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EVALUATION OF ADOLESCENTS WITH IDIOPATHIC SCOLIOSIS TREATED WITH POSTERIOR SPINAL FUSION

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ABSTRACT

Objective: In this investigation, we sought to assess the surgical and radiological results of patients with adolescent idiopathic scoliosis (AIS) who attended our clinic and underwent treatment.

Materials and Methods: Twenty-eight individuals with AIS with adequate follow-up and documentation who underwent posterior instrumentation and fusion surgery between 2011 and 2022 were retrospectively evaluated. Analysis of the clinical and radiological outcomes from the preoperative period, immediate postoperative period, and final examination were noted. Participants completed the Scoliosis Research Society (SRS)-22 questionnaire during the most recent follow-up.

Results: A total of 78.6% of patients were female and 21.4% were male. The average follow-up was 28.79±16.098 months, and the mean age was 14.79±1.969 years. Lenke classification was as follows: 57.1%, Type I; 3.6%, Type II; 3.6%, Type III; 25%, Type V; and 10.7%, Type VI. According to the Risser findings, 7.1% were in Stage 2, 14.3% in Stage 3, 57.1% in Stage 4, and 21.4% in Stage 5. The mean Cobb angle was 52.11° before surgery, 7.11° postoperatively, and 11.07° final postoperatively. The mean preoperative kyphosis angle was 29.21°, 27.25°, and 29.71°. The mean preoperative lumbar lordosis angle was 41.89°, postoperative 40.07°, and final 41.68°. The Cobb angle changed significantly ($p<0.05$). The preoperative and postoperative SRS-22 questionnaire ratings differed ($p<0.05$).

Conclusion: Early diagnosis and treatment are crucial for scoliosis. Posterior instrumentation and fusion are appropriate treatment options. To assess the complication rates and outcomes more fully, additional studies with larger sample sizes and control groups are required.

Keywords: Adolescent, scoliosis, posterior fusion

INTRODUCTION

Spinal abnormalities are categorized based on age groups and, the etiology of idiopathic scoliosis is not entirely understood. There are three types: adolescent idiopathic scoliosis (AIS) (between 10-18 age), Juvenile Idiopathic Scoliosis (between 3 and 9 years of age), and Infantile Idiopathic Scoliosis (below 3 years of age)[1]. AIS is defined as a lateral curve of the spine greater than 10° after the age of 10. Contrary to congenital, neuromuscular, and mesenchymal-associated scoliosis, it is more frequent. The lack of underlying congenital or neuromuscular defects makes AIS distinct. It has a prevalence of 0.47% to 5.2%[2]. Gender and AIS prevalence are strongly correlated, with females having a higher prevalence[3]. Thoracic curvatures are most commonly seen in AIS. Thoracolumbar and lumbar curvatures are more frequent in males, while thoracic and double curvatures are more common in females. Although the precise cause of AIS is unknown, it is thought to have a complex pathophysiology involving several variables[4]. Some of the most commonly cited causes include melatonin, calmodulin, growth hormone imbalances, leptin deficiency, connective tissue abnormalities with irregular elastic and collagen filaments, platelet conditions, and disorders of central and peripheral nervous system maturation[5]. While many people do not exhibit clinical symptoms throughout their lifetime, individuals with a Cobb angle higher than 40 degrees might experience major respiratory and aesthetic issues as the disease progresses. The treatment of AIS can be observational, supportive, or surgical[4].

The primary hypothesis of this study is that posterior spinal fusion and instrumentation will result in significant improvement in both surgical and radiological outcomes for patients with AIS. Specifically, we hypothesize that these procedures will lead to substantial correction of spinal deformity, as evidenced by changes in Cobb angle, and will also improve patient-reported outcomes as measured by the Scoliosis Research Society (SRS)-22 questionnaire. We aim to provide a comprehensive analysis of surgical results, including the degree of spinal correction achieved and the impact on patients' quality of life.

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MATERIALS AND METHODS

The investigation comprised 28 individuals with a diagnosis of AIS who visited our clinic between 2011 and 2022, underwent posterior instrumentation and fusion surgery, and had sufficient follow-up and documentation. Patients with non-idiopathic scoliosis, those with inconsistent follow-up visits, and people who weren't between the ages of 10 and 18 when their condition was discovered were excluded. Patients received the SRS-22 survey before their most recent follow-up appointment. The common patient-reported outcome measure for young individuals with AIS is the SRS questionnaire. The 22 questions on the 5-point Likert scale make up the SRS-22 scale. There are five domains in the SRS-22 questionnaire. Function/activity (5), pain (5), self-image/appearance (5), mental health (5), and satisfaction with management (2) are the domains and number of questions in each. There are five vocal response options for each question, numbered from 1 (worst) to 5 (best). The mean score for each domain (minimum: 1 point, maximum: 5 points) and the overall score (total sum of the domain divided by the number of items answered) are displayed as the SRS-22r results[6]. A retrospective analysis was done on the outcomes of the clinical and radiographic examinations performed before surgery, just after surgery, and during the last follow-up.

Informed patient consent was obtained from the patients themselves or from their parents. Studies were conducted with the most recent version of the Declaration of Helsinki as their foundation.

The location and direction of the curvature, as well as secondary sexual features including pubic, axillary, and breast hair, were evaluated during the clinical examination. Patients underwent orthopedic and neurological examinations, and the findings were noted.

The radiological examination included standing anteroposterior and lateral X-rays before surgery. Patients deemed necessary were also evaluated with spinal magnetic resonance imaging and computed tomography. Postoperative controls and subsequent visits involved standing anteroposterior and lateral X-rays. The Cobb method was used for calculating the angles of the curvatures. Patients were classified according to the Risser classification based on iliac apophysis in anteroposterior X-rays. The curvatures were categorized using the Lenke classification system before surgery. The following formula was used to get the coronal plane correction rate:

Correction ratio (in %)=[(Cobb angle before surgery-Cobb angle after surgery)/Cobb angle before surgery] * 100

The percentage of corrective loss was determined using standing anteroposterior and lateral X-rays collected at the last follow-up.

Correction lost (in %)=[(Cobb angle at last follow-up-Cobb angle after operation)/Cobb angle before operation] * 100

Surgical Technique

All patients received 1g of intravenous cefazolin sodium 30 minutes before surgery, and for procedures lasting longer than 4 hours, they received another dosage. To avoid abdominal and thoracic pressure, silicone lateral supports were applied from the armpits to the pelvis before turning the patients prone. After sterilizing the surgical area and draping, a vertical surgical incision was made based on the patient's deformity. Incisions reached the thoracolumbar fascia. Subperiosteally dissecting the paraspinal muscles and spinous processes after fascial opening. Each vertebra exposed its transverse processes and facet joint complexes. The facet joint capsule, interspinous, and supraspinous ligaments were all resected. All patients received posterior spinal instrumentation with polyaxial screws, contoured rods, and transverse connectors. The fusion level dependent at the distal stable and proximal neutral vertebrae. From the convex edge of the curve, pedicle screws at the appropriate levels and apical vertebrae started the instrumentation. The scoliotic curvature was straightened out by compression forces on the convex edge, distraction forces on the concave side, then derotation forces at the apex. Before putting the rods, the sagittal plane was contoured to maintain physiological kyphosis and lordosis. Neuro-monitoring devices were employed in all patients during surgery to detect neurological impairment early. To safeguard the fusion, alleviate discomfort, and compensate for secondary lumbar curvatures, all patients received thoracolumbosacral orthosis (TLSO) after surgery. The orthosis mobilized patients on day two after surgery. Patients left after 7 days on average. On day 14, the sutures were removed. The orthosis was used for 3 months.

An example of our cases; A male patient aged 13 arrived with

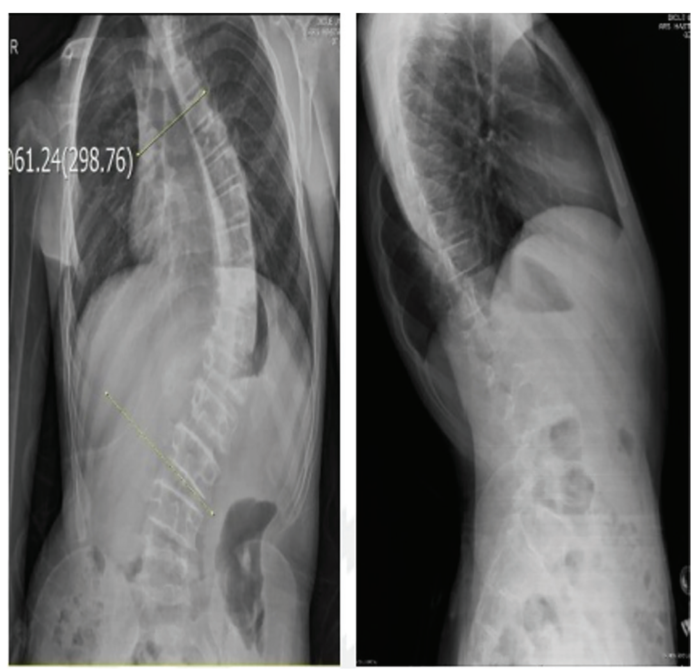

Figure 1. Diagnostic imaging of the patient before surgery

a thoracolumbar curvature of 61 degrees (Figure 1). Posterior segmental instrumentation from T2 to L4 was performed. The patient's final Cobb angle was measured as 9 degrees (Figure 2).

Ethical Approval

Dicle University Faculty of Medicine Non-Interventional Clinical Research Ethics Committee of our university approved this study (approval number: 36, date: 15.02.2022).

Level of Evidence

Level 4, therapeutic study.

Statistical Analysis

The statistical analysis was carried out using SPSS version 26 software. For variables with regularly distributed data, the mean and standard deviation values were given. A dependent t-test was used to evaluate the dependent variables. The Paired Sample t-test was used to assess changes over time in SRS-22 data that satisfied the condition for normal distribution while the Wilcoxon test was utilized for data linked to scoliometer measurement scores that did not meet the normal distribution criteria. Correlation investigations were carried out using the Spearman method. To compare two categorical independent groups, the chi-square test was used. The threshold for statistical significance was set at a p-value of ≤0.05.

RESULTS

Gender analysis of the patients showed that 78.6% of them were female and 21.4% were male. The mean follow-up duration was 28.79±16.09 months, and the mean age was 14.79±1.96 years. These statistics are reported in coupled with Risser staging details in Table 1. Based on radiological evaluations, Table 2 shows the distribution of Lenke classifications; it was found that 57.1% were categorized as Type I, 3.6% as Type II, 3.6% as Type III, 25% as Type V, and 10.7% as Type VI.

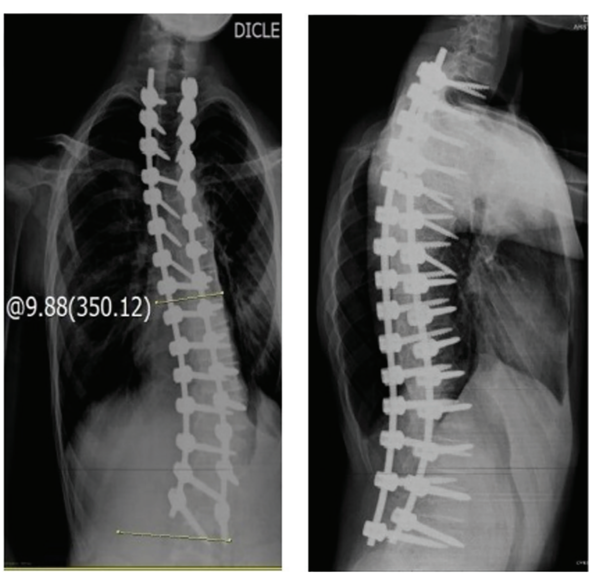

Figure 2. Images of the patient taken after surgery

In the frontal plane analysis of the patients, the correction rate was found to be 87.2%, and the correction loss was 7.5%. The mean values of preoperative, postoperative, and final Cobb angles, mean kyphosis angle and mean lumbar lordosis angle of the patients are shown in Table 3.

In patients, the preoperative Cobb angle (52.11±7.18°) significantly differed from the postoperative Cobb angle (7.11±4.21°) (p<0.05). Similarly, the preoperative Cobb angle (52.11±7.18°) significantly differed from the final Cobb angle (11.07±5.60°) (p<0.05). Based on the dependent t-test, there was also a statistically significant difference between the postoperative Cobb angle (7.11±4.21°) and the final Cobb angle (11.07±5.60°) (p<0.05).

The dependent t-test indicated no significant difference between the preoperative kyphosis angle (29.21±13.15°) and the postoperative angle (27.25±4.98°) (p>0.406), also between the preoperative kyphosis angle (29.21±13.150°) and the final angle (29.71±6.970°) were not statistically different (p>0.846). But the test showed a significant change between the postoperative kyphosis angle (27.25±4.986°) and the final angle (29.71±6.970°) (p<0.05).

Our study includes pre- and post-surgery SRS-22r questionnaires. Pain, looks, function-activity, mental health, and satisfaction averaged 2.9, 2.5, 3.3, 2.9, and 3.53 preoperatively. Postoperative scores were 4.08, 4.27, 4.15, 3.95, and 4.35. All score averages and total scores improved significantly postoperatively. The highest rate of change, at 66%, was observed in the external appearance subgroup (Table 4).

Age, patients' Cobb angles, the results of the SRS-22r scale, and the overall scale scores were all analyzed using Spearman correlation. Age and preoperative mental health were adversely correlated (p<0.05, r=-0.436). Age did not significantly affect the postoperative total score (p>0.05, r=-0.298), but it did significantly affect the preoperative total score (p0.05, r=-0.462). Cobb angles at the beginning, end, and following surgery did not correspond (p>0.05). Age and menarche age had no relationship with preoperative, postoperative, or final Cobb angles (p>0.05).

Table 1. Demographics and Risser grading of patients

*(μ±σ)	n	%
Sex		
Female	22	78.6
Male	6	21.4
Average age*	14.79±1.96	
Follow-up period*	28.79±16.09	
Risser classification		
Grade 2	2	7.1
Grade 3	4	14.3
Grade 4	16	57.1
Grade 5	6	21.4

Table 2. Lenke classification of patients

Curve type	Case numbers		Lumbar spine			Thoracic sagittal measures		
LENKE	n	%	A	B	C	-	+	n
Type I	16	57.1	11	2	3	0	2	14
Type II	1	3.6	1	0	0	1	0	0
Type III	1	3.6	0	1	0	0	1	0
Type IV	0	0	0	0	0	0	0	0
Type V	7	25.0	0	0	7	1	0	6
Type VI	3	10.7	0	0	3	0	1	2

DISCUSSION

The study demonstrates that posterior spinal fusion is an effective treatment for AIS, showing significant improvements in spinal alignment and patient-reported outcomes. Specifically, the Cobb angle was significantly reduced from a preoperative mean of 52.11° to 7.11° postoperatively and remained stable at 11.07° at the final follow-up. Specifically, our findings demonstrate an impressive correction rate of 87.2% and a significant improvement in all domains of the SRS-22 scores postoperatively, with the appearance domain showing the highest rate of change at 66%. Scoliosis is by far the most common spinal condition affecting young people. It is a progressive orthopedic condition that can lead to social impairment, emotional disorders, pain in the back, cosmetic deformity, and functional impairment. Due to AIS, the spine is distorted in all three planes the coronal, sagittal, and transverse planes to varying degrees. A full and thorough medical history should be taken before evaluating a kid with scoliosis, with particular attention paid to pain complaints, neurological symptoms such as bowel and bladder problems, physical development, and information regarding sports participation[7]. Over 80% of our patients had moderate discomfort for a long period. However, spine curvature did not affect pain. No patient had neurological impairments. We found that 3.6% of our patients (n=1) had respiratory distress, contrary to Addai et al.[7] scoliosis occurred in the families of six of our patients. We observe that it contradicts the study conducted by Addai et al.[7] These findings could be attributable to the variety of cases considered and to potential racial, ethnic, and socioeconomic differences.

In the Korean study by Suh et al.[8], 1,134.890 children between the ages of 10 and 14 were examined (584,554 boys and 550,336 girls). The prevalence was 3.36%, and the F/M ratio was 2/3, according to the statistics. In Cilli[9] study in Sivas, 3175 children between the ages of 10-15 were evaluated. Girls were found to have AIS twice as often as males in this small patient sample. The F/M ratio in our investigation was discovered to be 3.67:1. It can be seen that the male-to-female ratio in our study is different from that in past studies. It is significant to emphasize that our study only included subjects who required surgical intervention. It is accurate to say that some of our patients receive non-operative follow-ups but don't need surgery right now or in the future.

Table 3. Patients' pre-op, post-op, and final Cobb, kyphosis, and lordosis angles

	n	Minimum	Maximum	Mean ± Standard deviation
Preoperative Cobb angle	28	42	67	52.11±7.18
Postoperative Cobb angle	28	2	21	7.11±4.21
Final Cobb angle	28	2	23	11.07±5.60
Preoperative kyphosis	28	8	57	29.21±13.15
Postoperative kyphosis	28	16	38	27.25±4.98
Final kyphosis	28	16	48	29.71±6.97
Preoperative lordosis	28	10	63	41.89±12.52
Postoperative lordosis	28	16	53	40.07±7.77
Final lordosis	28	27	54	41.68±6.52

Si et al.[10] conducted a retrospective analysis on 112 patients in 2021, 78 of them were female. Fourteen was the mean age. These patients averaged 48 degrees preoperative Cobb angle. 35% of patients were Lenke-1. The postoperative follow-up duration was 32 months[10]. The average Cobb angle of our patients before surgery was 52.11°, and their average age was 14. The majority, 57%, had Lenke-1. The average amount of time for monitoring was 28 months. We closely examined patients with preoperative Cobb angles <40 degrees (5 patients, mean follow-up 6 months) and those in the growth and development stage (Risser 0-1) (3 patients, mean follow-up 9 months) using TLSO braces. We operated on patients with lower Cobb angles that climbed above 40 degrees during follow-ups and lower Risser stages that progressed beyond stage 2. These eight patients had no pulmonary or cardiac pathology. Our study follows the literature[11]. The number of Lenke-1 patients differed from Si et al.[10] data, but the patients' profiles were similar. Race and geography may explain this.

Table 4. Distribution of patients' SRS-22r scoliosis scale in preoperative and postoperative assessments

	n	Mean ± standard deviation	p-value
Pain before surgery	28	2.99±0.39	<0.05
Pain after surgery	28	4.08±0.23	
Appearance before surgery	28	2.57±0.49	<0.05
Appearance after surgery	28	4.27±0.29	
Function before surgery	28	3.35±0.37	<0.05
Function after surgery	28	4.15±0.28	
Mental health before surgery	28	2.90±0.37	<0.05
Mental health after surgery	28	3.95±0.31	
Preoperative satisfaction with the procedure	28	3.53±0.52	<0.05
Postoperative satisfaction with the procedure	28	4.30±0.47	

SRS: Scoliosis Research Society

Ylikoski[12] reported that the average age of menarche was 13.1 years in his research about the prognosis of female patients with AIS. According to one study, the average age of menarche was 12.3 years for girls having AIS and 12.1 years for girls in good health[13]. In our study, menarche was shown to happen on average at the age of 13. The average age of female patients who were subjected to surgery was 14.7 years. Patients continue to grow from the time of their first menstrual cycle until almost 18 months later, according to Faldini et al.[14] Patients are therefore recommended to postpone surgery for between 18 months and 2 years after their first menstruation. The participants in our study underwent surgery about 20 months following their first menstrual cycle.

A child's skeletal maturity is ranked on a scale from 0 to 5 using the Risser system[15]. Particularly, patients in the Risser 0 and Risser 1 stages are known to experience rapid growth, and performing surgery during this period may hinder their growth and result in shorter stature[16]. Literature findings strongly support this observation. At our analysis, 57% of the patients who had surgery were at the Risser 4 stage. In the Risser 0 and Risser 1 groups, we did not do any operations. This part of our research agrees with the prior work.

Twenty-one patients participated in the study conducted by Rodrigues et al.[17], with an average age of 15.2 years, 16 girls (76.2%), and 5 men (23.8%). The study found an initial curve correction of 61.36%, a mean Cobb angle of 62.38° before surgery, and a mean Cobb angle of 38.8° after surgery. However, the length of the follow-up was not examined in their research[17]. Cui et al.[18] investigated patients with AIS who underwent surgical treatment with pedicle screws and were between the ages of 10 and 17. In their case series of 27 individuals, they found a mean Cobb angle loss of 2.5° (equivalent to 19.23% of the preceding adjustment) after a two-year follow-up. In our study, we found a higher correction rate of 87.2% and a mean Cobb angle of 11.07° after surgery, with a corrective loss of 7.5%. Comparing our study to many of the studies described above, we found a greater correction rate. Cui et al.[18] and coworkers reported a loss of 2.5%, whereas our investigation found a corrected loss of 7.5%[18].

The standard treatment for AIS has evolved into posterior spinal fusio[19]. In our study, we also performed all surgeries using a posterior approach. Neurological injury or deficit is the most concerning complication in scoliosis surgery. In Diab et al.[20] series of 1301 cases, the rate of neurological complications was found to be 0.69% (9 cases), including three cases of dural penetration, three cases of nerve root injury, and the rest being neuropraxia, with instrumentation removal reported in only one case. One patient had postoperative lower extremity neurological impairments in our 28 patient trial. Urgent reoperation removed all surgical tools. Intraoperative observations revealed no spinal cord compression from the screws. Postoperative monitoring improved neurological function. The patient's records showed intraoperative hypotension, which may have caused the deficiencies. After a week in the hospital and a posterior segmental instrumentation reoperation, the patient was discharged without neurological impairments. The patient's two-year follow-up was outstanding.

It has been suggested that SRS-22 scores and clinical indicators correlate in non-operative AIS patients. It has been demonstrated that there is a strong correlation between SRS-22 scores and the degree of severity of the curve as assessed by the Cobb angle[21]. Contrarily, Glattes et al.[22] demonstrated that patients with an average Cobb angle between 27° and 32° and those with an angle smaller than 11° obtained the same score. In our study, we gave the SRS-22 scale to the patients who were included both before and after surgery. Between the preoperative and postoperative tests, all score averages and total scores significantly improved. The appearance domain showed the largest rate of change, with a 66% improvement. This element of our study aligns with the body of previous research[23].

When discussing the important aspects of our study, we emphasize the following: This study provides a comprehensive analysis of a follow-up period (mean of 28.79 months) for AIS patients undergoing posterior spinal fusion and instrumentation, offering valuable insights into outcomes and stability of the surgical correction. A thorough assessment of patient-reported outcomes, emphasizing improvements in pain, function, self-image, mental health, and overall satisfaction is presented by employing the SRS-22 questionnaire preoperatively and postoperatively. The importance of safety measures to minimize neurological complications during scoliosis surgery is underscored by the inclusion of intraoperative neuro-monitoring and a detailed account of postoperative neurological outcomes. A detailed demographic analysis, including age, gender distribution, and Risser staging, which is crucial for understanding the patient population and the timing of surgical intervention concerning skeletal maturity is provided. We have offered a comparative analysis with previous research, highlighting differences in correction rates, complication rates, and patient outcomes. A detailed description of the surgical technique, including the use of polyaxial screws, contoured rods, and TLSO, provides valuable information for surgical planning and execution, potentially serving as a reference for future studies. By analyzing the correlation between SRS-22 scores and clinical indicators such as Cobb angles, we tried to add to the understanding of how surgical correction impacts patient quality of life and functional outcomes. The detailed account of managing surgical complications, such as the case of postoperative lower extremity neurological impairments, provides practical insights into handling such issues effectively, contributing to better patient care practices.

The study on posterior spinal fusion and instrumentation for AIS is constrained by several limitations. Its small sample size of 28 patients, predominantly female (78.6%), limits the generalizability of findings to the broader AIS population. Being retrospective, the study is susceptible to selection and information biases inherent in relying on existing records and patient recall, potentially leading to incomplete or inaccurate data. The mean follow-up duration of 28.79±16.09 months varies widely among patients, necessitating longer periods to fully capture long-term outcomes and complications. The absence of a control group hinders comparisons with non-surgical or alternative surgical treatments, complicating the attribution of outcomes solely to the intervention. Variability in radiographic techniques introduces potential discrepancies in Cobb angle measurements, affecting curvature assessments. Detailed postoperative data on complications, including infection rates and long-term spinal health, were not thoroughly analyzed, limiting comprehensive understanding. Technological advancements over the study period (2011-2022) could also introduce variability in surgical approaches and outcomes. Future research with larger, diverse populations, longer follow-ups, control groups, and comprehensive psychosocial assessments is essential to validate and expand upon these findings, providing a more nuanced understanding of AIS treatment outcomes.

CONCLUSION

In treating adolescents with idiopathic scoliosis, factors like curvature magnitude, type, flexibility, age, and maturity should be considered. Treatment options include observation, conservative measures, or surgery. During surgery, potential risks like decompensation and neurological problems should be evaluated, and fusion levels and curve flexibility precisely determined to avoid excessive correction. Surgical treatment with posterior segmental instrumentation and fusion is effective, successful, and associated with high patient satisfaction, corrective outcomes, and low complication rates.

Ethics

Ethics Committee Approval: Dicle University Faculty of Medicine Non-Interventional Clinical Research Ethics Committee of our university approved this study (approval number: 36, date: 15.02.2022).

Informed Consent: Informed patient consent was obtained from the patients themselves or from their parents.

Authorship Contributions

Surgical and Medical Practices: Y.T., S.A.U., Ş.Y., A.A., Concept: R.A., S.A.U., E.Ö., Design: Y.T., Ş.Y., A.A., Data Collection or Processing: R.A., S.A.U., Ş.Y., A.A., Analysis or Interpretation: Y.T., R.A., S.A.U., E.Ö., Literature Search: R.A., E.Ö., A.A., Writing: Y.T., E.Ö., Ş.Y.

Conflict of Interest: The authors have no conflicts of interest to declare.

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