

Outcomes of Surgery for Adolescent Idiopathic Scoliosis (AIS)

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Background: The majority of adolescent idiopathic scoliosis (AIS) cases can be treated conservatively. Surgical correction is an essential treatment for major structural curves or patients with risk of progression. Despite the evolution of different instrumentation systems, surgery for the AIS remains a major intervention.

Objective: To evaluate the outcome of surgery for idiopathic adolescent scoliosis.

Design: A Retrospective Study of Case Series.

Setting: Salmaniya Medical Complex, Orthopedics Department, Kingdom of Bahrain.

Method: Radiographic, surgical and clinical outcome of 39 patients with AIS between 2014 and 2018 were documented. Radiographic curve type, pre- and postoperative major Cobb angle were documented. In addition, a self-perceived outcome questionnaire was administered to the patients at 1-year follow-up.

Result: Thirty-three (85%) patients were females. The mean age was 15 years. More than 50% of the patients had Lenke type 1 or type 5 curve; 10 (25.6%) had type 1 and 11 (28.2%) had type 5. The average correction percentage was 60%±11. Thirty-seven (95%) patients reported good to excellent satisfaction rate postoperatively using the SRS-24 questionnaire. The average hospital stay was 6.6 days. All the patients had posterior fusion only. One (2.6%) patient had fusion to the sacrum. The average number of levels fused was 11.

Conclusion: Results of surgery had been comparable to the international outcomes. We believe our findings largely reflect international trends and results.

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Many orthopedic deformities were described millennia ago, including scoliosis, which was described and treated by Hippocrates (AD 460-370)^{1,2}. Scoliosis is a Greek word meaning crooked or bent. Over the past few decades, it was defined as Cobb angle of $\geq 10^\circ$ in the coronal plane. Curves $< 10^\circ$ are referred to as “spinal asymmetry”. With better understanding and more careful evaluation of this complex condition, scoliosis is now considered a three-dimensional (3D) spinal deformity^{3,4}.

Idiopathic scoliosis is the most common type of scoliosis. It is further divided into three sub-groups according to age: infantile (0-3 years), juvenile (4-9 years) and adolescent (10 years to maturity)⁵. It is most commonly seen in pre-adolescent and adolescent females⁶. In contrast to other types of scoliosis, the exact cause is still unknown. Several hypotheses were suggested, such as genetic, developmental, hormonal, neural and musculoskeletal dysfunction^{7,8}. In addition, geographic latitude and sunlight exposure were contemplated⁹.

The AIS prevalence rate is 1-4%; most have low risk of progression and could be treated conservatively¹⁰⁻¹³. In severe cases, high risk of progression is anticipated. Surgical intervention is warranted to prevent disability, pulmonary function compromise, severe deformity and mortality associated with larger curves¹⁴.

The pedicle screw fixation has replaced Harrington rods or the hook-rod system^{15,16}. Despite the evolution of different instrumentation, surgery for the AIS remains a major intervention with complication rates between 5-23%^{17,18}.

The aim of this study is to evaluate the outcome of surgery for idiopathic adolescent scoliosis.

METHOD

Thirty-nine patients with adolescent idiopathic scoliosis (AIS) between 2014 and 2018 were included in the study. All patients had anteroposterior or posterior-only instrumentation using pedicle screw-rod system. All patients had preoperative and postoperative full-length spine radiographs. All patients were asked to complete a questionnaire at a minimum of 1-year follow-up.

Radiography was assessed by two spine surgeons with high interobserver reliability percentage and kappa value indicating good-to-excellent reliability. Radiographic parameters included coronal Cobb angle and curve type of Lenke classification.

The coronal Cobb angle of the major curve was measured using the “Cobb Angle Tool in I-Seha Software” before and after surgery. The magnitude of the coronal Cobb angle at 6-months

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follow-up was subtracted from the preoperative coronal Cobb angle and divided by the preoperative Cobb angle, calculating the postoperative percent correction of the major coronal curve.

The classification system is based on the regional columns of the spine: proximal thoracic (PT), main thoracic (MT), thoracolumbar/lumbar (TL/L)¹⁹. These are then divided into structural or nonstructural based on radiographic criteria, which is coronal with a lateral bending and sagittal radiographs. After identification of the curve type, a lumbar curve modifier and sagittal thoracic modifier are added to form the complete triad classification system^{19,20}.

An electronic Arabic version of Scoliosis Society Research 24 (SRS-24) questionnaire was filled by the patients. The 24 questions represent seven major patient-based outcome domains: pain, general self-image, postoperative self-image, postoperative function, function from back condition, general level of activity and satisfaction. The domain scores were calculated by the sum of points and the normal score was calculated by dividing the number of questions in the specific domain. The total SRS 24 score was calculated by means of the total sum score and normalized by dividing with the total number of questions²¹⁻²³.

All patients received general anesthesia and were monitored using somatosensory evoked potentials (SSEPs) and motor evoked potentials (MEPs), Stangara wake-up test was performed in a few cases. Operative time, intraoperative blood transfusion, number of the levels fused, anterior or posterior procedure, procedures extending to the sacrum, length of hospital stay, and the surgical complications were documented.

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) software (version 22).

RESULT

Thirty-nine patients with AIS were included in the study; 6 males (15.4 %) and 33 females (84.6 %). The mean age at surgery was 15.1±2.3 years and 17.3 ± 3.1 years at follow-up. The mean follow-up was 26.4 months, see table 1.

Table 1: Characteristics of Patients Surgically Treated for Adolescent Idiopathic Scoliosis (AIS)

Sex, n (%)	
Female	33 (84.6 %)
Male	6 (15.4 %)
Age at surgery (years)	
Mean ± (SD)	15.1 ± 2.3
Range	11-21
Age at follow up (years)	
Mean ± (SD)	17.3 ± 3.1
Range	12-24
Mean follow up (months)	26.4

The patients had anteroposterior or posterior-only instrumentation using pedicle screw-rod system, see figure 1.

The Cobb angle of the major curve decreased from 53.3±12.1° to 21.6±8.7° (P< 0.05) after surgery (decreased by 31.8±8.4°), the mean correction rate was 60±11 % (P< 0.05), see table 2.

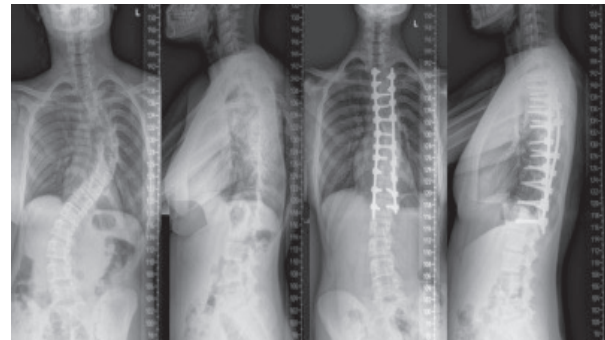


Figure 1: Posteroanterior and Lateral Radiographs of a 13-Year-Old Girl with a Primary Thoracic Curve before and after Surgery Treated with Posterior Fusion

Table 2: Radiographic Results in Patients Surgically Treated for Adolescent Idiopathic Scoliosis (AIS) (n=39)

Mean ± SD (Range)	
Preoperative Major Cobb Angle	53.3 ± 12.1 (30.3 - 89.6)
Postoperative Major Cobb Angle	21.6 ± 8.7 (10.7 - 46.3)
% of Correction	60 ± 11% (39.3-75.9%)

According to the Lenke classification for AIS, 10 (25.6%) patients were type 1 (main thoracic), 5 (12.8%) were type 2 (double thoracic), 7 (17.9%) were type 3 (double major), none were type 4 (triple major), 11 (28.2%) were type 5 (thoracolumbar/main lumbar), and 6 (15.4%) were type 6 (thoracolumbar/main thoracic). We found a lumbar modifier of type A in 16 (41.0%) patients, type B in 6 (15.4%) patients, and type C in 17 patients (43.6%). The sagittal thoracic modifier was as follows hypokyphosis in 6 (15.4%) patients, normal in 29 (74.4%) patients, and hyperkyphosis in 4 (10.3%) patients, see table 3.

Table 3: Curve Prevalence of Patients Surgically Treated for Adolescent Idiopathic Scoliosis (AIS) According to Lenke Classification (n=39)

	No. of Cases (n=39)	%
Curve Type		
1	10	25.6 %
2	5	12.8 %
3	7	17.9 %
4	0	0 %
5	11	28.2 %
6	6	15.4 %
Lumbar Modifier		
A	16	41.0 %
B	6	15.4 %
C	17	43.6 %
Thoracic Sagittal Profile		
Hypo (-)	6	15.4 %
Normo (N)	29	74.4 %
Hyper (+)	4	10.3 %
Risser Stage		
0-3	20	51.3 %
4-5	19	48.7 %

The overall SRS-24 score was 3.99 ± 0.57 . Thirty-seven (95%) patients were satisfied with the results of the surgery. The range of satisfaction score was 3.67-5.0. The mean scores were highest in the activity level and pain domains, 4.27 ± 1.11 and 4.23 ± 0.54 , respectively. The lowest mean score was of the postoperative function domain, $2.921.42 \pm$, see figure 2.

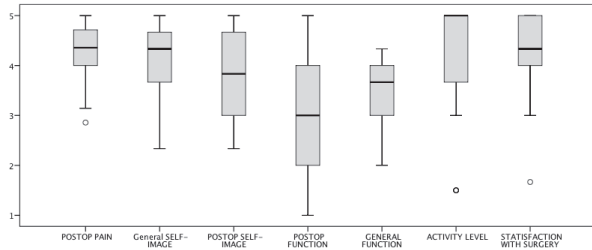


Figure 2: Results of the Total Cohort of Patients in Each SRS-24 Domain

Furthermore, we tested the correlation between the “satisfaction” domain and the other six domain scores in the SRS 24 questionnaire, see table 4. The Pearson correlation test showed a significant correlation between all the domain scales and satisfaction. The strongest correlation was found between satisfaction and general self-image ($r=0.66$), and between satisfaction and activity level ($r=0.58$).

Table 4: Simple Pearson Correlation Coefficients between Satisfaction and Other SRS 24 Domains (n=39)

SRS 24 Domain	R	P
General self-image	0.66	< 0.01
Activity Level	0.58	< 0.01
General function	0.54	< 0.01
Pain	0.53	< 0.01
Postop function	0.45	< 0.01
Postop self-image	0.44	< 0.01

The mean anesthesia time was 323 minutes (range, 135–670 min). The average amount of blood transfused was 1.6 U (range, 0–5 U). All patients had posterior fusion. The average number of fused levels was 11 (range, 4–17). The average number of hospital stay days was 6.6 (range, 3–21 days), see table 5 (A and B).

Table 5 (A): Operative Outcome of Patients Surgically Treated for Adolescent Idiopathic Scoliosis (AIS) (n=39)

	Mean (Range)
Anesthesia Time (Hours)	5.38 (2.25-11.16)
Intraoperative Blood Transfusion (PRBCs Units)	1.6 (0-5)
Length of Hospital Stay (Days)	6.6 (3-21)

ASA	No. (%)
I	26 (66.7%)
II	10 (25.6%)
III	3 (7.7%)

Table 5 (B): Operative Outcome of Patients Surgically Treated for Adolescent Idiopathic Scoliosis (AIS) (n=39)

	Mean (Range)
No. of Levels Fused	11 (4-17)

Fusion	No. (%)
Anterior	0 (0%)
Posterior	39 (100%)

Distal Fusion Level	No. (%)
Thoracic	6 (15.3%)
Lumbar	32 (82.1%)
Sacral	1 (2.6%)

The major complications were defined as requiring prolonged hospitalization or readmission, or resulted in significant disability. The overall major complications rate was 7.7%. One patient required 21 days hospitalization and admission to the intensive care unit postoperatively. One patient had a chronic infection and fistula which was treated successfully after fusion and union. One patient had pedicle screw malposition and it was revised.

DISCUSSION

The evolution of surgical technique in AIS over the past 20 years was reviewed by Looner et al, they found a cessation of anterior only surgery, increasing use of all screw constructs, less blood loss, greater use of antifibrinolytic, shorter operative times and length of hospital stay (LOS), and few major complications²⁴. Our data were comparable in terms of radiographic correction, operative time, complications rate and length of stay in the hospital.

Merola et al published a multicenter study of the outcomes of the surgical treatment of AIS using SRS 24 questionnaire²⁴. We found that the score in the postoperative function domain score remains the lowest among the domains in the SRS 24 questionnaire, mirroring the trend in our data results.

In our study, there was no direct estimation of intraoperative blood loss. This was mainly due to inadequate documentation or improper measure techniques. Intraoperative blood transfusion averaged 1.6 units of packed red blood cells/patient. The use of cell salvage system in major spine deformity surgeries resulted in a decrease in the need for intraoperative allogenic blood transfusion²⁶. This method of recycling blood proved to be safe and effective and should be considered.

Recently, tranexamic acid (TXA) has shown to effectively reduce blood loss and blood transfusion in idiopathic scoliosis correction surgery²⁷. The use of TXA in patients undergoing surgery for AIS resulted in 27-43% reduction of blood loss^{28,29}. The use of such antifibrinolytic agents in the future can be beneficial for our patients.

Our study shows promising early results of surgical treatment of AIS in Bahrain over the past 4 years. It is advised to do a follow-up study on the long term outcomes, looking at the union or revisions rates, degenerative changes and loss of correction percentages, the effect on growth and the cardiopulmonary function, function and satisfaction scores. All these issues need to be addressed in the future.

CONCLUSION

Our surgical result had been comparable to the international outcomes. We believe that our finding is largely reflecting international trends and results. Present treatments for AIS would result in better outcomes in the future.

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