



Long-term follow-up after surgical treatment of adolescent idiopathic scoliosis using high-density pedicle screw constructs: Is 5-year routine visit required?

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Abstract

Purpose The objective of this study is to determine whether routine follow-up 5 years after adolescent idiopathic scoliosis (AIS) surgery is likely to affect postoperative care for patients treated with high-density pedicle screw constructs, when routine 2-year follow-up has been performed.

Methods We reviewed 80 patients undergoing surgery for AIS using high-density pedicle screw constructs and followed routinely 2 and 5 years after surgery. Quality of life (QOL) was assessed using the SRS-30 outcome questionnaire. Reoperations occurring between 2 and 5 years after surgery were identified.

Results Curve correction and QOL were similar between 2- and 5-year visits. Two patients required revision surgery after presenting during unplanned visits between the 2- and 5-year follow-ups. One patient presented at the routine 5-year visit with an asymptomatic undisplaced rod fracture without loss of correction, and it was decided to follow-up only as needed.

Conclusions In AIS patients for whom routine follow-up 2 years after surgery using high-density pedicle screw constructs was uneventful, additional routine 5-year follow-up is not likely to affect postoperative care and revision rate. Patients developing complications and needing reoperation between 2 and 5 years after surgery will most likely present during unplanned visits rather than during routine follow-up appointments. Easy access to emergent visits on an as-needed basis is therefore important for this population if routine 5-year follow-up is not planned.

Graphical abstract

These slides can be retrieved under Electronic Supplementary Material.

Key points

- Patients with adolescent idiopathic scoliosis needing reoperation between 2 and 5 years after surgery will most likely present during unplanned visits rather than during routine follow-up appointments;
- Curve correction was similar between 2- and 5-year visits;
- Quality of life was similar between 2- and 5-year visits.

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Variable	Preoperative	2-year follow-up	5-year follow-up	2- vs. 5-year (P value)
Radiographic assessment				
Main Cobb angle (°)	61.9±10.6	16.9±5.2	17.6±5.3	0.8
Thoracic kyphosis (°)	22.1±11.6	20.6±1.1	20.1±0.4	0.2
Lumbar lordosis (°)	52.6±12.9	52.9±6.1	54.3±6.9	0.004*
Quality of life assessment				
Functionality	4.0±0.6	3.6±0.7	3.9±0.6	0.4
Pain	3.8±0.8	4.1±0.8	4.0±0.7	0.3
Self-image/appearance	3.4±0.7	4.0±0.7	4.1±0.5	0.6
Medical health	3.9±0.7	4.0±0.8	4.0±0.7	0.7
Satisfaction	—	4.4±0.9	4.4±0.8	0.4
Total score	3.6±0.5	4.1±0.6	4.1±0.5	0.9

* Significant when p value < 0.05.

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Take Home Messages

- Patients with adolescent idiopathic scoliosis needing reoperation between 2 and 5 years after surgery will most likely present during unplanned visits;
- When follow-up 2 years after surgery is uneventful, routine 5-year follow-up is not likely to affect postoperative care and revision rate;
- Easy access to emergent visits on an as needed basis is important if routine 5-year follow-up is not planned.

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Keywords Adolescent idiopathic scoliosis · Quality of life · Scoliosis · Spinal deformity · Spine

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Introduction

Several studies have documented the long-term outcomes after surgical treatment of adolescent idiopathic scoliosis (AIS). While most patients will be followed for a minimum of 2 years

after surgery, some studies suggest that longer clinical follow-up might be required. Ahmed et al. [1] reported that 5-year follow-up was required because reoperation can occur between 2 and 5 years after surgery. However, they did not determine whether routine follow-up 5 years after surgery was effective for reducing or preventing revision surgery. Moreover, they did not specifically analyze patients treated using all-pedicle screw constructs, although they are now widely used in posterior surgical treatment of AIS [2]. In addition, pedicle screw constructs have been shown to decrease mid- and long-term revision and complication rates compared to hook and hybrid constructs [12, 13]. Moreover, many surgeons will opt for high-density constructs involving a high number of fixation anchors in an attempt to reach optimal curve correction. While some studies failed to demonstrate increased curve correction with high-density constructs [3–7], others have shown that increasing the number of fixation anchors provides improved correction of the main curve [8–11]. In particular, a recent study [10] has shown that a high implant density (number of vertebral anchors divided by the number of available anchor sites within the instrumented segment multiplied by 100) $\geq 70\%$ was associated with optimal coronal curve correction for posterior AIS surgery. Consequently, posterior AIS surgery using pedicle screw constructs with an implant density $\geq 70\%$ remains a technique that is often used nowadays.

Garg et al. [14] have previously questioned the need for routine radiographs after posterior surgery in AIS and stated that after obtaining baseline postoperative radiographs, additional radiographs during the first year after surgery may not be required in the absence of clinical symptoms. In their study of 227 patients, they concluded that additional radiographs for asymptomatic patients were not likely to affect treatment, while increasing radiation exposure to patients and healthcare costs. Unfortunately, there is no study that assessed the benefits of routine long-term follow-up beyond 2 years after AIS surgery with the specific intent to determine whether it can effectively affect postoperative care and the rate of revision surgery.

The purpose of this study is therefore to determine whether routine follow-up 5 years after AIS surgery is likely to affect postoperative care, particularly in terms of revision surgery. Because high-density pedicle screw constructs are widely used nowadays, this work will focus on AIS patients undergoing posterior surgery using pedicle screw constructs with an implant density $\geq 70\%$. As a secondary objective, we will determine whether the radiographic and clinical outcomes differ between the 2- and 5-year follow-up visits.

Materials and methods

This retrospective study involves a consecutive cohort of patients who underwent posterior instrumentation and fusion for AIS at a single pediatric hospital between January 1,

2006, and July 31, 2013. There were 80 patients (10 males and 70 females) aged 14.5 ± 2.2 years. The inclusion criteria were: (1) diagnosis of AIS, (2) age at surgery between 10 and 18 years, and (3) attendance to routine follow-up visits 2 and 5 years after surgery. Prior to surgery and at each follow-up visit, all patients had standing full spine postero-anterior and lateral radiographs and answered the SRS-30 questionnaire to assess their quality of life (QOL). The study has been approved by the local institutional review board.

All patients underwent posterior instrumentation and fusion by one of 3 spine surgeons using all-pedicle screw constructs. In 71 patients, transverse process hooks were used only at the uppermost instrumented level, but all other vertebral anchors consisted of pedicle screws. Implant density was $\geq 70\%$ for all patients. This threshold was selected based on a previous study [10] showing that curve correction was comparable for constructs with a high implant density $\geq 70\%$.

All complications leading to reoperations have been collected prospectively in the local database for scoliosis surgery and updated during each visit to the spine clinic or during hospitalizations for spine-related conditions at our hospital. Medical charts were also reviewed in order to determine whether the decision to proceed to revision was made during routine follow-up visits or during unplanned visits. Main Cobb angle, thoracic kyphosis (T4–T12) and lumbar lordosis (T12–S1) were measured by a single observer on the radiographs obtained prior to surgery, as well as 2 and 5 years following surgery. QOL was quantified from domain and total SRS-30 scores prior to surgery, as well as 2 and 5 years following surgery. Preoperatively, domain scores were computed for function/activity, pain, self-image/appearance and mental health. Postoperatively after 2 and 5 years, the domain score related to satisfaction with management was also calculated. In addition to descriptive statistics, direct comparisons between the radiographic and QOL measures were made using paired Student *t* tests and a level of significance of 0.05.

Results

There were 29 (36.3%) patients with Lenke 1 curves, 10 (12.5%) patients with Lenke 2 curves, 17 (21.3%) patients with Lenke 3 curves, 5 (6.3%) patients with Lenke 4 curves, 9 (11.3%) patients with Lenke 5 curves and 10 (12.5%) patients with Lenke 6 curves.

There was no revision surgery performed before the 2-year routine follow-up. Between the 2- and 5-year visits, 2 patients required implant removal. The first patient underwent uneventful posterior instrumentation and fusion from T9 to L3 for her AIS. However, she was complaining of diffuse thoracolumbar pain at every follow-up visit

and was treated with physiotherapy and pain medication (nonsteroidal anti-inflammatory drug, amitriptyline and pregabalin). She requested an emergent appointment at our clinic 21 months after her index surgery due to pain primarily in the left paravertebral region at the level of the proximal implants. It was then decided to plan complete implant removal, which was performed 9 months later (30 months after the index surgery) and confirmed the presence of a solid fusion mass from T9 to L3. She was significantly improved with only occasional back pain 30 months after implant removal.

A second patient had uneventful posterior instrumentation and fusion from T4 to L4 for her AIS. She was complaining of occasional low back pain at the 2-year follow-up visit. Later, she underwent excision of a skin lesion in the left paravertebral region in a community hospital by a plastic surgeon. She developed a superficial infection following this procedure that required local irrigation and debridement by her plastic surgeon. She then presented to our clinic on an emergent basis 69 months after her index surgery for persisting wound drainage at the surgical site of the skin excision. We diagnosed a deep wound infection with fistula formation connecting with the spine. She therefore underwent irrigation, debridement, complete implant removal and antibiotic treatment. She remains free of infection 1 year after the revision procedure.

One patient had uneventful posterior instrumentation and fusion from T3 to T12 for her AIS and was asymptomatic throughout follow-up. She presented at the routine 5-year visit with an undisplaced titanium alloy rod fracture without

loss of correction, which was not present at the 2-year follow-up visit. The patient remained asymptomatic, and it was decided to follow up only as needed in the presence of pain and/or change in posture, appearance or shoulder/spine balance.

Radiographic and QOL values are shown in Tables 1 and 2, respectively. There was no difference in main Cobb angle between assessments made 2 and 5 years after surgery. Thoracic kyphosis was also similar for 2- and 5-year follow-up visits. However, lumbar lordosis was slightly increased by less than 2° on average. As for QOL assessments, there was no difference between 2- and 5-year follow-up visits.

Discussion

The advent of all-pedicle screw constructs has decreased the long-term risks of complications and revision surgery [12, 13]. It is therefore important to select a follow-up strategy that will optimize the use of healthcare and patients/parents resources and minimize costs and radiation exposure. While a previous study [14] suggested that it was safe to reduce the number of postoperative radiographs for asymptomatic patients in the first year following posterior surgery in AIS, our study is the first to question the benefits of routine follow-up 5 years after AIS surgery using high-density pedicle screw constructs. The results primarily suggest that when routine follow-up 2 years after surgery is uneventful, additional routine 5-year follow-up is not likely to affect postoperative care and the rate of reoperation.

Table 1 Preoperative and postoperative radiographic assessments ($n = 80$)

Variable	Preoperative	2-year follow-up	5-year follow-up	2- versus 5-year (P value)
Main Cobb angle (°)	61.9 ± 10.6	16.9 ± 5.2	17.0 ± 5.3	0.8
Thoracic kyphosis (°)	27.2 ± 13.6	28.6 ± 9.1	29.1 ± 8.4	0.3
Lumbar lordosis (°)	52.6 ± 12.9	52.9 ± 9.1	54.5 ± 8.9	0.004*

*Significant when P value < 0.05

Table 2 Preoperative and postoperative quality-of-life assessments from the SRS-30 patient questionnaire ($n = 80$)

Domain	Preoperative	2-year follow-up	5-year follow-up	2- versus 5-year (P value)
Function/activity	4.0 ± 0.6	3.9 ± 0.7	3.9 ± 0.6	0.4
Pain	3.8 ± 0.8	4.1 ± 0.8	4.0 ± 0.7	0.3
Self-image/appearance	3.4 ± 0.7	4.0 ± 0.7	4.1 ± 0.5	0.6
Mental health	3.9 ± 0.7	4.0 ± 0.8	4.0 ± 0.7	0.7
Satisfaction	–	4.4 ± 0.9	4.4 ± 0.8	0.6
Total score	3.6 ± 0.5	4.1 ± 0.6	4.1 ± 0.5	0.9

*Significant when P value < 0.05

The 5-year revision rate observed in our series (2.5%) was slightly better than that reported by Ahmed et al. [1] (6.1%) and might be explained by the strict inclusion of high-density pedicle screw constructs in our study. Accordingly, the 5-year revision rate in their subgroup of patients treated with high-density pedicle screw constructs (3.0%) reported in a separate study [15] was similar to our cohort. Unfortunately, previous studies reporting the long-term outcomes following AIS surgery did not address the relationship between routine follow-up visits and the onset of complications leading to reoperations. We have therefore examined these relationships in order to better define the clinical relevance of routine long-term follow-up 5 years after surgery for guiding the treatment of patients, when follow-up at 2 years has previously been performed.

For the 2 cases requiring revision surgery between 2 and 5 years after the index surgery, the need for reoperation was not determined during the routine follow-up visits, since both patients presented on an emergent basis during unplanned visits upon their request. Likewise, there was no new spine-related condition observed in the remaining patients during the routine 5-year visit that has not been identified previously at the 2-year follow-up, except for one patient with an undisplaced rod fracture diagnosed at the 5-year visit. Because this patient was asymptomatic and correction was well maintained, follow-up as needed was chosen for this patient.

There was no major benefit from adding routine 5-year follow-up to the routine 2-year visit in relationship with the radiographic parameters and QOL scores measured in this study. Similar to Hwang et al. [15], we observed that main curve correction and thoracic kyphosis remained similar between the 2- and 5-year visits. However, lumbar lordosis slightly increased between the 2- and 5-year visits, but this is not likely to be clinically significant since the difference was less than 2° on average. All QOL scores at 5 years were comparable to QOL scores assessed at 2 years. Overall, Hwang et al. [15] also noted that SRS scores were similar between 2- and 5-year follow-up visits, although there was slight deterioration in pain and mental health scores.

Study limitations

The main limitation relates to the small number of patients included in the study. However, our cohort is representative of patients treated with high-density pedicle screw constructs, since the baseline characteristics and outcomes are comparable to those observed in another paper studying a similar AIS subpopulation [15]. The similarity in terms of revision rate, radiographic and QOL outcomes with another study supports the validity of our results, despite the limited number of patients in our cohort. It is important, however, to underline that the conclusions are only applicable

to patients undergoing posterior surgery with high-density pedicle screw constructs.

We have specifically analyzed the benefit of routine 5-year visit in addition to the 2-year follow-up because surgeons often use this follow-up strategy after AIS surgery. Whether another long-term follow-up protocol such as routine visits 2 and 10 years after surgery would be beneficial cannot be determined from the current investigation and should be addressed in future studies. Similarly, the need for long-term follow-up during adult life should be considered to assess the changes in the distal uninstrumented segment and sagittal balance. In addition, further study addressing the cost-effectiveness of long-term follow-up should be performed in the future.

Conclusions

In AIS patients for whom routine follow-up 2 years after surgery using high-density pedicle screw constructs was uneventful, additional routine 5-year follow-up is not likely to affect postoperative care and the rate of revision. Patients developing complications and needing reoperation between 2 and 5 years after surgery will most likely present during unplanned visits rather than during routine follow-up appointments. Easy access to emergent visits on an as-needed basis is therefore important for this population if routine 5-year follow-up is not planned.

While this study does not support the clinical relevance of routine 5-year follow-up to guide the individual postoperative care and prevent the reoperation when 2-year follow-up is available, long-term follow-up remains an important aspect of research and epidemiological investigations on larger populations, particularly to assess sagittal balance and the status of the uninstrumented spine.

Compliance with ethical standards

Conflict of interest No funding was received for this research. There is no conflict of interest directly related to this research. JMMT, SP and HL are co-founders and board members of Spinologics Inc. RR and JJ have no competing interests associated with this work.

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