



## Case series

## Pelvic parameter improvement following deformity correction in adolescence idiopathic scoliosis: A case series

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## ABSTRACT

**Introduction:** Scoliosis is defined as 3-dimensional deformity of the spine with lateral deviation more than 10° and rotation of the vertebrae. Adolescence idiopathic scoliosis (AIS) is scoliosis that affect children between the age of 11–18 years old without any identifiable cause or underlying disease.

**Presentation of case:** This study will compare the pelvic parameters and functional score of the patients before and after the procedure. Pelvic parameters are represented by 3 angles: pelvic incidence (PI), pelvic tilt (PT), and sacral slope (SS) of 5 adolescence idiopathic scoliosis patients. Functional outcomes were evaluated using Indonesian SF-36 questionnaire and also pain scale of preoperative and postoperative.

**Discussion:** An important outcome of this study was a statistically significant improvement in coronal alignment, functional capacity, pain, and role of limitation due to physical health. Coronal angle deformity correction of AIS patients is correlated with sagittal improvement which caused by compensatory alteration of pelvic parameter.

**Conclusion:** This finding correlates with the improvement of functional outcome of the patients.

## 1. Introduction

Scoliosis is defined as 3-dimensional deformity of the spine with lateral deviation more than 10° and rotation of the vertebrae. Scoliosis can be classified into idiopathic, neuromuscular, congenital, and developmental. Idiopathic scoliosis itself can be further classified as infantile (0–3 years), juvenile (4–10 years), and adolescence (11–18 years) based on the onset of the scoliosis [1,2].

Adolescence idiopathic scoliosis (AIS) is scoliosis that affect children between the age of 11–18 years old without any identifiable caused or underlying disease. AIS is the most common form of scoliosis, encompassing 80% of all idiopathic scoliosis with the prevalence of 2%–4% of adolescents. AIS more common in girls with a female to male ratio of 1.5:1 to 3:1, and almost 90% of them will show right-sided thoracic curve [1,3,4,5].

The indications for surgery treatment in AIS are curves >45°–50° or rapidly progressing curves. The goals of the surgery are to correct deformity and stabilize the spinal curve while also considering for overall spinal balance, including sagittal balance. Sagittal balance can

be maintained through 3 compensatory mechanisms, which may happen in the spine, pelvic, and lower limb [3].

The deformity correction surgery in scoliosis will mainly focus on coronal alignment correction. However, in scoliosis there was 3-dimensional deformity which are identified in coronal, sagittal, and axial plane. For this case the deformity of all planes is related to each other, it means that correction of coronal alignment will also alter the spinal sagittal balance including pelvic parameter.

In this study the coronal alignment based on Lenke classification, which is proximal thoracic, main thoracic, and thoracolumbar/lumbar curvature and sagittal balance with spine parameter (TK and LL) and pelvic parameter (PI, PT, SS) of the spine along with sagittal vertebral axis (SVA) of AIS patients who underwent deformity correction surgery, pre and post operatively were measured. We also correlate this finding with clinical symptoms using Indonesian SF-36 questionnaire of the patient after the surgery.

This case report is presented and written in line with the SCARE 2018 criteria.

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**2. Material and methods**

This is a cross sectional study with five cases included that were diagnosed with Adolescent Idiopathic Scoliosis and treated operatively in Dr. Sardjito General Hospital. The patients were admitted at Dr. Sardjito General Hospital in Yogyakarta from February 2016 until June 2021. Ethical approval was done through the Gadjah Mada University Ethical committee. Written informed consent was obtained from the patient 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.

The same attending senior spinal surgeon performed all surgical procedure. Segmental pedicle screws with titanium rod were used in all patients. All patients received posterior surgery.

Standing full length anteroposterior (AP) and lateral radiographs before surgery and at the last follow up of minimum 16 weeks after surgery (after the patients free of orthoses) were measured. In the AP standing radiograph, 3 coronal Cobb's angle based on Lenke classification were measured: proximal thoracic (PT), main thoracic (MT), Thoracolumbar curvature (TL/L). In the lateral standing radiographs, five sagittal parameters were measured: thoracic kyphosis, (TK), lumbar lordosis (LL), Sagittal vertical axis (SVA), sacral slope (SS), pelvic tilt (PT), and pelvic incidence (PI) [6].

Thoracic parameter is represented in thoracic kyphosis that is measured between the upper T1 and the lower endplate of T12. The theoretical value of thoracic kyphosis is 0.75 times the global lumbar lordosis angle, usually range between 20° – 50°. However, many articles measure thoracic kyphosis between T4 – T12 due to structures superposition in normal radiographs made it difficult to identify the T1 vertebrae. Lumbar lordosis is measured between the upper endplate of L1 and upper endplate of S1 with normal value range between 20° – 80°, average 60°. Almost 70% of the global lordosis is happen in the level of L4 – S1. The sagittal vertical axis is measured as the horizontal distance between a plumb line drawn from center of C7 and a line drawn from center of C7 to posterior superior corner of S1 [7,8].

Pelvic parameters are represented by 3 angles: pelvic incidence (PI),

pelvic tilt (PT), and sacral slope (SS). PI is an angle between the perpendicular to the upper S1 endplate passing through its center and the line connecting this point to the center of femoral head. This angle is constant in each person and independent to the spatial orientation of the pelvis. SS is defined by an angle between a line tangent to the upper S1 endplate and horizontal line, the more vertical the sacrum, the lower the SS angle. While PT is an angle between the vertical line and the line connecting the center S1 upper endplate to the center of femoral head. PT angle will increase during retroversion of the pelvis. SS and PT are positional and related to the pelvic orientation. PI, SS, and PT has a correlation between each other with formula of  $PI = SS + PT$  [7–11].

Functional outcomes were evaluated using SF-36 questionnaire and also pain scale of preoperative and postoperative.

**3. Case series**

**3.1. Case 1**

A female, 16 years old was diagnosed with Adolescent idiopathic scoliosis Lenke 2A. She had no response to conservative treatment and planned for operative procedure.

In this patient we performed deformity correction and stabilization with long segment fusion with pedicle screw at the level of 3rd thoracal – 1st lumbar spine (Fig. 1).

Post-operative sagittal parameters were measured and compared with pre-operative radiologic (Table 1). From coronal alignment, we found decrease of proximal thoracic of 23°, main thoracic of 31°, thoracolumbar curve of 6°. From sagittal alignment, we found there is increase of thoracal kyphotic of 8°, lumbar lordotic of 9°. From pelvic parameters, there is increase of sacral slope of 10°, and there is decrease of pelvic tilt of 10°. Pain scale improved from 4 to 1 compared with preoperative.

**3.2. Case 2**

A female, 17 years old was diagnosed with Adolescent idiopathic

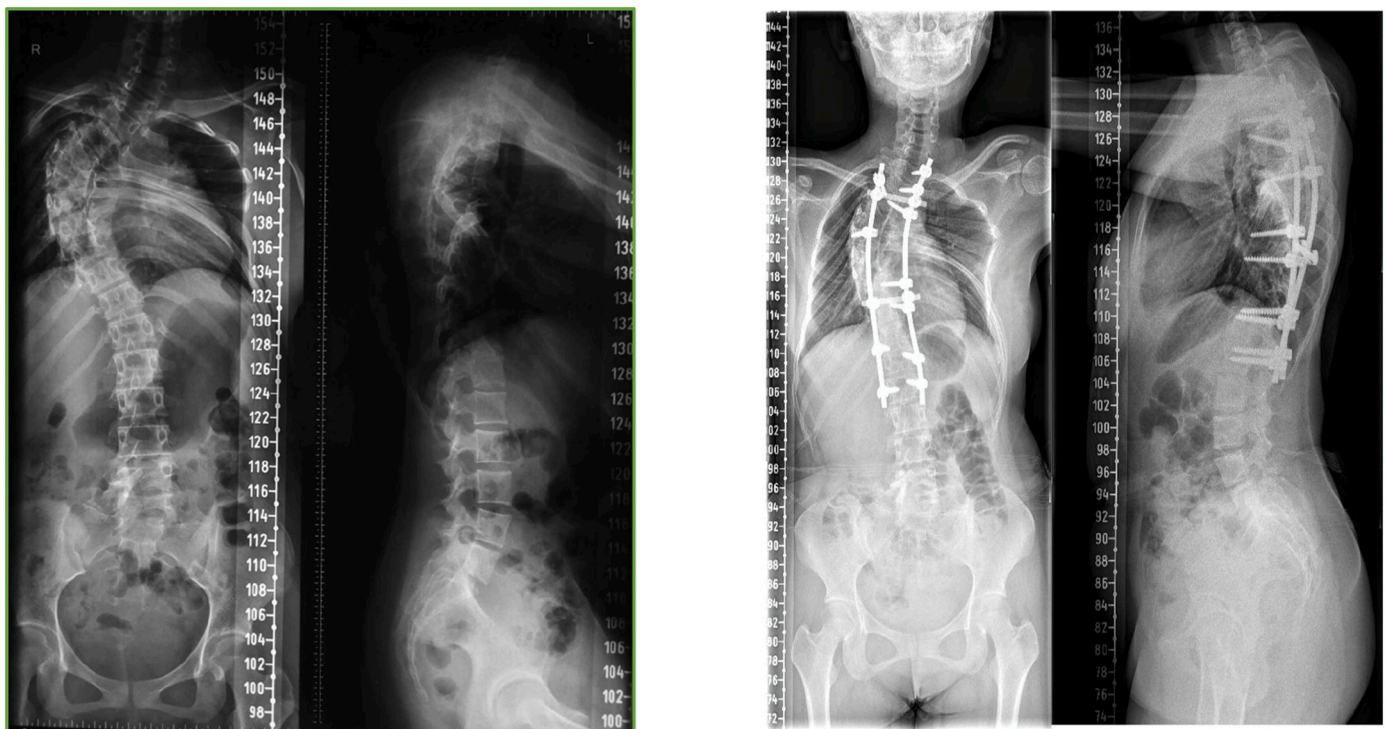


Fig. 1. Case 1 radiograph presentation.

**Table 1**

Case 1 radiograph parameter.

Pre-operative	Post-operative
Coronal: Proximal thoracic: 65° (secondary structural) Main thoracic: 70° (primary). Apex T6 Thoracolumbar curve: 17° (secondary non-structural)	Coronal: Proximal thoracic: 42° (secondary structural) Main thoracic: 39° (primary). Apex T6 Thoracolumbar curve: 11° (secondary non-structural)
Sagittal: Thoracic kyphotic: 13° (20–40) Lumbar lordotic: 40° (40–60) SS: 36° (30–50) PT: 22° (10–25) PI: 58° (40–65) SVA: +2	Sagittal: Thoracic kyphotic: 9° (20–40) Lumbar lordotic: 49° (40–60) SS: 36° (30–50) PT: 12° (10–25) PI: 58° (40–65) SVA: +2

scoliosis Lenke 2A. She had no response to conservative treatment and planned for operative procedure.

In this patient we performed deformity correction and stabilization with long segment fusion with pedicle screw at the level of 4th thoracic – 1st lumbar spine (Fig. 2).

Post-operative sagittal parameters were measured and compared with pre-operative radiologic (Table 2). From coronal alignment, we found decrease of proximal thoracic of 32°, main thoracic of 36°, thoracolumbar curve of 3°. From sagittal alignment, we found that there is increase of thoracic kyphotic of 7°, lumbar lordotic of 19°. From pelvic parameters, there is decrease of sacral slope of 12°, and there is increase of pelvic tilt of 12°. Pain scale improved from 4 to 1 compared with preoperative.

3.3. Case 3

A female, 16 years old was diagnosed with Adolescent idiopathic scoliosis Lenke I BN. She had no response to conservative treatment and planned for operative procedure.

In this patient we performed deformity correction and stabilization with long segment fusion with pedicle screw at the level of 5th thoracic – 3rd lumbar spine (Fig. 3).

Post-operative sagittal parameters were measured and compared

**Table 2**

Case 2 radiograph parameter.

Pre-operative	Post-operative
Coronal: Proximal thoracic: 56° (secondary structural) Main thoracic: 63° (primary). Apex T7 Thoracolumbar curve: 19° (secondary non-structural)	Coronal: Proximal thoracic: 24° (secondary structural) Main thoracic: 27° (primary). Apex T7 Thoracolumbar curve: 16° (secondary non-structural)
Sagittal: Thoracic kyphotic: 7° (20–40) Lumbar lordotic: 31° (40–60) SS: 48° (30–50) PT: 10° (10–25) PI: 58° (40–65) SVA: -1	Sagittal: Thoracic kyphotic: 8° (20–40) Lumbar lordotic: 50° (40–60) SS: 36° (30–50) PT: 22° (10–25) PI: 58° (40–65) SVA: Neutral

with pre-operative radiologic (Table 3). From coronal alignment, we found decrease of proximal thoracic of 2°, main thoracic of 43°, thoracolumbar curve of 17°. From sagittal alignment, we found there is increase of thoracic kyphotic of 7°, lumbar lordotic of 25°. From pelvic parameters, there is decrease of sacral slope of 7°, and there is increase of pelvic tilt of 7°. Pain scale improved from 3 to 1 compared with preoperative.

3.4. Case 4

A female, 16 years old was diagnosed with Adolescent idiopathic scoliosis Lenke 3 BN. She had no response to conservative treatment and planned for operative procedure (Fig. 4).

In this patient we performed deformity correction and stabilization with long segment fusion with pedicle screw at the level of 2nd thoracic – 3rd lumbar spine.

Post-operative sagittal parameters were measured and compared with pre-operative radiologic (Table 4). From coronal alignment, we found decrease of proximal thoracic of 3°, main thoracic of 47°, thoracolumbar curve of 27°. From sagittal alignment, we found there is increase of thoracic kyphotic of 12°, lumbar lordotic of 12°. From pelvic parameters, there is decrease of sacral slope of 8°, and there is increase of pelvic tilt of 8°. Pain scale improved from 2 to 2 compared with



Fig. 2. Case 2 radiograph presentation.

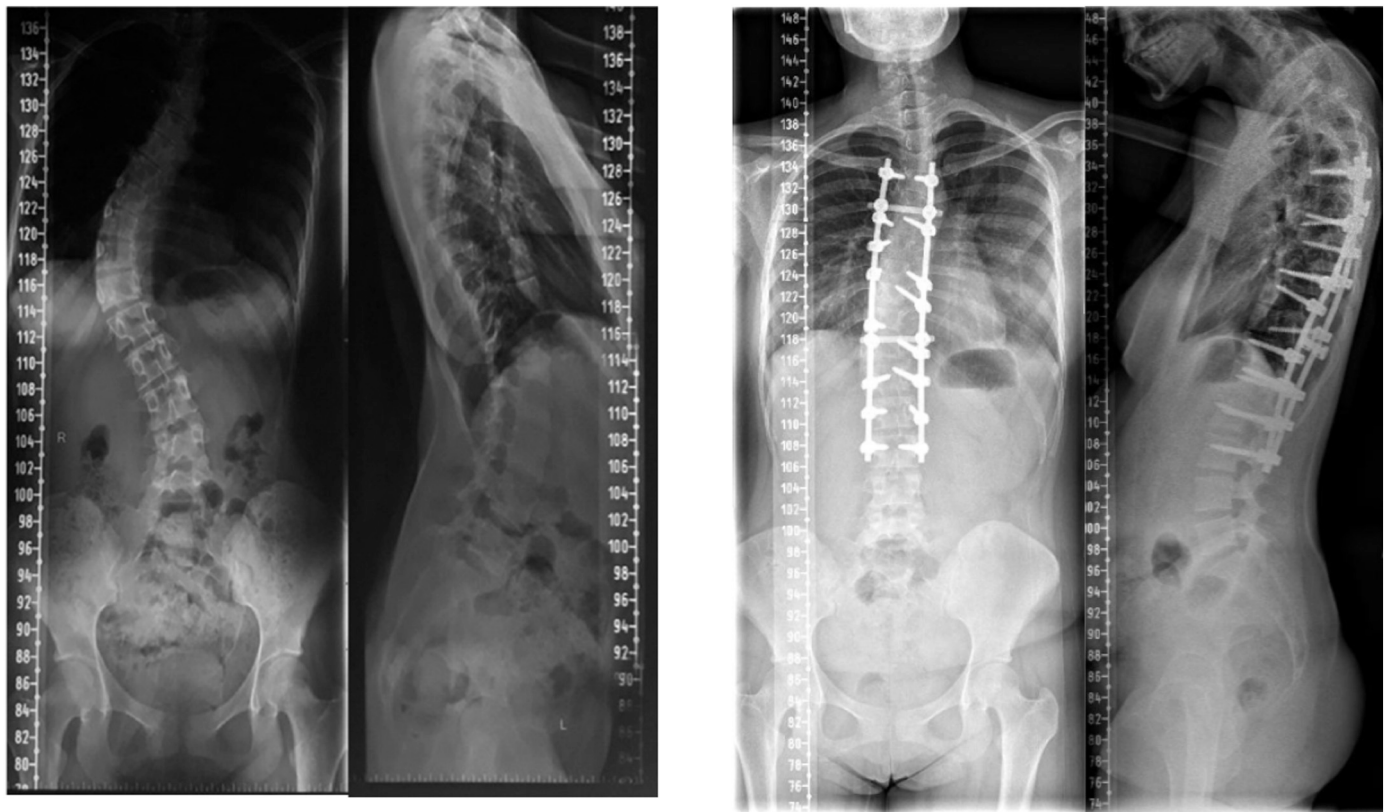


Fig. 3. Case 3 radiograph presentation.

**Table 3**  
Case 3 radiograph parameter.

Pre-operative	Post-operative
Coronal:	Coronal:
Proximal thoracic: 24° (secondary non-structural)	Proximal thoracic: 22° (secondary non-structural)
Main thoracic: 59° (primary). Apex T9	Main thoracic: 16° (primary). Apex T9
Thoracolumbar curve: 24° (secondary non-structural)	Thoracolumbar curve: 7° (secondary non-structural)
Sagittal:	Sagittal:
Thoracic kyphotic: 16° (20–40)	Thoracic kyphotic: 23° (20–40)
Lumbar lordotic: 25° (40–60)	Lumbar lordotic: 50° (40–60)
SS: 44° (30–50)	SS: 37° (30–50)
PT: 11° (10–25)	PT: 18° (10–25)
PI: 55° (40–65)	PI: 55° (40–65)
SVA: +1	SVA: +0.5

preoperative.

### 3.5. Case 5

A male, 17 years old was diagnosed with Adolescent Idiopathic Scoliosis Lenke 6CN Risser 5 Sanders 8. He had no response to conservative treatment and planned for operative procedure.

In this patient we performed deformity correction and stabilization with long segment fusion with pedicle screw at the level of 5th thoracic – 2nd lumbar spine (Fig. 5).

Post-operative sagittal parameters were measured and compared with pre-operative radiologic (Table 5). From coronal alignment, we found decrease of proximal thoracic of 10°, main thoracic of 36°, thoracolumbar curve of 8°. From sagittal alignment, we found there is increase of thoracic kyphotic of 29°, lumbar lordotic of 6°. From pelvic parameters, there is increase of sacral slope of 13°, and there is decrease of pelvic tilt of 13°. Pain scale improved from 2 to 2 compared with

preoperative.

Functional outcomes were evaluated using Indonesian SF-36 questionnaire and found there is improvement in 3 out of 8 domains which is the domains physical function, pain and role limitation due to physical health compared with preoperative (Tables 6 and 7).

## 4. Discussion

The spine is a complex structure balanced by multiple forces that implement structural changes in attempt to compensate the sagittal and coronal vertical axis, so that the human being can maintain as balanced a movement as possible. Sagittal balance can be maintained through three main compensatory mechanisms, which may occur in the spine, pelvis and/or lower limb areas, including reduction of TK/hyperextension of adjacent segments, pelvis retroversion (increase of PT and rotation of the pelvis), knee flexion and ankle extension [12,13].

Many studies investigated the sagittal spinopelvic parameter in adults, but little research has been devoted to examining this relationship on patients with Adolescent Idiopathic Scoliosis. Very little studies focused on the spinal balance in Adolescent Idiopathic Scoliosis (AIS) [14,15], but its relation to pelvic configuration is not define detailed in the literature.

In our studies, we found from the mean of coronal alignment based on Lenke classification there is decrease of 39.4° of main thoracic, 17.4° of thoracolumbar/lumbar curvature, and 14.4° of proximal thoracic compared with preoperative. Also, from mean of sagittal alignment there is increase 2.8° of thoracic kyphosis and 12.8° of lumbar lordosis. And from mean of pelvic parameter showed there is decrease 2.8° of sacral slope and increase 0.8° of pelvic tilt. This is similar with the recent literature regarding variances relevant to some spinopelvic parameters in patients with AIS following surgical management. La Maida et al. reported a statistically increase in pelvic tilt (PT) [16], similarly Tanguay et al. acquired significant relationship between lumbar lordosis

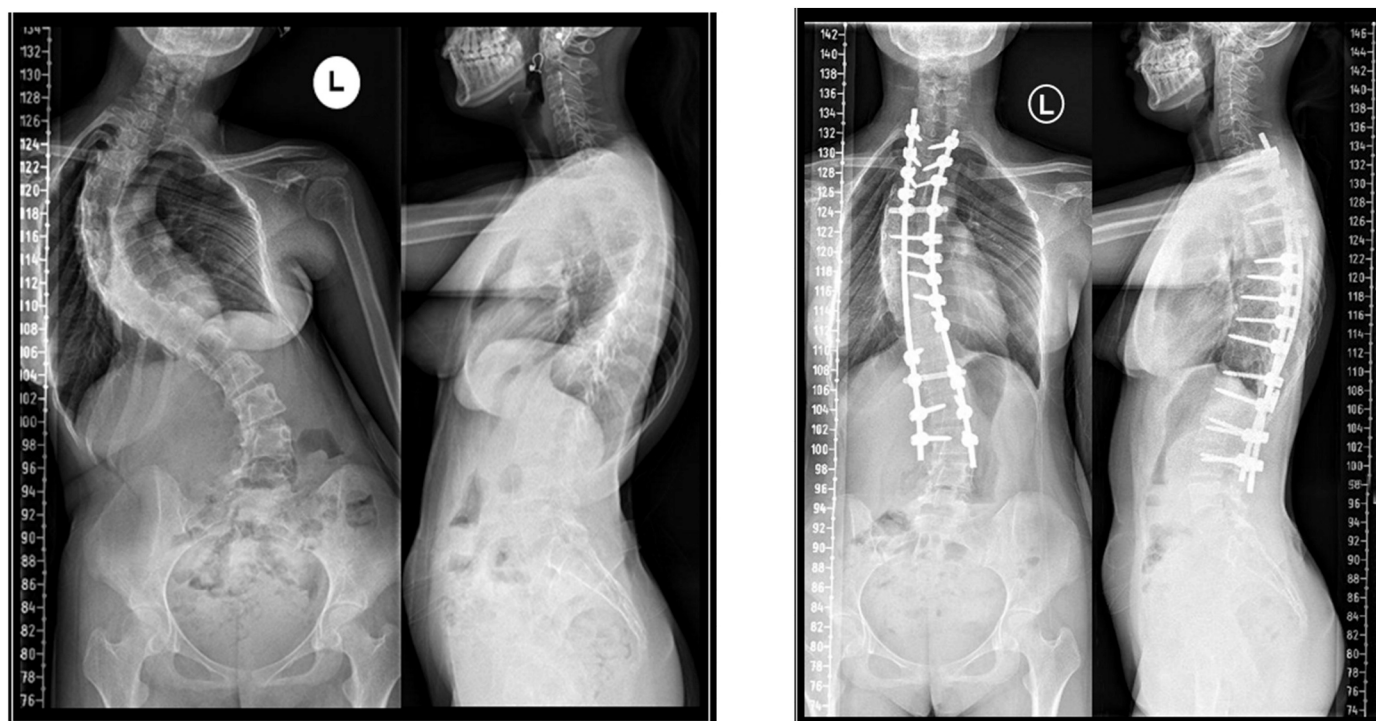


Fig. 4. Case 4 radiograph presentation.

**Table 4**  
Case 4 radiograph parameter.

Pre-operative	Post-operative
Coronal:	Coronal:
Proximal thoracic: 13° (secondary non-structural)	Proximal thoracic: 10° (secondary non-structural)
Main thoracic: 90° (primary). Apex T6	Main thoracic: 43° (primary). Apex T6
Thoracolumbar curve: 47° (secondary structural)	Thoracolumbar curve: 20° (secondary structural)
Sagittal:	Sagittal:
Thoracic kyphotic: 10° (20–40)	Thoracic kyphotic: 22° (20–40)
Lumbar lordotic: 43° (40–60)	Lumbar lordotic: 55° (40–60)
SS: 53° (30–50)	SS: 45° (30–50)
PT: 12° (10–25)	PT: 20° (10–25)
PI: 65° (40–65)	PI: 65° (40–65)
SVA: Neutral	SVA: +2

(LL) and pelvic parameter below and within the fusion from the analysis of 60 patients with AIS following posterior spinal instrumentation and fusion surgery [17].

In the present sample, we found mean of PI is 60.2°, and there is relatively difference of LL and PI for ±10°. This is similar to studies conducted by Le Huec et al. that reported when the incidence is over 50°, the lordosis tends to be less ±10° than the PI [18]. Thereby, it was possible to confirm a strong connection between the pelvic geometry and lumbar lordosis.

In this study, we used the SF-36 questionnaire to evaluate the quality of life of the patients with AIS, due to convenience. This questionnaire can be applied to more than 130 conditions, including spinal-related problems, which may considerably affect the quality of life related to health [19]. An important outcome of this study was a statistically significant improvement in functional capacity, pain, and role of limitation due to physical health, a result similar to that found by Cabral et al. [20]

There are several limitations in our study. First the number of patients is relatively small. Second, this study was cross sectional and some of the patients had a relatively short follow up period. However, the major strength of this study is the detailed description between the

coronal alignment, sagittal balance and pelvic parameter before and after surgery. Moreover, pedicle screws were the only instrumentation method in every case, and all surgical procedures were performed by 1 senior surgeon. Nonetheless, a larger, longer follow-up study is necessary to further validate our findings.

### 5. Conclusion

Sagittal spinopelvic parameters are important in treating adolescent idiopathic scoliosis and must be taken into account before and after the surgery. Coronal angle deformity correction of AIS patients is correlated with sagittal improvement which caused by compensatory alteration of pelvic parameter. This finding correlates with the improvement of functional outcome of the patients.

### Provenance and peer review

Not commissioned, externally peer-reviewed.

### Funding

This study is funded by the authors.

### Sources of funding

There's no particular sponsor for this research.

### Ethical approval

Ethical approval was done by the Gadjah Mada University Ethical comitee.

### Consent

Consent was given before the study.

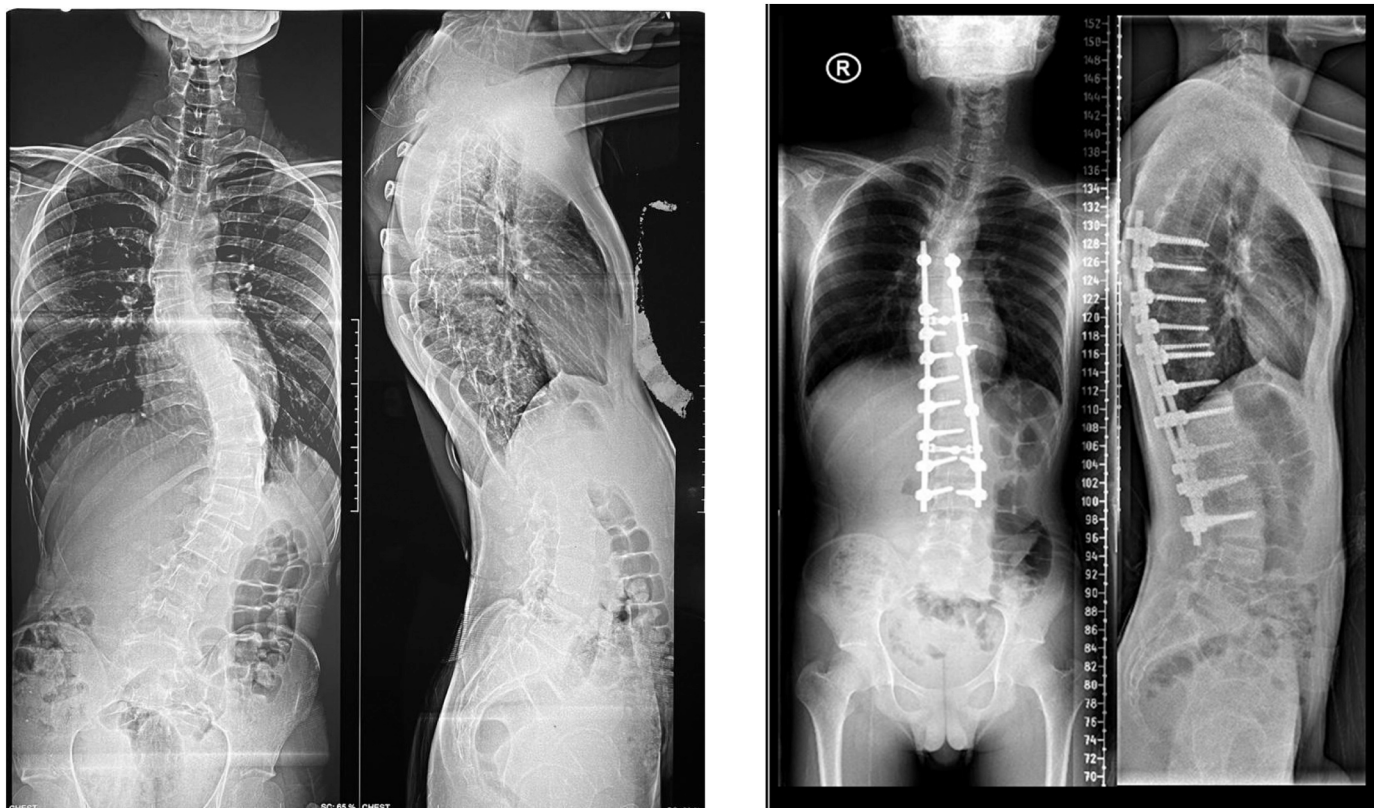


Fig. 5. Case 5 radiograph presentation.

Table 5

Case 5 radiograph parameter.

Pro-operative	Post-operative
Coronal:	Coronal:
Proximal thoracic: 12° (secondary non-structural)	Proximal thoracic: 22° (secondary non-structural)
Main thoracic: 11° (primary). Apex T12	Main thoracic: 47° (primary). Apex T12
Thoracolumbar curve: 22° (secondary structural)	Thoraolumbar curve: 30° (secondary structural)
Sagittal:	Sagittal:
Thoracic kyphotic: 38° (20–40)	Thoracic kyphotic: 9° (20–40)
Lumbar lordotic: 55° (40–60)	Lumbar lordotic: 49° (40–60)
SS: 53° (30–50)	SS: 40° (30–50)
PT: 12° (10–25)	PT: 56° (10–25)
PI: 65° (40–65)	PI: 40 (40–65)
SVA: +1.5	SVA: -1

Magetsari, R: Conceptualization, Supervision.  
 Pratama, B.Y: Conceptualization. Reviewing, Editing.  
 Cein, C.R: Writing, Reviewing, Editing.  
 Tampubolon, Y.O: Writing, Reviewing, Editing.  
 Mafaza, A: Writing, Reviewing, Editing.

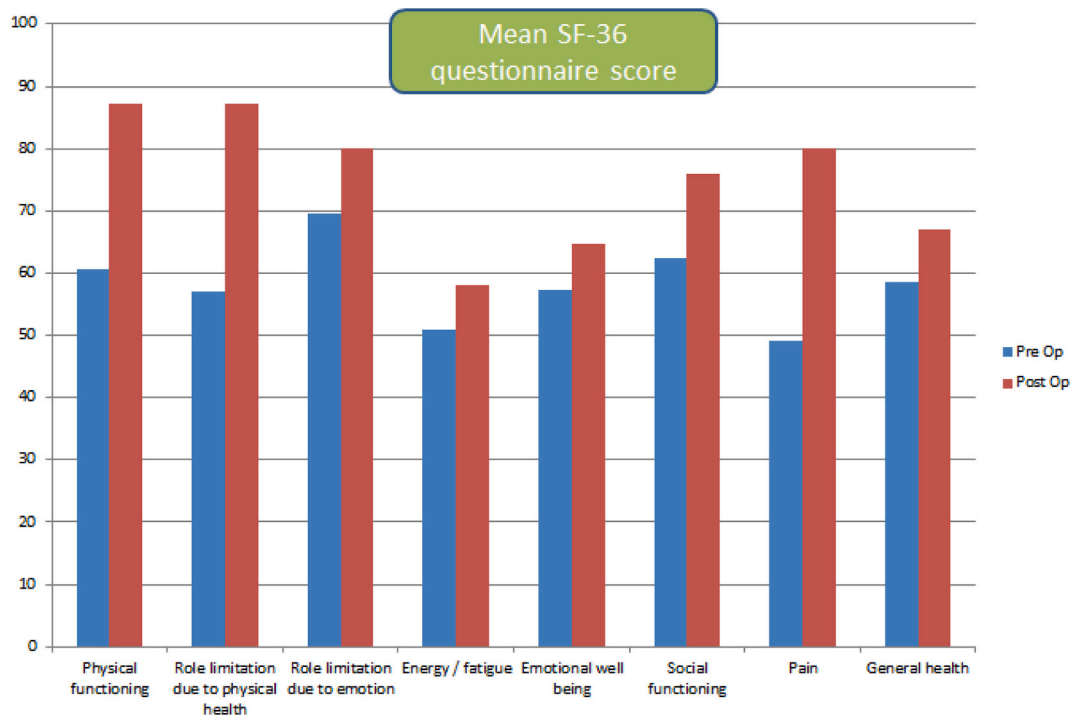
**Declaration of competing interest**

There is no conflict of interest in this study.

**CRedit authorship contribution statement**

Sakti, Y.M: Conceptualization, Supervision.

**Table 6**  
SF-36 questionnaire score.



**Table 7**  
SF-36 questionnaire score improvement.

Domains of SF-36	Pre Operative (Mean)	Post Operative (Mean)	Improvement
Physical functioning	60.64	87.25	26.61%
Role limitation due to physical health	56.92	87.25	30.33%
Role limitation due to emotion	69.56	79.96	10.40%
Energy / fatigue	51	58	7%
Emotional well being	57.2	64.8	7.60%
Social functioning	62.42	76	13.58%
Pain	49	80.05	31.05%
General health	58.6	67	8.40%

Appendix 1. Lenke classification

**A**

<b>CURVE TYPE</b>				
Type	Proximal Thoracic	Main Thoracic	Thoracolumbar/Lumbar	Description
1	Non-Structural	Structural (Major)*	Non-Structural	Main Thoracic (MT)
2	Structural	Structural (Major)*	Non-Structural	Double Thoracic (DT)
3	Non-Structural	Structural (Major)*	Structural	Double Major (DM)
4	Structural	Structural (Major)*	Structural	Triple Major (TM) <sup>§</sup>
5	Non-Structural	Non-Structural	Structural (Major)*	Thoracolumbar/Lumbar (TL/L)
6	Non-Structural	Structural	Structural (Major)*	Thoracolumbar/Lumbar-Main Thoracic (TL/L-MT)

**STRUCTURAL CRITERIA (Minor Curves)**

- Proximal Thoracic - Side Bending Cobb  $\geq 25^\circ$   
- T2-T5 Kyphosis  $\geq 20^\circ$
- Main Thoracic - Side Bending Cobb  $\geq 25^\circ$   
- T10-L2 Kyphosis  $\geq 20^\circ$
- Thoracolumbar/Lumbar - Side Bending Cobb  $\geq 25^\circ$   
- T10-L2 Kyphosis  $\geq 20^\circ$

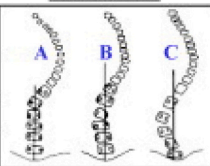
\*Major = Largest Cobb measurement, always structural  
Minor = All other curves with structural criteria applied  
<sup>§</sup>Type 4 - MT or TL/L can be major curve

**LOCATION OF APEX (SRS Definition)**

CURVE	APEX
Thoracic	T2-T11/12 Disc
Thoracolumbar	T12-L1
Thoracolumbar/Lumbar	L1/2 Disc-L4

**MODIFIERS**

Lumbar Spine Modifier	Center Sacral Vertical Line to Lumbar Apex
A	CSVL between pedicles
B	CSVL touches apical body(ies)
C	CSVL completely medial



Thoracic Sagittal Profile T5-T12	
- (Hypo)	<10°
N (Normal)	10° - 40°
+ (Hyper)	>40°

Curve Type (1-6) + Lumbar Spine Modifier (A, B, C) + Thoracic Sagittal Modifier (-, N, +) = Classification (e.g. **1B+**): \_\_\_\_\_

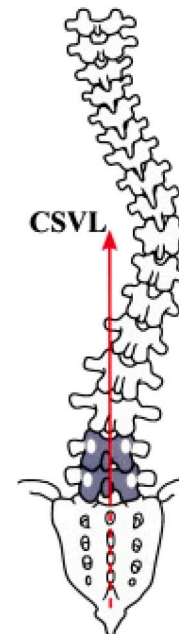
**B**

**LUMBAR SPINE MODIFIER RULES**

**A, B, C**

1. Examine upright coronal radiograph.
2. Accept pelvic obliquity <2 cm. If >2 cm, then must block out leg length inequality to level pelvis.
3. Draw CSVL = Center Sacral Vertical Line with a fine tipped pencil/marker. Bisection proximal sacrum and drawn vertical to parallel lateral edge of radiograph.
4. Stable Vertebra – Most proximal lower thoracic or lumbar vertebra most closely bisected by CSVL. If a disc is most closely bisected, then choose next caudad vertebra as stable.
5. Apex of curve is the most horizontal and laterally placed vertebral body or disc.
6. SRS Definitions

Thoracic Curves	T2-T11-12 disc
Thoracolumbar Curves	T12-L1
Lumbar Curves	L1-2 disc to L4





## References

- [1] M.N. Choudhry, Z. Ahmad, R. Verma, Adolescent idiopathic scoliosis, *Open Orthop. J.* 10 (2016) 143–154.
- [2] S.M. McDonald, Magnetic resonance imaging of scoliosis, *Imaging* 22 (2013) 1–10.
- [3] A. Jada, C.E. Mackel, S.W. Hwang, A.F. Samdani, J.H. Stephen, et al., in: *Evaluation and Management of Adolescent Idiopathic Scoliosis: A Review* 43, 2017, pp. 1–9, 4.
- [4] J.P. Horne, B. Flannery, S. Usman, Adolescent idiopathic scoliosis: diagnosis and management, *Am. Fam. Physician* 89 (3) (2014) 193–198.
- [5] S.R. Garfin, F.J. Eismont, G.R. Bell, J.S. Fischgrund, C.M. Bono, Rothman-Simeone, Herkowitz, *The Spine*, 7th Ed., Elsevier, 2018.
- [6] S.F. Calloni, T.A.G.M. Huisman, A. Poretti, B.P. Soares, Back pain and scoliosis in children: when to image, what to consider, *The Neurology Journal* (00) (2017) 1–12.
- [7] J.C.L. Huec, W. Thompson, Y. Mohsinaly, C. Barrey, A. Faundez, Sagittal balance of the spine, *Eur. Spine J.* 28 (2019) 1889–1905.
- [8] D. Kim, D.D. Davis, R.P. Menger, *Spine Sagittal Balance*. <https://www.ncbi.nlm.nih.gov/books/NBK534858/>, 2021.
- [9] E.M. Pinto, J. Alves, A. Teixeira, A. Miranda, Sagittal balance in adolescent idiopathic, *Scoliosis* 18 (3) (2019) 182–186.
- [10] X.M. Xu, Wang Fe, X.Y. Zhou, Z.X. Liu, X.Z. Wei, Y.S. Bai, M. Li, Sagittal balance in adolescent idiopathic scoliosis, *Medicine* 94 (45) (2015) 1–7.
- [11] O. Ozkunt, K. Sariyilmaz, T. Akgul, F. Dikici, U. Domanic, Analyzing the preoperative and postoperative spinopelvic parameters in Lenke type 1 adolescent idiopathic scoliosis patients, *J. Turk. Spinal Surg.* 28 (4) (2017) 233–236.
- [12] C. Barrey, P. Roussouly, G. Perrin, J.C. Le Huec, Sagittal balance disorders in severe degenerative spine. Can we identify the compensatory mechanisms? *Eur. Spine J.* 20 (5) (2011 Sep) 626–633.
- [13] M. Yagi, N. Hosogane, E. Okada, K. Watanabe, M. Machida, M. Tezuka, M. Matsumoto, T. Asazuma, Keio spine research group. Factors affecting the postoperative progression of thoracic kyphosis in surgically treated adult patients with lumbar degenerative scoliosis, *Spine* 39 (8) (2014) E521–E528. Apr 15.
- [14] T. de Jonge, J.F. Dubousset, T. Illés, Sagittal plane correction in idiopathic scoliosis, *Spine* 27 (7) (2002 Apr 1) 754–760.
- [15] J.M. Mac-Thiong, H. Labelle, M. Charlebois, M.P. Huot, J.A. de Guise, Sagittal plane analysis of the spine and pelvis in adolescent idiopathic scoliosis according to the coronal curve type, *Spine* 28 (13) (2003 Jul 1) 1404–1409.
- [16] G.A. La Maida, L. Zottarelli, G.V. Mineo, B. Misaggi, Sagittal balance in adolescent idiopathic scoliosis: radiographic study of spino-pelvic compensation after surgery, *Eur. Spine J.* 22 (6) (2013 Nov) 859–867.
- [17] F. Tanguay, J.M. Mac-Thiong, J.A. de Guise, H. Labelle, Relation between the sagittal pelvic and lumbar spine geometries following surgical correction of adolescent idiopathic scoliosis, *Eur. Spine J.* 16 (4) (2007 Apr) 531–536.
- [18] J.C. Le Huec, W. Thompson, Y. Mohsinaly, C. Barrey, A. Faundez, Sagittal balance of the spine, *Eur. Spine J.* 28 (9) (2019 Sep) 1889–1905.
- [19] A.A. Patel, D. Donegan, T. Albert, The 36-item short form, *J. Am. Acad. Orthop. Surg.* 15 (2) (2007) 126–134.
- [20] L.T.B. Cabral, E.S. Valesin Filho, F.H. Ueno, A.M. Yonezaki, L.M.R. Rodrigues, Avaliação da qualidade de Vida em pacientes com escoliose idiopática do ado-lescente após tratamento cirúrgico pelo questionário SF-36, *Coluna/Columna* 8 (3) (2009) 315–322.