22 PROMs, which presents a limitation to the study. These were also done early on, at one time point postoperatively, and the long-term gain is not captured. Going forward, it would be useful to increase the cohort size as well as the duration of follow-up.

Ethics statement

The authors declare that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010.

Prior to commencement of the study, ethical approval was obtained from the University of Cape Town Research Ethics Committee (ref: R039/2013). All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Patients included in the study are all managed in a teaching environment where there is implicit consent.

Declaration

The authors declare authorship of this article and that they have followed sound scientific research practice. This research is original and does not transgress plagiarism policies.

Author contributions

LN: data capture, data analysis, first draft preparation

MMK: data capture, data analysis:

RND: study conceptualisation, database creation and operative data entry, data analysis, manuscript planning, supervision and revision

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