Posterior Only Surgical Correction of Adolescent Idiopathic Scoliosis

Radwan Nouby[a], Yasser Mahmuod El-Banna[b], Ashraf A. Abdellatif [c] Eslam Elsayed Elkhatib[c]

[a]Neurosurgery Department, Faculty of Medicine, Assiut University, Assiut, Egypt.
[b]Neurosurgery Department, Faculty of Medicine, Alexandria University, Alexandria, Egypt.
[c]Neurosurgery Department, Faculty of Medicine, South Valley University, Qena, Egypt.

Abstract

Background: Adolescent Idiopathic Scoliosis (AIS) is defined as an abnormal spinal curvature of more than ten degrees, noticed in adolescence, with an unexplained cause.

Objectives: To evaluate the results of posterior-only surgical intervention for adolescent idiopathic scoliosis.

Patients and methods: This prospective cross-sectional study was a research study conducted on thirty children with idiopathic scoliosis admitted to the outpatient clinic of the Neurosurgery department in Qena University Hospital, South Valley University, Egypt, and the Students' hospital in Alexandria, Egypt in the duration from January 2022-December 2023.

Results: The postoperative Cobb angle of the main thoracic and thoracolumbar curves was significantly less than preoperative curves (P value less than 0.001). Thoracic kyphosis (T4-T12) was significantly less after surgery than before (P value less than 0.001). Lumbar lordosis (L1-L5) was significantly less after than before surgery (P value less than 0.001).

Conclusion: The study supports the posterior-only surgical technique as a reliable, safe, and effective treatment for adolescent idiopathic scoliosis, providing substantial deformity correction and improving long-term spinal function and quality of life. These findings are consistent with a growing body of literature advocating for posterior-only correction in severe AIS cases, reinforcing its benefits in terms of safety, deformity correction, and functional outcomes.

Keywords: AIS; Cobb angle; Lumbar lordosis; Thoracic kyphosis.

DOI: 10.21608/SVUIJM.2025.359947.2115
***Correspondence:** ashrafabdellatef4@gmail.com
Received: 18 February,2025.
Revised: 20 March, 2025.
Accepted: 26 March, 2025.
Published: 21 June, 2025

Cite this article as Radwan Nouby, Yasser Mahmuod El-Banna, Ashraf A. Abdellatif Eslam Elsayed Elkhatib.(2025). Posterior Only Surgical Correction of Adolescent Idiopathic Scoliosis. *SVU-International Journal of Medical Sciences*. Vol.8, Issue 2, pp: 65-77.

Introduction

Adolescent Idiopathic Scoliosis is known as an abnormal spinal curvature of more than ten degrees, noticed in adolescence, with an unexplained cause. **(Kuznia et al., 2020).** Scoliosis is a spinal deformity that impacts all 3 anatomical planes. In the frontal plane, it presents as lateral curvature with vertebrae displaced from the midline. An overgrowth of the anterior of the vertebral bodies affects the sagittal alignment, leading to hypokyphosis & hyperlordosis. Each affected vertebra isn't only laterally deviated and tilted but additionally turned into the axial plane, indicating that the scoliotic spine is deformed in all 3 dimensions. **(Lacroix et al., 2023).**

Even though the spine shows deformation in all 3 planes, nevertheless, the assessment of scoliosis has traditionally relied on 2D frontal & lateral radiography evaluations. The best method for assessing scoliosis is the angle of Cobb **(Vavruch et al., 2018).**

Axial vertebral rotation (AVR) and right lateral deviation are relatively physiological in the mid and lower spine of thoracic during adolescence and beyond. This is hypothesized because of the heart's position in the chest. **(Janssen et al., 2011)**.

The main treatment modalities for scoliosis depend on curve magnitude and patient maturity, including observation, bracing, and surgical intervention. For curvature below twenty-five degrees, patients may be monitored every 6-12 months with clinical and radiological assessments **(Kuznia et al., 2020; Choudhry et al., 2020).**

Bracing should be indicated for immature cases with curves ranging from 25° to 45°. Correction operation is recommended for patients with spinal curvatures beyond 45°. Nevertheless, in certain instances, curves persisted in progression after skeletal maturity, particularly in cases with curves above 50° **(Negrini et al., 2015)**.

There are two primary methods for performing corrective operation: posterior and anterior. The posterior procedure is increasingly favored because of its safety and better correction outcomes. While anterior surgery may preserve surgical segments, the presence of several arteries and organs in the anterior region compromises surgical safety. In addition, pain of the back was more frequently noticed by adult cases compared to adolescent patients, potentially justifying the pursuit of corrective surgery. **(Erwin et al., 2020)**.

The main objective of corrective scoliosis operation in adolescents is to arrest curve development and to minimize pulmonary impairment and pain. The secondary objectives of operating correction are the restoration of three-dimensional spinal alignment and cosmesis. **(Cheng et al., 2015)**.

Since the creation of pedicle screws, posterior instrumentation has become the primary technique for corrective scoliosis operations. The posterior procedure is applicable for the treatment of all Lance classifications of scoliosis. Correction may be achieved using compression-distraction, rod derotation movements, in situ contouring, or in block and direct vertebral body derotation. **(Newton,2022)**.

This investigation aimed to assess the results of posterior-only surgical therapy for adolescent idiopathic scoliosis.

Patients and methods

This prospective cross-sectional study has been performed on thirty kids with idiopathic scoliosis admitted to the outpatient clinic of the Neurosurgery department in Qena University Hospital, South Valley University, Egypt, and the the Students' hospital in Alexandria, Egypt in the duration from January 2022 to December 2023. The investigation has been permitted by the Ethics Committee of the

Faculty of Medicine, Qena University, Egypt. An informed written consent has been acquired from each patient's parent. There are adequate provisions to maintain the privacy of participants and the confidentiality of the data.

Inclusion criteria: Aged from 10 to 18 years old, children with curves of 45 degrees or more and children with idiopathic scoliosis.

Exclusion criteria: Patients with ages more than 18 or less than 10 years old, children with curves less than 45 degrees, and children with other types of scoliosis.

Methods

All cases have been exposed to the following: full history taking, general examination, local examination, complete neurologic examination, full routine laboratory tests, and imaging investigations.

Procedure: According to the standarized protocol of posterior only surgical correction of adolescent idiopathic scoliosis. The patients were operated upon by the same surgical team to ensure consistency. Patients underwent surgery in the prone position on a transparent surgical board, with arms positioned at a maximum abduction of 90° and elbow flexion to alleviate the risk of axillary nerve injury. Foam padding was applied to the chest to ensure the nipples were directed straight down along the midline. The abdomen was allowed to hang freely to avert venous congestion, while the chest, anterior superior iliac spines (ASIS), and knees were adequately padded, with the hips and knees slightly flexed as shown in (**Fig.1**). All patients were administered with general anesthesia, and hypotensive anesthesia was utilized to minimize hemorrhage. An intravenous single dosage of one gram of a third-generation cephalosporin antibiotic is administered following a sensitivity test, and a Foley catheter is implanted in all patients. The back is thoroughly sterilized, reaching the anterior axillary line anteriorly and down to the mid-thigh bilaterally, utilizing povidone iodine (Betadine). The whole body is then covered, exposing only the back at the desired level and the posterior iliac crest to harvest bone graft if needed. The operative field is sealed with an adhesive sterile sheet.

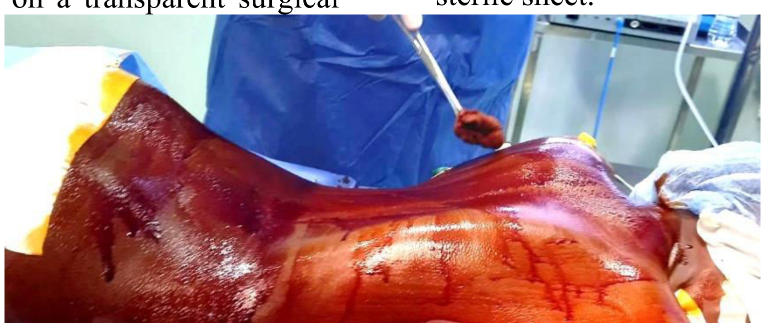

Fig. 1. Patient positioning and sterilization of the surgical field

Following sterilizing and draping, a midline longitudinal incision is positioned directly opposite the apical vertebrae discovered via fluoroscopy. This planned incision starts at the spinous process one level above the upper instrumented vertebra (UIV) and terminates at the spinous process of the selected lower instrumented vertebra (LIV). The fascia is incised in line with the skin incision, the paraspinous muscles are elevated subperiosteally, exposing the spinous process, the lamina, and the transverse process laterally. The inferior articular facets at each thoracic level are osteotomized using a thin osteotome to enhance spinal flexibility and reveal the superior articular facet. Revealing the superior articular facet enables complete excision of the cartilaginous surface to enhance fusion and serves as a reference point for the accurate positioning of thoracic pedicle screws. If required, the lumbar segments are similarly osteotomized. All osteotomized bones are retained for bone grafting purposes. Pedicle screws have been located more than 80 percent of the time in pedicles cephalic and caudal to the apical vertebrae using the hand technique. At least two levels of caudal and two levels cranial are used as anchorage points. Extended head screws were routinely utilized on the concave side to facilitate apical reduction. Following the completion of the insertion of the pedicle screws, their appropriate positioning was by verified fluoroscopy throughout surgery as shown in (**Fig.2)** (**Block et al., 2022**).

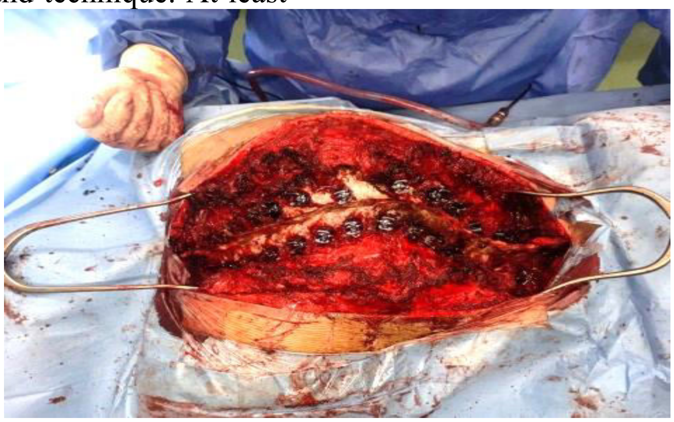

Fig.2.Exposure and pedicle screws insertion.

Bilateral facetectomy at the fusion levels was commonly performed to enhance curve flexibility and facilitate fusion. Additional release operations have been performed in particular cases involving hard curves, encompassing numerous Ponte osteotomies and asymmetrical pedicle subtraction osteotomies (PSOs).

Following the insertion of pedicle screws at the specified levels, the selection of the suitable rod contour and length was performed with the rod template, and rod contouring was carried out with the rod bender. The rod is positioned within the curve's concavity before derotation. An implant holder and/or derotation forceps can be used for rod insertion. The set screws shouldn't be firmly locked at this stage to permit motion of the rod in the screw heads.

The set screw is connected to the set screw holder to be inserted in each pedicle. To ensure the placement of the set screw and avoid cross-threading, the set screw tube was used as a guide. The rod is persuaded into the implant head by utilizing a rod persuader or rocker. If the rod is not fully seated, rod pushers or reducers are used to push the rod in the screw head. When the rod is in the screw head, one of the set screw holders could be used to insert it through the reducer into the screw head. This step is repeated for all the screws that will be part of the apical cluster. The rod is axially rotated at 90° to restore the sagittal plane balance as shown in **(Fig.3)**.

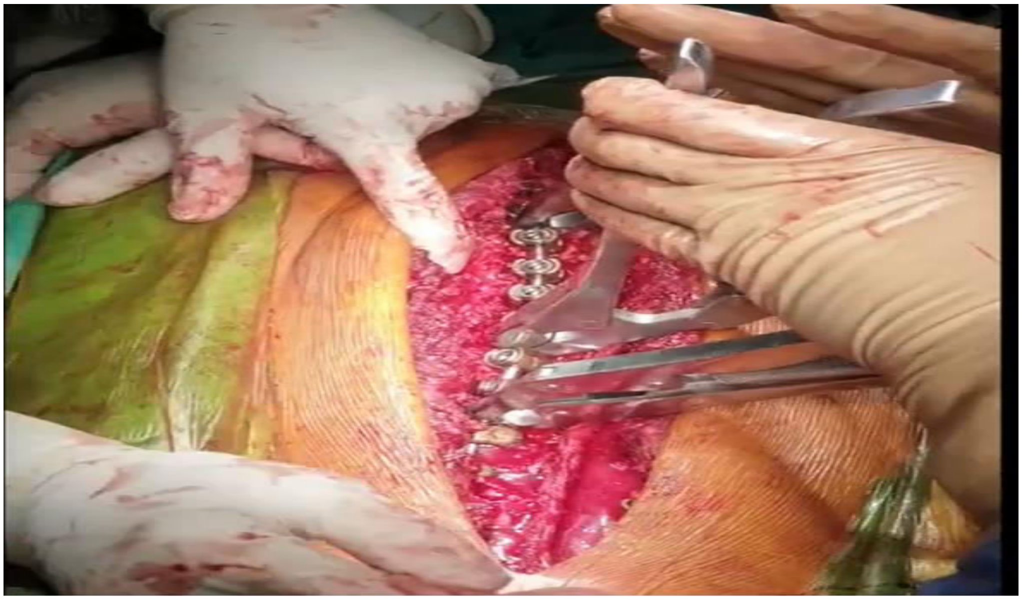

Fig.3. Rod placement.

Two derotation forceps are attached to the rod. Derotation of the rod to have its curvature moving from the frontal plane to the sagittal plane as shown in **(Fig.4)**. All the set screws should be slightly loose before performing any rod derotation maneuvers. Once the derotation is complete, the set screws of the most proximal screw are firmly tightened. Remove the derotation forceps. Final tightening of each screw in the construct is done by using the counter torque tight fit and final tightener as shown in **(Fig.5)** (**Balsano et al., 2022**). Due to the unavailability of intraoperative neuro monitoring in our hospital, the Stagnara wake-up test has been conducted immediately following the insertion of the second rod in each case to confirm neuronal integrity **(Elnady et al., 2017).** Subsequent posterior fusion was performed utilizing autologous local bone graft. This study did not utilize iliac bone grafts, local antibiotics weren't introduced into the bone graft, costoplasty was not performed, and tranexamic acid wasn't routinely administered.

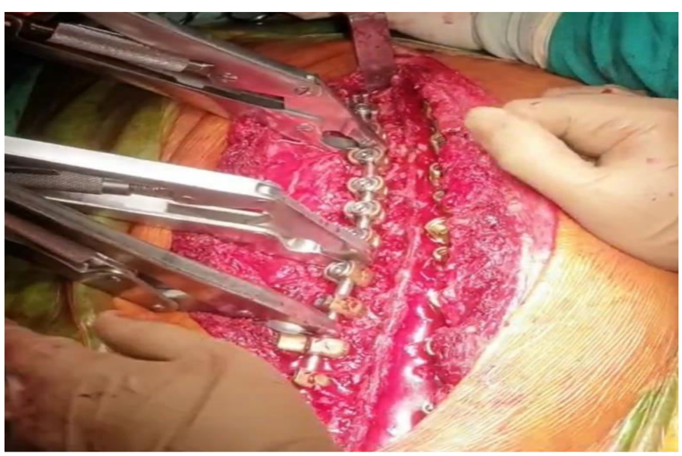

Fig.4. Rod derotation.

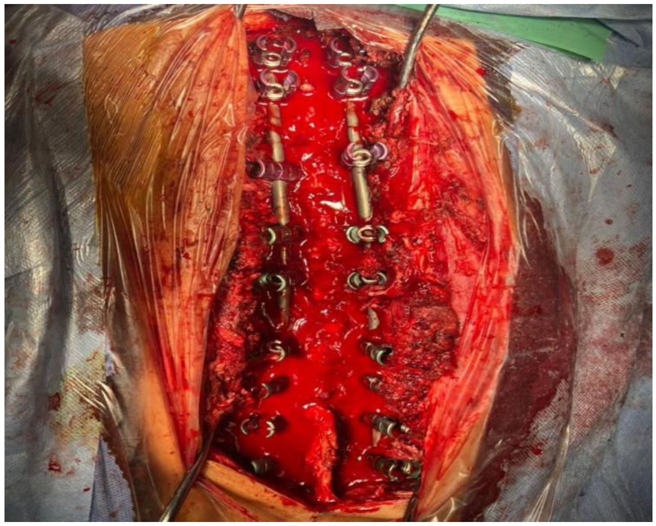

Fig.5. After rod derotation.

The wound was finally closed in layers over a suction drain. The duration of the procedure, anticipated hemorrhage, and intraoperative complications, such as dural tear and pulmonary complications, will be recorded.

All cases have been mobilized as soon as they were able, without any external support. The preoperative radiological parameters have been re-evaluated immediately post-operation and clinical assessment was done during examination visits at 2, 6, and 12 months after surgery, as well as at annual intervals thereafter.

Post-intervention standing posterior-anterior (PA) and lateral radiographs of the whole spine, involving the hip joints, are recorded on a single 3-foot film. Post-intervention full neurological examination. To facilitate bone healing and establish solid arthrodesis, a limitation on sports activities, particularly contact sports, is often recommended for a duration of six months. In the first follow-up visit after 2 weeks of operation, which is usually needed for wound healing (**Gadiya et al., 2021**).

Study outcomes: Technical success (achieve curve correction) and clinical success (obtain a balanced spine and improve cosmesis)

Ethical approval: All subjects included in the study signed a written informed consent from their parents before their inclusion in the study, and the institutional ethical committee of the Faculty of Medicine, Qena, approved the study (IRB NO. SVUMED-NES014-2-22-4-390)

Statistical analysis

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). The Shapiro-Wilks test and histograms were used to evaluate the normality of the distribution of data. Quantitative parametric data were presented as mean and standard deviation (SD). Quantitative non-parametric data were presented as mean and standard deviation (SD) and compared between the two groups utilizing unpaired Student's t- test. Quantitative non-parametric data were presented as median and interquartile range (IQR). Qualitative variables were presented as frequency and percentage (%) and were analyzed utilizing Fisher's exact test when appropriate. A two tailed P value < 0.05 was considered statistically significant.

Results

Regarding patient characteristics, Age ranged from 11 to 18 years with a mean value (± SD) of 14 (± 2.1) years. There were

5 (16.67%) males and 25 (83.33%) females. Time of detection ranged from 1 to 5 years with a mean value (± standard deviation) 2.4 ± 1.3 years as shown in **(Table .1)**.

Table 1. Baseline characteristics of the examined patients

Variables		(number=30)
Age (years)	**Mean ± SD**	14 ± 2.1
	Range	11 - 18
Sex	**Male**	5 (16.67%)
	Female	25 (83.33%)
Time of detection (years)	**Mean ± SD**	2.4 ± 1.3
	Range	1 - 5

Regarding Lenke type and as shown in **(Table .2)**, type 1 was present in 15 (50%) patients, type 3 was present in 8 (26.67%) patients, type 5 was found in 4 (13.33%) patients and type 6 was found in 3 (10%) patients.

Table 2. Lenke type of the examined patients

Variables	(number=30)
Type 1	15 (50%)
Type 3	8 (26.67%)
Type 5	4 (13.33%)
Type 6	3 (10%)

The main thoracic curves ranged from 45 to 81 degrees with a mean value (± SD) of 62.6 (± 12.06) degrees and median value of 61.5 degrees, and the bending angle ranged from 32 - 72 degrees with an average value (± SD) of 52 (± 12.11) degrees and median value of 51 degrees. The thoracolumbar curves ranged from 40 to 92 degrees with a mean value (± SD) of 55.2 (± 16.87) degrees and median value of 48 degrees, and the bending angle ranged from 24 t- 80 degrees with a mean value (± standard deviation) of 42.7 (± 17.5) degrees and median value of 33 degrees as shown in **(Fig.6).** Standing Cobb angle was significantly higher than bending angle according to MT and TL/L curve location (P value less than 0.001) as seen in **(Table .3).**

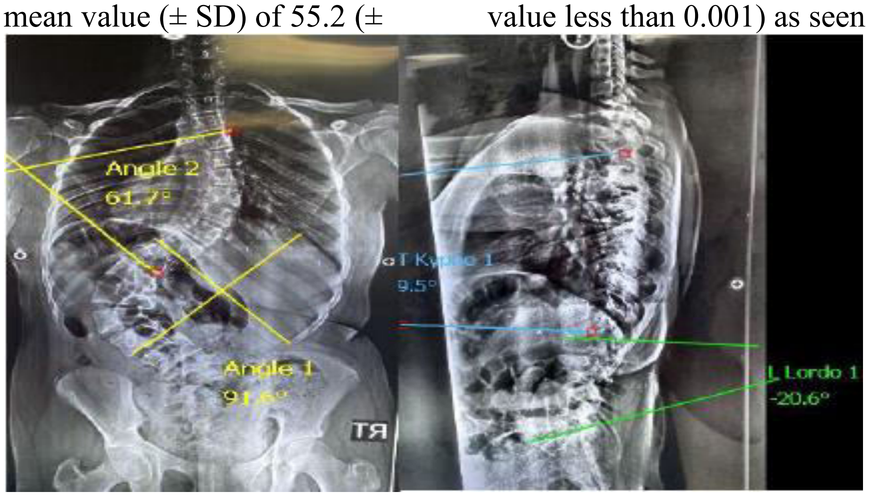

Fig.6. Preoperative measurements: a) PA standing x-ray with Cobb angles of the main thoracic and thoracolumbar curves shown. b) Lateral standing x-ray showing the degree of thoracic kyphosis and lumbar lordosis.

Table 3. Angle of Curve Cobb regarding to curve location.

Pre-intervention	Cobb angle	Bending angle
MT (n=30) **Min. – Max.** **Mean ± SD.** **Median**	45 – 81 62.6 ± 12.06 61.5	32 – 76 52 ± 12.11 51
TL/L(n=30) **Min. – Max.** **Mean ± SD.** **Median**	40 – 92 55.2 ± 16.87 48	24 – 80 42.7 ± 17.5 33

The postoperative Cobb angle of the main thoracolumbar and thoracic curves were significantly lower than preoperative curves (P value less than 0.001) as demonstrated in **(Fig.7)** and shown in **(Table.4).**

Fig.7. Postoperative imaging: a) CT dorsolumbar spine showing Cobb angles of the main thoracic and thoracolumbar curves. b) CT dorsolumbar spine, lateral view,showing the degree of lumbar lordosis. c) CT dorsolumbar spine, lateral view, showing the degree of thoracic kyphosis.

Table 4. Spread of the examined cases regarding to Cobb angle.

Cobb angle	Pre-intervention	Post-intervention	Change	% of change
MT (n=26) **Min. – Max.** **Mean ± SD.** **Median**	45 – 81 62.6 ± 12.06 61.5	12 – 24 16.7 ± 3.64 16	28 – 62 46 ± 15.4 49	62– 83 72.5 ± 6.8 71
P value	**<0.001***			
TL/L (n=15) Min. – Max. Mean ± SD.	40 – 91 55.2 ± 16.87 48	12 – 21 15.4 ± 3.02 15	27 – 70 39.9 ± 20.6 31	62 –81 70.4 ± 18.3 68

Median				
P value	**<0.001***			

Thoracic kyphosis (T4-T12) was significantly less in postoperative than preoperative (P value less than 0.001) as shown in **(Table .5)**.

Table 5. Thoracic kyphosis of a studied patients.

Variables		**(n=30)**
Preoperative	**Mean ± SD**	35.4 ± 20.43
	Range	10 - 74
Postoperative	**Mean ± SD**	33.1 ± 8.96
	Range	21 - 49
P value	**<0.001***	

Lumbar lordosis (L1-L5) was significantly lower in postoperative than preoperative (P value less than 0.001) as shown in **(Table .6)**.

Table 6. Lumbar lordosis of a studied patients.

Variables		**(n=30)**
Preoperative	**Mean ± SD**	52 ± 13.21
	Range	20 - 77
Postoperative	**Mean ± SD**	46.6 ± 8.22
	Range	32 - 59
P value	**<0.001***	

The preoperative Nash & Moe grading of axial vertebral rotation of the main structural curves has been scored: 3 curves (10 percent) was grade1, 15 curves (50 percent) was grade 2, 6 curves (20 percent) was grade 3, and 6 curves (20 percent) was grade 4. Postoperative Nash and Moe grading of the curves were scored: 12 curves (40 percent) was grade 0, 15 curves (50 percent) was grade1, and 3 curves (10 percent) was grade1 as shown in **(Table.7)**.

Table 7. Comparison between before & after surgery Nash MOE scoring.

Nash MOE grading	**Before surgery**		**After surgery**		**P value**
	No.	**%**	**No.**	**%**	
0	0	0.0	12	40.0	<0.001
I	3	10.0	15	50.0	
II	15	50.0	3	10.0	

III	6	20.0	0	0.0	
IV	6	20.0	0	0.0	

Regarding complications, Intraoperatively, two patients suffered from screw pull out during correction. One of them was at the apex, and in the other patient the screw pull out was at the upper anchor which was managed by inserting pedicle screws at the segment above.

Postoperatively, Early postoperatively, there was one case that suffered of transient ileus, which was totally recovered at the third postoperative day with fluid and conservative treatment. Other two cases suffered from superficial wound infection that healed totally with daily dressing and antibiotic according to culture results within 10 days.

Discussion

In terms of demographic data, the current study revealed that participants' ages ranged from 11 to eighteen years, with an average age of fourteen years (± 2.1). The sample contained five males (16.67%) and twenty-five females (83.33 percent). The time of detection varied from 1 to 5 years, with an average duration of 2.4 years (± 1.3).

These findings align with previous studies reporting a female predominance in adolescents with idiopathic scoliosis. **Abd-Elmonem et al. (2023)** observed that 80% of their adolescent sample with idiopathic scoliosis were female, with ages ranging from 10 to 18 years; notably, 70% were below fifteen years of age.

Preoperatively, right shoulder elevation was present in nine patients (30%), while left shoulder elevation was observed in twelve patients (40%). These findings reflect the common compensatory mechanisms in scoliosis, where the direction and location of the spinal curvature can lead to uneven shoulder alignment. The asymmetry in shoulder elevation is often a result of spinal deformity, with the body adjusting to maintain balance, which can be corrected through surgical intervention aimed at improving spinal alignment. With respect to the Lenke classification, Type 1 was the most prevalent in the current study, observed in 15 patients (50%). This was followed by Type 3 in 8 patients (26.67%), Type 5 in 4 patients (13.33%), and Type 6 in 3 patients (10%).

These findings are aligned with those of **Chovatiya (2021)** who reported that Type 1 was the most common Lenke curve among adolescents with idiopathic scoliosis.

Similarly, **Hwang et al. (2020)** indicated that most patients exhibited Lenke Type 1 curves (38.7%), while 19.4% had Lenke Type curves.

The study found that the Cobb angle was significantly more than the bending angle for both the main thoracic (MT) and thoracolumbar/lumbar (TL/L) curves. For the MT curve, the Cobb angle ranged from 45 to 81 degrees (mean 62.6°), and the bending angle ranged from 32 to 72 degrees (mean 52°). For the TL/L curve, the Cobb angle ranged from 40 to 91 degrees (mean 55.2°), and the bending angle ranged from 24 to 80 degrees (mean 42.7°). This difference is due to the Cobb angle reflecting the static curvature of the spine, measured in a neutral posture, while the bending angle measures flexibility during forward bending, where the curve reduces as the spine straightens. Therefore, the Cobb angle consistently shows higher values, reflecting the curve's rigidity in a standing.

In comparison, **Elnady et al. (2017)** reported that the mean Cobb angle for the major curve was 61.33° (± 15.4) before surgery, while the mean Cobb angle for the minor curve was 38.16° (± 15.4). Similarly, **Mirzashahi et al. (2020)** observed a significantly higher preoperative Cobb angle for the major curve, with a mean of 97.58° (range: 82–131°) in the coronal plane.

Furthermore, a systematic review and meta-analysis by **Traversari et al. (2022)** found that the mean Cobb angle of the major curve varied from 80.0° (± 7.3) to 110.8° (± 12.1), indicating a considerable range in the severity of scoliosis across different studies.

The postoperative Cobb angle of the main thoracic and thoracolumbar curves was significantly lower than preoperative curves (P value less than 0.001).

In support of these findings, **Abd-Elmonem et al. (2023)** conducted a study on twenty adolescent idiopathic scoliosis patients who underwent posterior-only surgical correction. Their study showed that the mean Cobb angle ranged from 45° to 85°, and the secondary Cobb angle ranged from 0° to 50° preoperatively, with a significant reduction in both angles after surgery.

Thoracic kyphosis (T4-T12) was significantly less in postoperative than preoperative (P value less than 0.001).

Elnady et al. (2017) reported a reduction in mean thoracic kyphosis from 38.4° preoperatively to 29.76° postoperatively, with a slight increase to 30.36° at the last follow-up, reflecting stable long-term outcomes.

Lumbar lordosis (L1-L5) was significantly less after than before surgery (P value less than 0.001).

Zhang et al. (2022) demonstrated that the preoperative lumbar lordosis (LL) of 39.05° ± 4.08° increased to 44.95° ± 2.26° postoperatively, reinforcing the effectiveness of posterior-only surgical correction in improving lumbar curvature and overall spinal alignment. These studies collectively highlight the ability of posterior-only surgical correction to improve lumbar lordosis, an important factor for long-term spinal function and overall patient outcomes in AIS treatment.

The Nash & Moe scoring before the operation of axial vertebral rotation of the main structural curves was scored: 3 curves (10%) were grade 1, 15 curves (50%) were grade 2, 6 curves (20%) were grade 3, and 6 curves (20%) were grade 4. Postoperative Nash and Moe grading of the curves were graded: 12 curves (40%) were grade 0, 15 curves (50%) were grade 1, and 3 curves (10%) were grade 1.

Overall, the findings of the current study demonstrate that posterior-only surgical correction of AIS results in positive clinical outcomes, including effective deformity correction and improved spinal alignment.

Gatam et al. (2020) reported that posterior-only correction provides three-dimensional deformity correction and achieves stable results for severe scoliosis, with the only complications being lowgrade, late implant-associated infections. **Hwang et al. (2020)** observed high correction rates for the thoracic (83.1%) and thoracolumbar/lumbar (80.2%) curves in AIS cases, without significant loss of correction at the last examination.

Regarding complications encountered in our cases, two patients suffered from screw pull out during correction. One of them was at the apex, and in the other patient the screw pull out was at the upper anchor which was managed by inserting pedicle screws at the segment above.

Early postoperatively, there was one case that suffered of transient ileus, which was totally recovered at the third postoperative day with fluid and consevative treatment. Other two cases suffered from superficial wound infection that healed totally with daily dressing and antibiotic according to culture results within 10 days. In the study conducted by **Hariharan et al. (2022),** the complications were surgical site infection (37%), adding-on (26%), pulmonary (16%), neurologic (11%), instrumentation (5%), and gastrointestinal (5%).

Study limitations: The limited sample size of subjects included in this study but this can be due to the rarity of the disease. The study does not evaluate clinical aspects such as postoperative pain and disability in patients with adolescent idiopathic scoliosis. The follow up period was limited to 12 months. A longer follow up period is needed to evaluate the occurrence of long term complications such as recurrence and proximal junctional kyphosis, etc.

Conclusion

The study supports posterior-only surgical technique as a safe, reliable, and effective treatment for adolescent idiopathic scoliosis, providing substantial deformity correction and improving long-term spinal function and quality of life. These findings are consistent with a growing body of literature advocating for posterior-only correction in severe AIS cases, reinforcing its benefits in terms of safety, deformity correction, and functional outcomes.

References

- **Abd-Elmonem AM, El-Shoura SA, Negm MA. (2023).** The Functional Outcome of Surgical Treatment of Adolescent Idiopathic Scoliosis. International Journal of Medical Arts, 5 (1):2983-90.
- **Balsano M, Vacchiano A, Bagnis F, Segalla S, Spina M. (2022)**. Rod Link Reducer system in adolescent idiopathic scoliosis: a retrospective observational trial. International Orthopaedics, 46(8):1847–1853.
- **Block AM, Tamburini LM, Zeng F, Mancini MR, Jackson CA, et al. (2022**). Surgical treatment of pediatric scoliosis: historical origins and review of current techniques. Bioengineering, 9(10):600.
- **Cheng JC, Castelein RM, Chu WC, Danielsson AJ, Dobbs MB, et al. (2015).** Adolescent idiopathic scoliosis. Nature reviews disease primers, 1(1):1-21.
- **Choudhry MN, Ahmad Z, Verma R. (2016)**. Adolescent idiopathic scoliosis. The open orthopaedics journal, 10:143.
- **Chovatiya K. (2021).** Results of posterior only approach for adolescent idiopathic scoliosis. International Journal of Orthopaedics, 7(2):112-4.
- **Elnady B, El-Sharkawi MM, El-Meshtawy M, Adam FF, Said GZ. (2017)**. Posterior-only surgical correction of adolescent idiopathic scoliosis: an Egyptian experience. Société Internationale de Chirurgie Orthopédique et de Traumatologie journal, 3.
- **Erwin J, Carlson BB, Bunch J, Jackson RS, Burton D. (2020).** Impact of unoperated adolescent idiopathic scoliosis in adulthood: a 10-year analysis. Spine deformity, 8:1009-16. **Gatam L, Luthfi AP, Gatam AR, Djaja YP. (2020).** A posterior-only approach for treatment of severe adolescent idiopathic scoliosis with pedicle screw fixation: A case series. International Journal of Surgery Case Reports, 77:39-44.
- **Gadiya AD, Koch JE, Patel MS, Shafafy M, Grevitt MP, et al. (2021)**. Enhanced recovery after surgery (ERAS) in adolescent idiopathic scoliosis (AIS): a meta-analysis and systematic review. Spine Deformity, 9(4):893–904.

- **Hariharan AR, Shah SA, Petfield J, Baldwin M, Yaszay B, et al. (2022)** Harms Study Group. Complications following surgical treatment of adolescent idiopathic scoliosis: a 10-year prospective follow-up study. Spine Deformity, 10(5):1097-1105.
- **Hwang CJ, Baik JM, Cho JH, Yoon SJ, Lee DH, et al. (2020).** Posterior correction of adolescent idiopathic scoliosis with high-density pedicle screw-only constructs: 5 years of follow-up. Yonsei Medical Journal, 61(4):323.
- **Janssen MM, Kouwenhoven JW, Schlösser TP, Viergever MA, Bartels LW, et al. (2011)**. Analysis of preexistent vertebral rotation in the normal infantile, juvenile, and adolescent spine. Spine, 36(7):486-91.
- **Kuznia AL, Hernandez AK, Lee LU. (2020).** Adolescent idiopathic scoliosis: common questions and answers. American family physician, 101(1):19-23.
- **Lacroix M, Khalifé M, Ferrero E, Clément O, Nguyen C, et al. (2023)**. Scoliosis. InSeminars in Musculoskeletal Radiology, 27(5):529-544.
- **Mirzashahi B, Moosavi M, Rostami M. (2020).** Outcome of posterior-only approach for severe rigid scoliosis: a retrospective report. International Journal of Spine Surgery,14 (2):232-8.
- **Negrini S, Minozzi S, Bettany-Saltikov J, Chockalingam N, Grivas TB, et al. (2015).** Braces for idiopathic scoliosis in adolescents. Cochrane Database of Systematic Reviews, (6).
- **Newton PO. (2022)**. Idiopathic scoliosis: the harms study group treatment guide.
- **Traversari M, Ruffilli A, Barile F, Viroli G, Manzetti M, et al. (2022).** Surgical treatment of severe adolescent idiopathic scoliosis through one-stage posterior-only approach: A systematic review and meta-analysis. Journal of Craniovertebral Junction and Spine, 13 (4):390-400.
- **Vavruch, L. (2018)**. Adolescent Idiopathic Scoliosis: A Deformity in Three Dimensions (Vol. 1635). Linköping University Electronic Press.
- **Zhang HQ, Deng A, Guo CF, Tang MX, Alonge E. (2022).** Posterior-only surgical correction with heavy halo-femoral traction for the treatment of extremely severe and rigid adolescent idiopathic scoliosis (> 130°). Archives of Orthopaedic and Trauma Surgery, 1:1-8.