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Does pedicle screw density matter in Lenke type 5 adolescent idiopathic scoliosis?

Kerim Sariyilmaz, MD[a,*], Okan Ozkunt, MD[a], Gokhan Karademir, MD[b], Halil Can Gemalmaz, MD[a], Fatih Dikici, MD[a], Unsal Domanic, MD[a]

Abstract

The aim of this study is to compare the effects of high versus low implant density on correction in Lenke type 5 adolescent idiopathic scoliosis (AIS) patients. A retrospective study of 59 Lenke type 5 AIS patients treated at a single institution were divided into to 2 groups according to implant density. Implant density, preoperative, early postoperative, and last follow-up thoracolumbar/lumbar (TL/L) curves were measured. Thirty-one constructs were high and 28 constructs were low density. The groups were similar in terms of age, sex, Cobb angle, and follow-up time. Mean implant density in low density group and high density group was 75.4% and 96.6%, respectively. High versus low-density comparison showed that there is no significant difference with regard to curve correction in early postoperative and last follow-up periods. The results show that pedicle screw density being low or high, does not affect curve correction rates in the short and long term in our patients.

Abbreviations: 3D = 3-dimentional, AIS = adolescent idiopathic scoliosis, AP = anteroposterior, PF = preoperative flexibility, POC = postoperative correction, TL/L = thoracolumbar/lumbar.

Keywords: adolescent idiopathic scoliosis, early follow-up, last follow-up, Lenke type 5, pedicle screw density

1. Introduction

Posterior spinal instrumentation became the standard surgical procedure of adolescent idiopathic scoliosis (AIS) in the recent years. To apply a correction force to the vertebra, an anchor is needed and the most common used anchors are hooks and pedicle screws. Recent studies have shown that pedicle screws have lower revision rates and higher biomechanical properties than hook or hybrid constructs.[1–3] Additionally, pedicle screw constructs have better corrective advantages for posterior spinal surgery.[4,5]

Despite the superior biomechanical and correctional properties of the pedicle screws, there is potential of neurological, vascular, and visceral complications resulting from screw misplacement.[6,7] Furthermore, with the introduction of pedicle screws, the surgery costs have increased due to higher pedicle screw expenses.[8] For these reasons, some spine surgeons prefer to use fewer screws to reduce the cost and decrease the risk of malposition. On the contrary, some surgeons prefer to use more pedicle screws, thus aiming to obtain stronger construct with the final goal of better correction and leaving more mobile segments.

Because of this paradox, a new term called "anchor density" has been proposed which is defined as number of implants (pedicle screws, hooks, wires) per spinal level fused.[9] Several studies have reported little correlation between curve correction and anchor density.[9–15]

Lenke type 5 curve is a major thoracolumbar/lumbar (TL/L) curve and recommended surgery is to fuse this curve.[16] Because of the fact that lumbar vertebrae are major contributors to the spinal mobility, the aim is to fuse minimum levels with maximum correction. For this reason, some surgeons prefer to use as much as possible screws to compensate for shorter instrumentation and fusion. However, the differences between high versus low anchor density constructs on curve correction in Lenke type 5 patients is unclear. Thus, in this study we aimed to compare the effect of high versus low implant density on correction in Lenke type 5 AIS patients.

2. Methods

An institutional ethics committee approved (ethics committee permission number 2017/17–3) retrospective study of Lenke 5 AIS patients treated at a single institution by a single surgeon was conducted. Inclusion criteria included: a diagnosis of Lenke type 5 AIS, patients treated with posterior pedicle screw only instrumentation, no previous spine surgery, full sets of preoperative, early postoperative, and last follow-up standing full-length anteroposterior (AP) and lateral radiographs. Patients who had previous spinal surgery, suffered from congenital deformities, hybrid constructs, anterior surgery, and osteotomy were excluded. Those whose radiographs did not meet standards were also excluded in order to prevent measurement error.

The main indication for the surgical treatment of AIS patients was the Cobb angle, which was >35° in the thoracolumbar/lumbar region. A few of the patients demonstrating Cobb angle of

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[a] Department of Orthopaedics and Traumatology, Acibadem University School of Medicine, [b] Department of Orthopaedics and Traumatology, Istanbul Medical School, Istanbul University, Istanbul, Turkey.

[*] Correspondence: Kerim Sariyilmaz, Acibadem University Atakent Hospital, Halkali/Kucukcekmece, Istanbul 34303, Turkey (e-mail: ksariyilmaz@gmail.com).

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<35° were operated due to rapid progression of their deformity before skeletal maturity, trunkal shift, and cosmetic reasons.

All surgical procedures were performed by the same senior surgeon. All patients underwent general anesthesia and placed in a prone position on a surgical table. After a posterior midline incision was made, subperiosteal paraspinal muscles were dissected to expose the posterior elements of the spinal fusion levels. The pedicle screws were inserted by a free-hand technique and checked with intraoperative fluoroscopy. First, a lordotic shape titanium rod was placed at the convex side of curvature to obtain lordosis and correct the coronal deformity. Concave rod was given less lordosis than the first rod. Curve correction was achieved using the rod-rotation maneuver with convex rod, followed by slight convex compression and concave distraction. After decortication of the posterior elements and facet excision autogenous and allogenic bone grafts were used for fusion. Early postoperative x-rays were taken before the patients discharged from the hospital, within the first week of surgery.

Preoperative, early postoperative, last follow-up standing full-length AP and preoperative supine bending radiographs were measured by a surgeon who did not attend the surgeries. In the AP radiographs coronal TL/L Cobb angles, fusion levels, number of screws were assessed. The Surgimap software (New York, NY) was used to measure the Cobb angles. The following ratios were determined:

$$\text{Preoperative flexibility(PF) (\%)} = \frac{\text{Preoperative Cobb angle} - \text{Supine bending Cobb angle}}{\text{Preoperative Cobb angle}} \times 100$$

$$\text{Postoperative Correction(POC) (\%)} = \frac{\text{Preoperative Cobb angle} - \text{Postoperative Cobb angle}}{\text{Preoperative Cobb angle}} \times 100$$

In 68 Lenke type 5 AIS patients, 59 were included in the study who met all the inclusion criteria. Three patients treated with anterior surgery, 2 revision surgery patients and 4 patients who were lost during follow-up were excluded. Pedicle screw density was defined as number of implants per spinal level fused. Ideal anchor density is not a clear value in the literature. In a review article by de Kleuver et al,[17] they aimed to establish an international consensus about optimal surgical care for adolescent idiopathic scoliosis, and achieved a consensus considering curves with a Cobb angle of 40° to 70°, an implant density <80% was optimal. Thus, in our study, implant density <80% was considered as low density, 80% and higher density considered as high density. Kolmogorov–Smirnov test was utilized to assess distribution of study parameters between groups which did not yield a normal distribution. High density versus low density comparisons was done by Mann–Whitney *U* test.

3. Results

The demographic characteristics and clinical measurement data are shown in Table 1. There were 55 female and 4 male patients. Mean age was 16.7 (SD ±3.8) years. Mean follow-up was 43 (SD ±18.05) months. Thirty one constructs were high and 28 constructs were low density.

In the low anchor density group, 26 patients were women and 2 patients were men. The mean implant density was 75.4% (SD ±4.2). Mean follow-up was 41.21 (SD ±18.71) months. Preoperative TL/L Cobb angle was 42.8° (SD ±8.9°), early postoperative TL/L Cobb was 8.7° (SD ±7.4°), and last follow-up Cobb was 8.7° (SD ±7.3°). Mean instrumented level was 7.6 (SD ±1.3). Lowest instrumented vertebra was L3 in 8 patients, L4 in 18 patients, and L5 in 2 patients. Mean preoperative supine bending Cobb was 18.66° (SD ±12.11°). Mean preoperative flexibility was 60.03% (SD ±21.16), mean postoperative correction rate in the early postoperative period was 79% (SD ±15) and last follow-up was 78% (SD ±15).

Table 1

Demographic characteristics and clinical measurement data.

	Low anchor density (N: 28)	High anchor density (N: 31)	*P*
Age	17.3±3.6	16.2±3.8	.11
Sex	F: 26	F: 29	.91
	M: 2	M: 2	
Follow-up (mo)	41.21±18.71	44.61±17.59	.46
Instrumented levels	7.6±1.3	7.7±1.3	.88
Lowest instrumented vertebra	L3: 8	L3: 11	.48
	L4: 18	L4: 19	
	L5: 2	L5: 1	
Mean implant density	75.4%±4.2	96.6%±3.9	<.001
Preoperative TL/L Cobb	42.8±8.9	41.1±8.8	.22
Preoperative supine bending Cobb	18.66±12.11	15.22±6.9	.19
Preoperative flexibility %	60.03±21.16	68.73±14.62	.16
TL/L Cobb early Postop	8.7±7.4	8.5±7.3	.74
TL/L Cobb last follow-up	8.7±7.3	9.4±7.2	.62

N=number, TL/L=thoracolumbar/lumbar.

In the high anchor density group, 29 patients were women and 2 patients were men. The mean implant density was 96.6% (SD ±3.9). Mean follow-up was 44.61 (SD ±17.59) months. Preoperative TL/L Cobb angle was 41.1° (SD ±8.8°), early postoperative TL/L Cobb was 8.5° (SD ±7.3°), and last follow-up Cobb was 9.4° (SD ±7.2°). Mean instrumented level was 7.7 (SD ±1.3). Lowest instrumented vertebra was L3 in 11 patients, L4 in 19 patients, and L5 in 1 patient. Mean preoperative supine bending Cobb was 15.22° (SD ±6.9°). Mean preoperative flexibility was 68.73% (SD ±14.62), mean correction rate in the early postoperative period was 77% (SD ±19), and last follow-up was 76% (SD ±19).

The groups were similar in terms of age, sex, preoperative Cobb angle, preoperative supine bending Cobb angle, preoperative flexibility, and follow-up time (Table 1).

High density versus low-density comparison showed that there is no significant difference with regard to curve correction in early postoperative and last follow-up periods ($P=.89$ and $P=.58$, respectively) (Table 2) (Fig. 1).

4. Discussion

This retrospective study of Lenke type 5 AIS patients treated with only pedicle screws investigated the relation between screw density and curve correction, and revealed that high versus low anchor density does not show difference in TL/L Cobb angle. Similar to our findings a multicenter study by Larson et al,[13] evaluated 952 AIS/juvenile idiopathic scoliosis patients with Lenke 1, 2, and 5 curves, and found a significant difference between high and low anchor density in Lenke 1 and 2 patients, however, similar with our study, no difference was found in Lenke 5 patients.

Table 2

Statistical results between high versus low implant density in early and last follow-up correction rates.

	High implant density (n=31) mean (SD)	Low implant density (n=28) mean (SD)	Mann–Whitney_U statistic and *P* value
Early correction rate (%)	77.99 (19.45)	79.55 (15.37)	*Z*=425.32 *P*=.891
Last follow-up correction rate (%)	76.17 (19.01)	78.59 (15.31)	*Z*=397.50 *P*=.580

SD=standard deviation.

All-pedicle screw constructs have become the standard instrumentation in the treatment of AIS. Because of the 3-column anchorage of pedicle screws, more corrective forces can be applied and thus allows 3-dimentional (3D) correction of the curve. Also it has been shown to improve pulmonary function and decrease pseudoarthrosis rates.[3,18,19] Most of the studies observed better curve correction with pedicle screws compared with hook only or hybrid constructs.[9,20–24] On the other hand, there have been concern about potential neurological, vascular, and visceral complications which can result from screw misplacement.[6,7,25] Furthermore, because of the high expenses of pedicle screws, hospital costs have been shown to increase with an average of 29%.[8,26] Therefore, decreasing the number of pedicle screws may lower the potential complication rate and surgical cost.

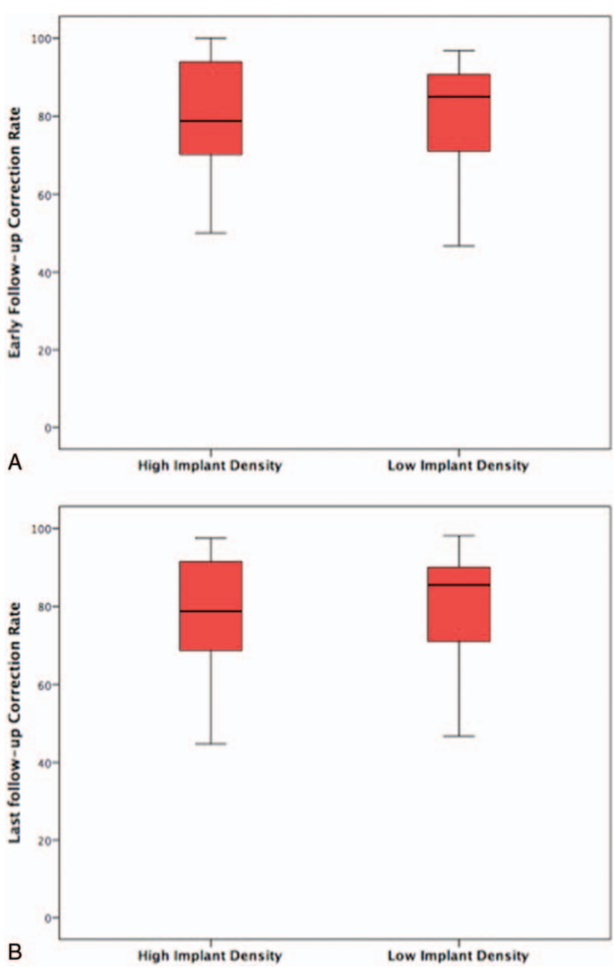

Figure 1. At the early (A) and last follow-up (B), no statistically significance was found between high implant density versus low implant density (P=.89 and P=.58).

Anchor density is defined as number of implants per spinal level fused. The effect of anchor density on curve correction and patient-reported outcome scores has not been well documented. A review by Larson et al[27] shows a wide variety in the mean anchor density between 1.04 and 2.0 and mean correction rate 64% to 70%. In our cohort mean anchor density was 1.7 (86.5%) and mean correction rate was 78.7% in the early period and 77.8% in the last follow-up.

Factors associated with curve correction involve magnitude of curve, flexibility, correction maneuver, and fixation anchors. Better correction rates with high anchor points, regardless of the anchor type, have been reported in the previous literature.[13,28,29] In contrast, there is also evidence proving that reduction in number of screws does not affect curve correction.[11,30,31] Chen et al[32] have explained this paradox as to be a result of variation in the deformity flexibility of the studied patients. To eliminate for such a bias Vora et al[23] have proposed a concept called "correction index," which is actually a ratio of postoperative correction to preoperative side-bending flexibility. Another study evaluating the influence of implant density in Lenke type 5 patients, reported significant correlation between screw density and amount of correction, meanwhile it did not report any significant correlation with correction index.[32] Up to our knowledge of the current literature, this is the only study evaluating the effect of implant density on Lenke type 5 curves apart from ours. However, this study differs from our study by lacking to compare short- and long-term follow-up parameters for possible correctional loss.

Nevertheless, there are some limitations to our study as well. First, this is a retrospective study and it lacks randomization. The measurements were done by a computer-based software and there could be some measurement errors. In addition, we did not evaluate the costs and patient reported outcome parameters, for the reason that they are out of the scope of our aim.

5. Conclusion

Superior mobility of the involved segment and other anatomic differences render Lenke type 5 curves different from other curve types. As a result of this fact, trying to minimize the number of fused levels while not sacrificing correction is the main priority. This study indicates that pedicle screw density may not have a very pronounced effect on curve correction rates in Lenke type 5 patients as proposed by some writers. On the other hand, further investigation is needed to clarify these findings and also define parameters regarding the number of anchors needed to obtain secure correction while keeping the number of fused levels at minimum.

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