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A posterior-only approach for treatment of severe adolescent idiopathic scoliosis with pedicle screw fixation: A case series

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ABSTRACT

INTRODUCTION: Adolescent idiopathic scoliosis (AIS) can lead to severe deformity. However, early detection and treatment can prevent its progression. Surgical instrumentation for scoliosis treatment has evolved from Harrington instrumentation to pedicle screws. However, there are still some concerns about the efficacy and long-term effects of pedicle screw fixation, and the clinical and radiographic outcomes of surgical treatment for severe AIS (>90°) by posterior spinal fusion alone need to be established.
PRESENTATION OF CASE: Eight patients with severe and rigid idiopathic scoliosis were recruited for this study. All surgeries were performed by one senior spine surgeon between 2015 and 2018. Free hand technique, intraoperative neurophysiologic monitoring (IONM), and intraoperative fluoroscopy to assess the screw position was performed.
DISCUSSION: Severe scoliosis results in a complex three-dimensional spinal deformity that often requires correction in multiple planes. Mean major coronal correction rate was 67% (45–80%). No major complications occurred during the perioperative period and after one year follow up.
CONCLUSION: Pedicle screws provide three-dimensional deformity correction. There were no complications other than the low-grade late implant-associated infections. Posterior spinal fusion with pedicle screw-only instrumentation obtains a good and stable correction for severe scoliosis.

1. Introduction

Adolescent idiopathic scoliosis (AIS) is a three-dimensional spinal deformity that may lead to a significant morbidity to its patients. Delay in diagnosis and treatment, as well as aggressive patterns, may lead to severe curve progression. Expert consensus has determined a maximum waiting time of 6 months for surgery in patients with AIS. Severe rigid idiopathic scoliosis has <25% of correction on bending films and major curve over 90°. In order to achieve optimal curve correction, adequate mobilization of this type of deformity is necessary. This often requires extensive surgical intervention, and care must be taken to avoid clinical and neurological complications. Halo traction, internal temporary distraction, anterior releases, osteotomies, and apical vertebral resection are often used in combination to achieve optimal results [1,2].

In the past, the treatment of severe idiopathic scoliosis (Main curve over 80 °Cobb) was performed by an anterior release with an open thoracotomy followed by posterior instrumented fusion [3,4]. However, anterior procedures in patients with severe curves are not ideal for those who have cardiopulmonary limitations which is prevalent in these group of patients [5,6]. Significant changes have occurred over the past three decades in the field of spinal instrumentation for the correction of adolescent idiopathic scoliosis (AIS). Initially designed primarily to apply distraction forces to the spine, the surgical instrumentation for scoliosis treatment has evolved from Harrington instrumentation into pedicle screw construct to achieve three-dimensional correction. Recently, some authors have used posterior-only fusion for the treatment of severe thoracic AIS to avoid the negative effects on pulmonary function which is related to the anterior release.

However, there are still some concern about the efficacy and long-term effect of these type of fixation [7,8]. The aim of the present study was to assess the clinical and radiographic outcome of surgical treatment for severe AIS (>90°) by posterior spinal fusion

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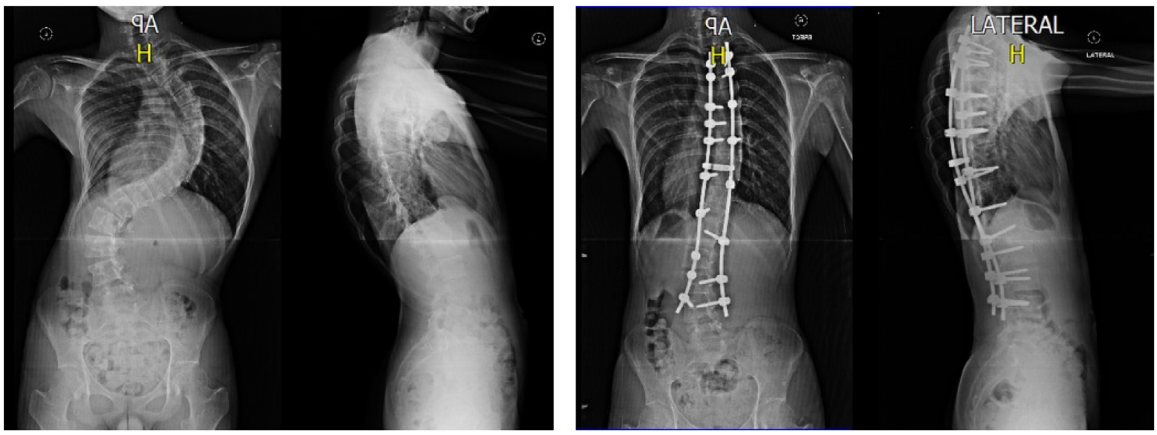

Fig. 1. Male age 17 years. A) Scoliosis main curve 99 °Cobb. b Post-operative X-rays 33 °Cobb. No patient or author details are included in the figures.

Fig. 2. Female age 19 years. A) Scoliosis main curve 90 °Cobb. B) Post-operative X-rays 28 °Cobb. No patient or author details are included in the figures.

alone (PSF). Written consent has been received from the subject. The authors declare no conflicts of interest. This work has been reported in line with the PROCESS criteria [9].

2. Presentation of case

Institutional review board approval was obtained prior to this study. This study is a prospective, single center, case series with consecutive cases. Eight consecutive patients with severe and rigid idiopathic scoliosis were recruited for this study. All surgeries were performed by one senior spine surgeons in a single tertiary spine center hospital between 2015 and 2018. Inclusion criteria were: patients aged 11–20 years old at the time of surgery; severe scoliosis (defined as main coronal curve > 80°); rigid scoliosis (defined with flexibility index < 25%) [10].

Patients who was diagnosed with other types of scoliosis (neuromuscular scoliosis, congenital scoliosis, etc.) were excluded. Patients that had intradural abnormalities (diastomatomyelia, tethered cord, etc) or history of previous spine manipulation or surgery were also excluded.

Chart review was performed to analyze the patients demographic at the initial examination (age, gender and BMI). Standing anteroposterior and lateral spine radiograph were within 2 months before the surgery. Lateral bending and stagnara suspesion radiograph were also taken. All radiographs expanded from C7 to S1 vertebrae. Initial major coronal curve magnitude, major compensatory coronal curve magnitude, major sagittal curve magnitude, and flexibility index were measured and recorded (Figs. 1 and 2).

2.1. Intraoperative techniques

All surgery was performed by one senior spine surgeon (LG) using free hand technique, intraoperative neurophysiologic monitoring (IONM), and intraoperative fluoroscopy to assess the screw position. Free hand technique was used for the placement of the pedicle screw, completely using the intraoperative visible and palpable anatomic landmarks for the accurate insertion of the pedicle screws [11]. The success of this technique highly depends on clear exposition and identification of the posterior elements' bony landmarks [12]. Accurate anatomic exposure of posterior bony structure of the spine was performed, starting with a subperiosteal muscular dissection, removing the spinal muscles insertion to reduce the curve's stiffness and minimizing the blood loss. Hemostasis was performed meticulously to maintain a clear operating field and visualize screw insertion's landmark (Figs. 3 and 4).

Contrary to other authors, we believe that there is no need to insert pedicle screws in every vertebra at the thoracic level Pedicle screws were only inserted in the vertebrae that were considered key points for obtaining curve correction on both the coronal and sagittal planes [13]. We performed facetectomy, but we do not routinely perform laminotomy to explore the pedicle direction before screw insertion, and we do not think that this step is usually necessary; we believe that it is generally sufficient to rely on the correct identification of the posterior anatomic landmark. Intraoperative parameters such as operation time, blood loss, and level instrumented were measured and recorded.

Post-operatively, all the patients were put in a thoracolumbar orthosis (TLSO) for 3 weeks and mobilization was started early as

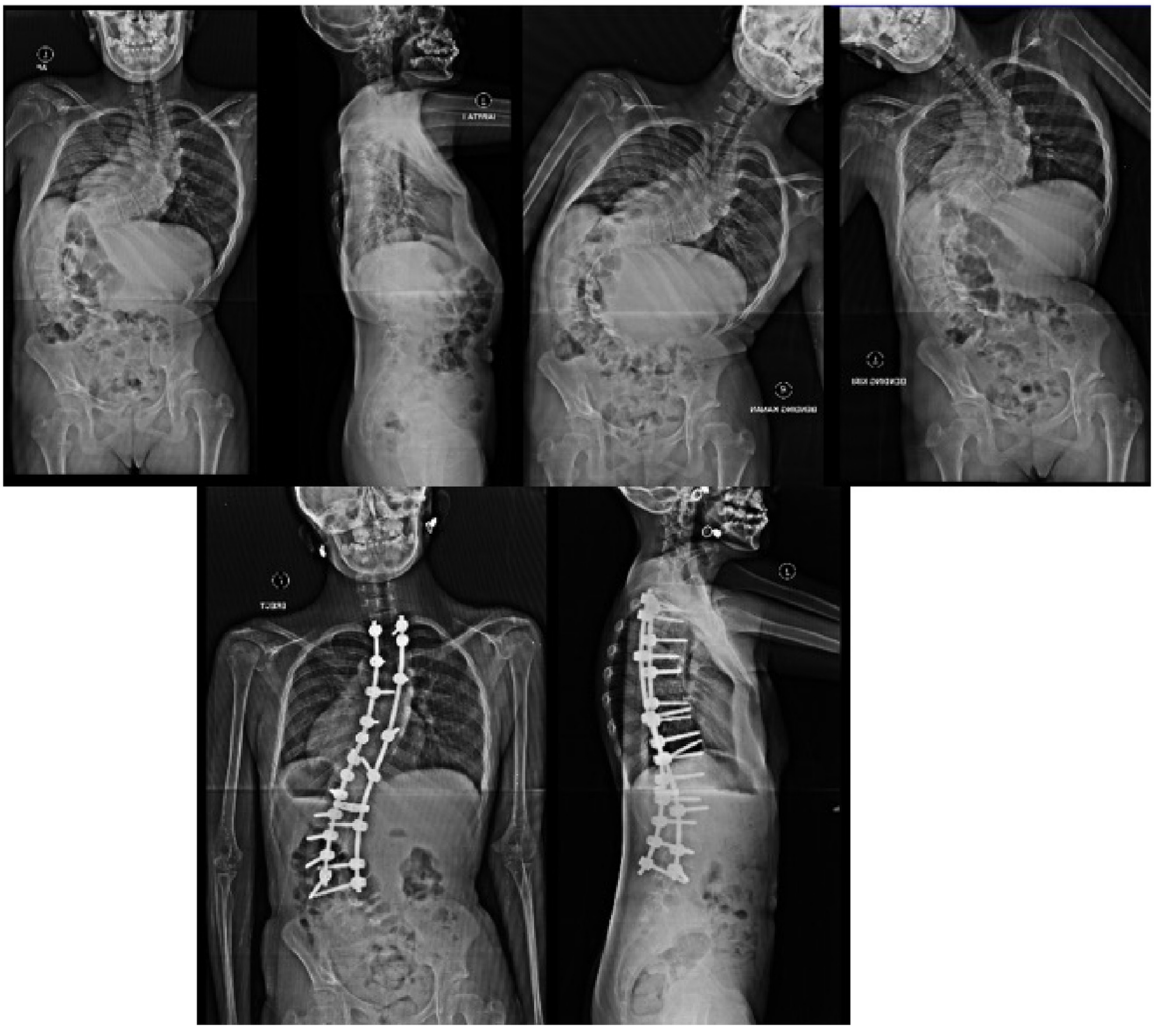

Fig. 3. Female age 15 years. A–B) Scoliosis main curve 125 °Cobb. C–D) Bending reduces to 102 °Cobb. E–F) Post-operatory X-rays 56 °Cobb. No patient or author details are included in the figures.

tolerated. Patient were closely monitored during the postoperative course especially the neurologic status

Post operative radiograph were obtained as soon as patient's condition allowed, from which the post-operative curve magnitude and correction rate were measured. Patients were followed until 1 year after surgery. Any complication found were recorded and treated accordingly.

Eight patients were included in our series. Patient demographics were summarized in Table 1. Most cases involved two structural curves since only one case classified as Lenke type 1. Mean major coronal correction rate was 67% (45–80%). The biggest correction was found in case number 2 with 79° correction, while the smallest correction was found in case 3 with 57° correction

Meanwhile case number 7 that has the highest initial coronal curve magnitude and the lowest correction rate. The summary of radiologic parameters was described in Table 2. No major complications (instrumentation loosening, infection, neurologic or visceral impairment) occurred during the perioperative period and after one year follow up. All patients were braced for a total of 3 weeks after surgery. All patient felt better than before the operation.

3. Discussion

Severe scoliosis results in a complex three-dimensional spinal deformity that often requires correction in multiple planes. Posterior instrumentation techniques using Harrington, Luque or

Table 1
Demographic characteristics.

Patient	Age/sex	Lenke Classification	No. of Screws	Cobb Angle Pre-Op	Cobb Angle Post-Op
1	15/F	3C+	16	106	42
2	14/F	2BN	15	99	20
3	19/F	4B+	17	94	37
4	17/F	4BN	18	111	36
5	17/M	3C–	18	99	33
6	19/F	1AN	19	90	18
7	15/F	3C–	20	125	56
8	15/F	2B+	18	105	33

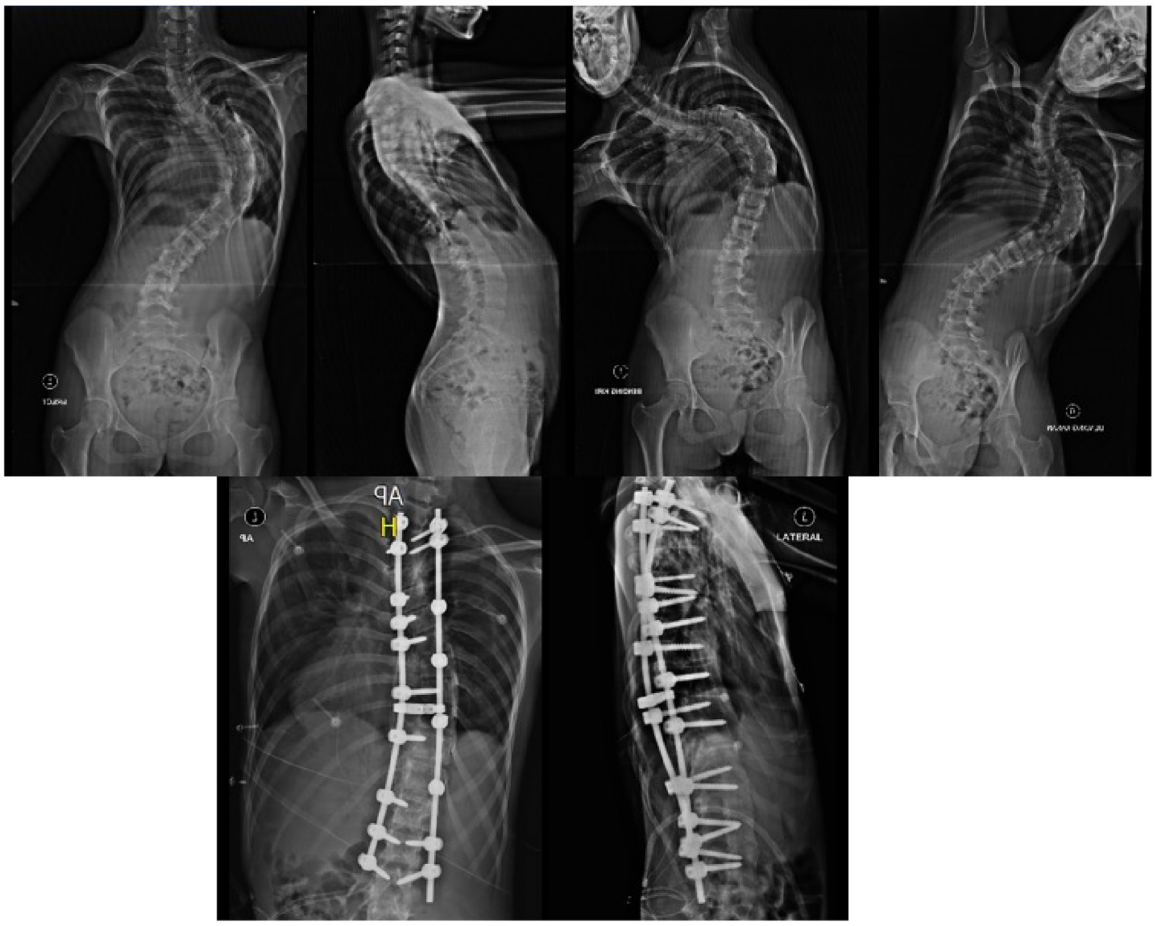

Fig. 4. Female age 15 years. A–B) Scoliosis main curve 105 °Cobb. C–D) Bending reduces to 88 °Cobb. E–F) Post-operatory X-rays 33 °Cobb.
No patient or author details are included in the figures.

Table 2
Preoperative and postoperative comparison of scoliosis parameters.

	Preoperative	Postoperative
Mean major Cobb angle	103	34
Mean kypho	35	24
Mean correction rate	67% (45–80%).	
Mean scoliosis curve (Cobb)	103° (90°–125°)	24° (18°–56°)
Mean T5-T12 kyphosis (Cobb)	35° (7°– 66°)	24° (10°–42°)
Center sacral vertical line (CSVL)	3 cm (0.5–4 cm)	0.9 cm (0.3–1.8 cm)
Mean curve degree		
PT	35°	18°
MT	100°	39°
LT	65°	25°
K	34°	
Mean coronal balance		
Shift to the left	42%	7%
Shift to the right	28%	7%
Normal	21%	85%
Mean sagittal balance		
Normal	35%	71%
Positive	14%	0%
Negative	50%	28%

Cotrel–Dubousset instrumentation are suboptimal for a three-dimentional deformity correction. Pedicle screw fixation using the strongest part of the spine as an anchor is a superior technique for three-dimensional deformity correction as it preserves lumbar motion segments. The lumbar region served to endure more weight than the cervical region, making stabilization as well as preservation of motion even more challenging [14]. The objective of preserving motion segments is to reduce the mobility of these segments in order to reduce the risk of adjacent level degeneration [15]. Several reports have demonstrated the superiority of pedicle screws over other posterior instrument systems. Posterior correction with pedicle screws has been widely used for the treatment of the scoliosis [16,17].

All-screw instrumentation allows better correction than wires/hooks and hybrid instrumentation and lesser correction loss at follow-up [18]. This is due to the screws better and deeper grip in the vertebral body, which offers a better and more prolonged vertebral control than hooks/wires. Screws have better initial stability which determines a more effective arthrodesis distribution and maturation after correction has been obtained; arthrodesis maturation in hooks/wires and hybrid instrumentation could be compromised by the hooks' minimum mobilization. It has been stated in many literatures that, the screws' arthrodesis loss of correction is better than the hooks' arthrodesis loss of correction. The use of screws at the thoracic level not only improves deformity correction and minimizes loss of correction at follow-up but also has become an essential technical necessity and an obligatory step in vertebral disease treatment as it is recognized as superior to other types of instrumentation.

The patients operated by posterior approach with all-screw instrumentation at thoracic and lumbar level if needed according to the deformity. Our series is undoubtedly numerically low and is not statistically significant; we believe, however, that it offers reliable information concerning the choice of posterior approach using only all-screw instrumentation when treating these patients. There were no complications other than the low-grade late implant-associated infections. There were neither acute infections, nor

neurological complications or pedicle screw-related complications.

The mean correction result of the major curve in our series was 67%, this result was comparable with the result from Babak et al. [19], from their comparative study, the mean correction result was 64.2% in all-pedicle screw instrumentation with posterior approach only. Other authors [20,21] reported also similar result with posterior only approach and shorter hospitalization compared to combined approach with less complication.

In our series we found no significant complication that might be happened when anterior release or combined approach were done. The anterior release and fusion are performed through either an endoscopic or open approach with similar results. Severe deformities course with anatomic changes on chest wall and spine making endoscopic approach impractical. Both approaches have negative impact on pulmonary function when compared to posterior-only approach as reported by some authors [22,23]. The use of total pedicular constructs, with the improved segmental fixation and better ability to tri-dimensionally correct the AIS curves, have diminished the need for anterior approach in selected curves [4].

4. Conclusion

Posterior spinal fusion with pedicle screw-only instrumentation obtains a good and stable correction of severe scoliosis; compared to hybrid instrumentation, it allows a greater coronal correction of deformity. Neurological and visceral complications in pedicle screw instrumentation of scoliosis are rarely reported in literature and, while medial pedicle wall violation by the screw misplacement is a concern particularly at thoracic level, the procedure when performed by an experienced spine surgeon is safe. “Free hand” pedicle—screw insertion is an effective technique, which relies only on posterior anatomic landmarks and on a very limited use of radioscopy to assess the screws positioning. It does not envisage the use of anatomic navigation aids. Intraoperative chest wall violation when combined or anterior approach were done produced detrimental pulmonary effects and could be prevented by using posterior-only approach.

Declaration of Competing Interest

The authors report no declarations of interest.

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Ethical approval

Ethical approval was not required in the treatment of the patient in this report.

Consent

Written informed consent was obtained from the patients for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Author contribution

Luthfi Gatam contributes in the study concept or design, data collection, analysis and interpretation, oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team.

Andi Praja Wira Yudha Luthfi contributes in the study concept or design, data collection, analysis and interpretation, activity planning and execution, including mentorship external to the core team.

Fachrisal contributes in oversight and leadership responsibility for the research, the study concept or design, data collection, analysis and interpretation.

Phedy contributes to the study concept or design, data collection and writing the paper.

Asrafi Rizki Gatam contributes to the study concept or design, data collection and writing the paper.

Yoshi Pratama Djaja contributes in the study concept or design, data collection, analysis and interpretation.

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Guarantor

Luthfi Gatam is the sole guarantor of this submitted article.

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CRediT authorship contribution statement

Luthfi Gatam: Conceptualization, Methodology, Investigation, Resources, Writing - review & editing, Supervision. **Andi Praja Wira Yudha Luthfi:** Methodology, Validation, Writing - original draft, Project administration. **Fachrisal:** Conceptualization, Validation, Resources, Writing - review & editing, Supervision. **Phedy:** Methodology, Investigation, Writing - original draft, Project administration. **Asrafi Rizki Gatam:** Methodology, Validation, Writing - original draft, Project administration. **Yoshi Pratama Djaja:** Conceptualization, Validation, Resources, Writing - review & editing.

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