



Assessment of Quality of Life for Scheuermann's Kyphosis Patients with Cobb's Angle 50°–65° Treated Conservatively or Surgically in North Jordan: A Prospective Comparative Study

Ziad Ali Audat, MD, Khalid Ahmed Kheirallah, MD*, Bayan Faisal Ababneh, Msc*, Hisham Zaidon Aljamal, MD[†], Jomana Waleed Alsulaiman, MD[‡], Yaman Sameer Bataineh, MD[†], Mohammad Moneer Algharibeh, MD[†], Abdarrahman Ziad Audat, MD[†]

Department of Orthopedic Surgery, King Abdullah University Hospital, Jordan University of Science and Technology, Irbid,

**Department of Public Health, Medical School, Jordan University of Science and Technology, Irbid,*

[†]Department of Orthopedic Surgery, King Abdullah University of Science and Technology, Irbid,

[‡]Department of Pediatrics, Medical School, Yarmouk University, Irbid, Jordan

Background: Scheuermann's disease is the most common cause of hyperkyphosis of the thoracic spine during the adolescence period. It causes neck and lower back pain, restriction of lung expansion, traction of the spinal cord, increased vulnerability to vertebral fracture, and a hump. Patients with curves < 60° are treated conservatively, while surgery is used for patients with curves > 60°. The purpose of this prospective cohort study was to assess the quality of life and functional changes in conservatively or surgically treated Scheuermann's disease patients with a curve size of 50°–65° in north Jordan.

Methods: Sixty-three adolescent patients with Scheuermann's kyphosis (aged between 10 and 18 years) were treated at our hospital between January 2014 and August 2018. All patients were investigated clinically, radiologically (Cobb's angle), and functionally (Oswestry Disability Index [ODI], Scoliosis Research Society 22 revision [SRS-22r] questionnaire, and pulmonary function test [PFT]) pre- and post-treatment (final follow-up). Patients were randomly selected for treatment method (conservative versus surgical).

Results: There were 31 patients (mean age, 15.48 ± 2.50 years) and 32 patients (mean age, 16.19 ± 1.51 years) treated conservatively and surgically, respectively. Mean ± standard deviation of ODI, SRS-22r, and Cobb's angle of the surgical group improved from 16.8% ± 14.3%, 3.5 ± 0.5, and 58.75° ± 3.59°, respectively, pre-surgery to 13.4% ± 10.8%, 4.2 ± 0.5, and 41.53° ± 3.94°, respectively, post-surgery, while those of the conservative group became worse from 12.6% ± 13.4%, 3.9 ± 0.7, and 56.1° ± 3.3°, respectively, to 20.1% ± 13.6%, 3.5 ± 0.7, and 58.8° ± 5.8°, respectively. The surgical group showed better improvement in all scores than the conservative group ($p < 0.05$), as well as in PFT.

Conclusions: Surgical treatment of Scheuermann's kyphosis with curves of 50°–65° resulted in better QOL, Cobb's angle, and PFT than conservative treatment. This was because of lower patient cooperation in the conservative management group, which made the curve less flexible for exercises and bracing.

Keywords: Scheuermann's kyphosis, Oswestry Disability Index, Conservative treatment, Surgical treatment, Quality of life SRS-22 score, Pulmonary function test

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Correspondence to: Ziad Ali Audat, MD

Department of Orthopedic Surgery, King Abdullah University Hospital, Jordan University of Science and Technology, Irbid 22110, Jordan

Tel: +962-79-905-1237, Fax: +962-2709-5999

E-mail: ziadaudat@yahoo.com

Kyphosis is the posterior prominence of the spine that is considered to some degree normal in the thoracic spine. According to the Scoliosis Research Society (SRS) classification system, normal thoracic kyphosis ranges between 20° and 45°. The mean thoracic kyphosis angle in children is 44°.¹⁾ Physiological kyphosis is crucial to the spine's sagittal balance, which has generated interest among many research groups.^{2,3)}

Scheuermann's disease (kyphosis) is the most common cause of hyperkyphosis of the thoracic or thoracolumbar spine during adolescence.⁴⁻⁶⁾ It more affects male adolescents than female counterparts despite evidence of equal prevalence in both sexes, with its incidence rates ranging between 0.4% and 8.0%.^{4,7,8)} Its etiology is unknown, but a multifactorial theory with a strong hereditary predisposition is the most prominent today. Recently, a theory of discordant vertebral endplate mineralization and ossification during adolescence has been proposed, which may cause abnormal vertebral body growth, resulting in wedge-shaped vertebral bodies in kyphosis.^{9,10)}

A five-degree wedging of the vertebral body of three or more consecutive vertebrae with hyperkyphosis is the most important radiological criterion to diagnose Scheuermann's disease. The disease is classified according to the affected part of the spine: type 1 involves thoracic spine with apex level at T7–9 and type 2 involves both thoracic and lumbar spines with apex level at T10–12.¹⁰⁾

Conservative and surgical treatment options for Scheuermann's disease depend on the size of deformity. Most cases are treated conservatively as the curves are less than 60°, whereas curves above 60° are surgically treated.^{7,11,12)} Psychosocial development is a significant milestone in the adolescents' maturation process, as they pay much attention to their self-image in front of peers and others. Patients with spine deformities tend to have less self-esteem and life satisfaction.¹³⁻¹⁵⁾ The long-term

impact of Scheuermann's kyphosis on patients has been established. Those patients had more pain than the control group and were at higher risk for disabilities in daily living activities such as carrying a 5-kg load at least 100 m and walking up one floor without resting.^{16,17)} Other possible long-term complications include neck and lower back pain and neurologic compromise, such as partial paralysis of lower limbs, is more common among the patients than normal people, in addition to cardiopulmonary complications, such as restrictive pulmonary disease, especially in patients with extreme kyphotic curves greater than 100°. ¹⁶⁻¹⁹⁾

Health-related quality of life and quality of life (QOL) are interchangeable terms, which reflect multidimensional domains of individuals' health including physical health, mental health, social health, and emotional health. QOL depends on diseases and their risk factors, so measuring QOL by using validated tools will determine the burden of preventable diseases such as disabilities and monitor the progress in achieving the nation's health objectives.^{20,21)}

In the current prospective study, we assessed the improvement in the QOL among patients with Scheuermann's disease with Cobb's angle approximately 60°, who were treated conservatively or surgically in our center. International QOL scores, Oswestry Disability Index (ODI), and the Scoliosis Research Society 22 revision (SRS-22r) were utilized to evaluate patients' QOL.

METHODS

This prospective cohort study was conducted between January 2014 and August 2018 at King Abdullah University Hospital, Jordan University of Science & Technology to treat Scheuermann's disease in an adolescent age group with a borderline curve size. Ethical approval from the

Table 1. Distribution of Patients by Sociodemographics, Comorbidities, Drug Allergy, and Surgical History (N = 63)

Variable	Conservative group (n = 31)	Surgical group (n = 32)	p-value
Age (yr)	15.48 ± 2.50 (10–18)	16.19 ± 1.51 (13–18)	0.925
Sex (male : female)	12 (38.7) : 19 (61.3)	25 (78.1) : 7 (21.9)	
Comorbidity	12 (38.7)	7 (15.6)	
Drug allergy	0	1 (3.1)	
Surgical history (non-spinal)	7 (22.6)	3 (9.4)	
Symptom	Kyphotic deformity	Kyphotic deformity	

Values are presented as mean ± standard deviation (range) or number (%).

Institutional Research Board of King Abdullah University Hospital, Jordan University of Science & Technology was obtained before data collection (IRB No. 527-2014). The informed consent form was signed by the patients' parents. The inclusion criteria for eligible patients were: (1) definitive diagnosis of Scheuermann's kyphosis, (2) age between 10–18 years at the time of the diagnosis, (3) Cobb's angle between 50° and 65°, and (4) lack of any other spine deformities. Patients with spinal cord anomalies, vertebral

column tumors, missing follow-up data at any stage of the study, previous spinal surgery for any disease, or previous treatment in another hospital were excluded. The patients were divided blindly into two groups: conservative group (patients treated with physiotherapy, extension spine exercises, and bracing) and surgical group (patients who underwent posterior instrumentation with pedicle screws and fusion).

Both groups were evaluated clinically, radiologi-

Table 2. Mean Scores of ODI, SRS-22r, and Cobb's Angle in Patients with Conservative Treatment

Variable	Mean ± SD	Range	Difference between pre- and post-treatment		
			Mean ± SD	95% CI	p-value
ODI (%)			-7.6 ± 9.0	-10.9 to -4.3	< 0.001
Pre	12.6 ± 13.4	0.0–60.0			
Post	20.1 ± 13.6	0.0–52.0			
Total SRS-22r			0.4 ± 0.4	0.2 to 0.5	< 0.001
Pre	3.9 ± 0.7	2.0–4.8			
Post	3.5 ± 0.7	2.0–4.7			
Function domain			0.3 ± 0.4	0.2 to 0.4	< 0.001
Pre	4.0 ± 0.8	1.8–5.0			
Post	3.7 ± 0.8	1.8–5.0			
Pain domain			0.5 ± 0.5	0.3 to 0.7	< 0.001
Pre	4.1 ± 0.8	2.2–5.0			
Post	3.6 ± 0.8	2.0–5.0			
Self-image domain			0.3 ± 0.5	0.1 to 0.5	0.011
Pre	3.6 ± 0.9	1.2–5.0			
Post	3.4 ± 0.9	1.0–5.0			
Mental health domain			0.3 ± 0.4	0.1 to 0.4	0.001
Pre	3.9 ± 0.8	1.6–5.0			
Post	3.6 ± 0.8	2.0–5.0			
Satisfaction domain			0.7 ± 1.0	0.3 to 1.0	0.001
Pre	3.8 ± 0.8	2.0–5.0			
Post	3.1 ± 0.9	1.0–4.5			
Cobb's angle (°)			-2.74 ± 5.98	-4.97 to -0.55	0.016
Pre	56.1 ± 3.3	52–64			
Post	58.8 ± 5.8	43–65			

Total sample: n = 31.

ODI: Oswestry Disability Index, SRS-22r: Scoliosis Research Society 22 revision, SD: standard deviation, CI: confidence interval, Pre: pre-treatment, Post: post-treatment.

cally, and in laboratory tests pre- and post-treatment (final follow-up: 1–5 years). For Clinical evaluation, medical history, physical examination, neurological examination, and international evaluating scoring systems (ODI and SRS-22r) were used. Radiological investigations were performed using long film whole spine X-rays (anteroposterior and lateral views) to measure Cobb's angles, magnetic resonance imaging of the whole spine to rule out spinal cord disorder or other disorders of the vertebral column, and abdominal ultrasound. Laboratory evaluation included hemoglobin, white blood cell and platelets count, kidney and liver function, blood group, international normalized ratio, urinalysis and culture, and the pulmonary function test (PFT).

Statistical Analysis

In this study, we analyzed results using SPSS ver. 21 (IBM Corp., Armonk, NY, USA). A paired sample *t*-test was used to compare the mean (\pm standard deviation [SD]) and 95% confidence interval (CI) of pre- and post-treatment values (SRS-22r, ODI, and Cobb's angle) within the same group and mean changes between the two groups. The results were considered significant if $p < 0.05$. Using SPSS (frequencies), the descriptive statistics of the study (sex, drug allergy, comorbidities, and PFT) were determined.

RESULTS

Age, sex, comorbidities, drug allergy, and non-spinal

surgical history are presented for both groups in Table 1. Pre- and post-treatment mean values of the conservative group subjects' QOL questionnaires (ODI and SRS-22r) are presented in Table 2. Mean ODI score significantly increased (deteriorated) from $12.6\% \pm 13.4\%$ pre-treatment to $20.1\% \pm 13.6\%$ post-treatment ($p < 0.001$), mean \pm SD of the increase was $7.6\% \pm 9.0$ (95% CI, -10.9 to -4.3). Mean total SRS-22r score decreased (not improved) from 3.9 ± 0.7 pre-treatment to 3.5 ± 0.7 post-treatment ($p < 0.001$); the mean of decrease was 0.4 ± 0.4 (95% CI, 0.2 to 0.5). Mean function domain score significantly decreased from 4.0 ± 0.8 to 3.7 ± 0.8 ($p < 0.001$); the mean of decrease was 0.3 ± 0.4 (95% CI, 0.2 to 0.4). Mean pain domain score significantly decreased from 4.1 ± 0.8 to 3.6 ± 0.8 ($p < 0.001$); the mean of decrease was 0.5 ± 0.5 (95% CI, 0.3 to 0.7). Mean self-image domain score significantly decreased from 3.6 ± 0.9 to 3.4 ± 0.9 , ($p = 0.011$); the mean of decrease was 0.3 ± 0.5 (95% CI, 0.1 to 0.5). Mean mental health domain score significantly decreased from 3.9 ± 0.8 to 3.6 ± 0.8 , ($p = 0.001$); the mean of decrease was 0.3 ± 0.4 (95% CI, 0.1 to 0.4). Mean satisfaction domain score significantly decreased from 3.8 ± 0.8 to 3.1 ± 0.9 ($p = 0.001$); the mean of decrease was 0.7 ± 1.0 (95% CI, 0.3 to 1.0). Cobb's angle improved in 5 out of 31 patients. Mean Cobb's angle significantly increased from $56.06^\circ \pm 3.265^\circ$ to $59.77^\circ \pm 6.677^\circ$ ($p = 0.003$); the mean of increase was $-3.71^\circ \pm 6.409^\circ$ (95% CI, -6.061 to -1.359) (Table 2, Figs. 1 and 2).

Pre- and post-treatment mean values of the surgical group subjects' QOL questionnaires (ODI and SRS-22r) are presented in Table 3. ODI mean scores decreased with-

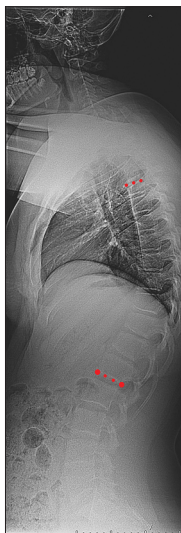


Fig. 1. Lateral whole spine X-ray of a 13-year-old boy with Scheuermann's kyphosis. Cobb's angle = 60° , > 2 wedge vertebrae, and irregular end plates. This patient was treated conservatively for 2 years.



Fig. 2. Lateral whole spine X-ray showing Scheuermann's kyphosis at final follow-up after conservative treatment. Cobb's angle was 64° , which means no improvement.

Table 3. Mean Scores for ODI, SRS-22r, and Cobb's Angle in Patients with Surgical Treatment

Scale	Mean ± SD	Range	Difference between pre- and post-treatment		
			Mean ± SD	95% CI	p-value
ODI (%)			3.4 ± 18.2	-3.2 to 9.9	0.301
Pre	16.8 ± 14.3	0.0–56.0			
Post	13.4 ± 10.8	0.0–40.0			
Total SRS-22r			-0.8 ± 0.8	-1.0 to -0.5	< 0.001
Pre	3.5 ± 0.5	2.45–4.50			
Post	4.2 ± 0.5	2.7–4.8			
Function domain			-0.1 ± 0.9	-0.5 to 0.2	0.484
Pre	3.9 ± 0.7	2.0–5.0			
Post	4.0 ± 0.6	2.6–5.0			
Pain domain			-0.5 ± 1.0	-0.8 to -0.1	0.013
Pre	3.7 ± 0.9	2.2–5.0			
Post	4.1 ± 0.6	2.4–5.0			
Self-image domain			-1.9 ± 1.3	-2.4 to -1.4	< 0.001
Pre	2.6 ± 1.0	1.0–4.6			
Post	4.5 ± 0.5	3.0–5.0			
Mental health domain			-0.4 ± 0.9	-0.7 to -0.02	0.030
Pre	3.6 ± 0.7	1.4–4.6			
Post	4.0 ± 0.7	2.0–5.0			
Satisfaction domain			-1.1 ± 1.0	-1.5 to -0.8	< 0.001
Pre	3.5 ± 0.9	1.5–5.0			
Post	4.6 ± 0.6	3.0–5.0			
Cobb's angle (°)			17.22 ± 3.22	16.06 to 8.38	< 0.001
Pre	58.75 ± 3.59	52–65			
Post	41.53 ± 3.94	35–49			

Total sample: n = 32.

ODI: Oswestry Disability Index, SRS-22r: Scoliosis Research Society 22 revision, SD: standard deviation, CI: confidence interval, Pre: pre-treatment, Post: post-treatment.

out any significance from 16.8% ± 14.3% pre-treatment to 13.4% ± 10.8% post-treatment ($p = 0.301$); the mean of this decrease (improvement) in scores was 3.4% ± 18.2% (95% CI, -3.2 to 9.9).

Mean total SRS-22r score increased from 3.5 ± 0.5 pre-treatment to 4.2 ± 0.5 post-treatment ($p < 0.001$); the mean of increase was 0.8 ± 0.8 (95% CI, -1.0 to -0.5). Mean function domain score increased from 3.9 ± 0.7 to 4.0 ± 0.6 ($p = 0.484$), and the mean of increase was 0.1 ±

0.9 (95% CI, -0.5 to 0.2). Mean pain domain score significantly increased from 3.7 ± 0.9 to 4.1 ± 0.6 ($p = 0.013$), and the mean of increase was 0.5 ± 1.0 (95% CI, -0.8 to -0.1). Mean self-image domain score significantly increased from 2.6 ± 1.0 to 4.5 ± 0.5 ($p < 0.001$), and the mean of increase was 1.9 ± 1.3 (95% CI, -2.4 to -1.4). Mean mental health domain score significantly increased from 3.6 ± 0.7 to 4.0 ± 0.7 ($p = 0.030$), and the mean of increase was 0.4 ± 0.9 (95% CI, -0.7 to -0.02). Mean satisfaction domain

score significantly increased from 3.5 ± 0.9 to 4.6 ± 0.6 ($p < 0.001$), and the mean of increase was 1.1 ± 1.0 (95% CI, -1.5 to -0.8). Cobb's angle improved in all patients after surgery. Mean angle significantly decreased from $58.75^\circ \pm 3.59^\circ$ pre-treatment to $41.53^\circ \pm 3.94^\circ$ at final follow-up ($p < 0.001$ and 95% CI, 16.058 to 18.380). The mean of improvement was $17.22^\circ \pm 3.22^\circ$ (Table 3, Figs. 3 and 4). Two patients developed late complications: one had screw prominence and skin breakage and the other complained of right medial scapular pain. The former patient was treated by removal of the screw and the latter conservatively. Both recovered without recurrence. Another patient developed adjacent kyphosis after the operation with spinal cord compression at the level of T2–3, which required extension of instrumentation and the deformity was corrected to release compression on the cord. None of the patients in the conservative group developed significant complications except brace discomfort in 1 patient and neck pain in 2 patients.

PFT of the conservative group was normal in 21 (67.7%) patients and decreased (abnormal) in 10 (32.2%) patients before treatment without any change at the final follow-up. In the surgical group, the test was found to be normal in 22 (68.8%) and abnormal in 10 (31.2%) patients before surgery. The normal 22 patients and 7 out of the 10 abnormal patients (90.6%) were classified as normal post-treatment, while 3 (9.4%) patients were classified as abnormal at the final post-treatment follow-up ($p < 0.001$).

The comparison of mean changes in results between the two groups showed a significant difference in all QOL scores and Cobb's angle ($p < 0.05$) (Table 4).



Fig. 3. Lateral whole spine X-ray of a 15-year-old boy with Scheuermann's kyphosis. Cobb's angle was 65° . The patient was treated surgically.

DISCUSSION

Previous studies have suggested treating patients with Scheuermann's kyphosis conservatively; by observation, physiotherapy, non-steroidal drugs, or bracing if the curve size (Cobb's angle) was less than 70° . Patients with curves greater than 70° , unpleasant deformity, cardiopulmonary complications, loss of sagittal balance, neurological deficits, progressive curve despite bracing, or presence of back pain are indicated for surgery.²¹⁻²³ Bracing of the immature Scheuermann's kyphosis can help the wedge vertebrae to remodel,²⁴ but one-third of the patients lost correction of the curve after discontinuation of bracing in a previous study.²³ Lack of improvement after the conservative treatment in the current study may be involvement of the relatively older patients (15.48 ± 2.50 years) and shorter follow-up period.^{25,26}

To the best of our knowledge, none of the previous studies discussed the conservative or surgical treatment of Scheuermann's kyphosis with a curve size between 50° – 70° . In this study, we investigated the QOL changes following conservative and surgical treatment for a total of 63 subjects diagnosed with Scheuermann's Kyphosis, in whom Cobb's angle ranged between 50° and 65° , utilizing a cohort study design and a pre- and post-treatment approach. Subjects were followed up for 1–5 years. The current study also compared the improvement in a spectrum of clinical and functional domains within each group pre- and post-treatment and between the two groups (conservative and surgical groups). Clinical and functional outcomes indicated limited improvement for conservative

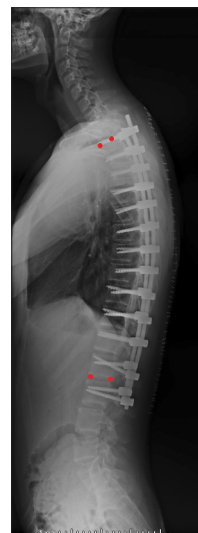


Fig. 4. Lateral whole spine X-ray showing Scheuermann's kyphosis at final follow-up after surgical treatment.

Table 4. Mean Changes (Improvement) between Pre- and Post-treatment in the Conservative and Surgical Treatment Groups (N=63)

Variable	Mean ± SD	Range	Difference between conservative and surgical groups		
			Mean	95% CI	p-value
ODI			-11.0	-18.2 to -3.7	0.004
Conservative	-7.6 ± 9.0	-24.0 to 12.0			
Surgical	3.4 ± 18.2	-34.0 to 46.0			
Total SRS-22r			1.1	0.8 to 1.4	< 0.001
Conservative	0.4 ± 0.4	-0.4 to 1.5			
Surgical	-0.8 ± 0.8	-1.8 to 1.4			
Function domain			0.4	0.1 to 0.8	0.026
Conservative	0.3 ± 0.4	-0.4 to 0.8			
Surgical	-0.1 ± 0.9	-2.2 to 2.2			
Pain domain			1.0	0.6 to 1.4	< 0.001
Conservative	0.5 ± 0.5	-0.6 to 1.4			
Surgical	-0.5 ± 1.0	-2.2 to 1.8			
Self-image domain			2.2	1.7 to 2.7	< 0.001
Conservative	0.3 ± 0.6	-1.2 to 1.8			
Surgical	-1.9 ± 1.3	-4.0 to 0.6			
Mental health domain			0.6	0.3 to 1.0	0.001
Conservative	0.3 ± 0.4	-0.6 to 1.0			
Surgical	-0.4 ± 0.9	-2.4 to 1.6			
Satisfaction domain			1.8	1.3 to 2.3	< 0.001
Conservative	0.7 ± 1.0	-1.0 to 4.0			
Surgical	-1.1 ± 1.0	-3.5 to 1.0			
Cobb's angle (°)			19.96	-19.8 to -14.07	< 0.001
Conservative	- 2.74 ± 5.98	-4.97 to -0.55			
Surgical	17.22 ± 3.22	16.06 to 8.38			

Total sample: conservative, n = 31; surgical, n = 32.

SD: standard deviation, CI: confidence interval, ODI: Oswestry Disability Index, SRS-22r: Scoliosis Research Society 22 revision.

treatment. ODI showed a slightly worsening outcome. The improvements in the total SRS-22r score, as well as subdomains of function, pain, self-image, mental health, and satisfaction, were not of clinical importance because the higher scores were at the pre-treatment phase as reported in the literature.¹⁸⁾

In the surgical group, improvement of ODI was not statistically significant as reported by Toombs et al.²⁷⁾ Results of total SRS-22r and each subdomain showed improvement except for the function domain. Similar find-

ings were obtained by Graat et al.²⁸⁾ as the mental health domain, self-image domain, and overall RS-22 score improved significantly ($p < 0.001$).

To the best of our knowledge, no previous study in the literature has measured the PFT of Scheuermann's Kyphosis patients pre- and post-treatment either conservatively or surgically. The results of our study showed significant improvement in the PFT in both groups without significant difference between the two groups.

Reduction of Cobb's angle that indicates an improve-

ment of kyphosis was significant in the surgical group and insignificant in the conservative group. This insignificant improvement in the conservative group contradicts the results reported by Etemadifar et al.²⁵⁾ in 2017 due to the different mean age of subjects; their subjects were younger and the duration of follow-up was longer than that in the current study.

A clinical comparison between the two groups of our study showed better improvement in the surgical group than the conservative group in back functional outcome and ODI score (even with statistical insignificance). QOL scores of total SRS-22r score and all subdomains (function, pain, self-image, mental health, and satisfaction) were better in the surgical group than in the conservative group (Table 4).

Improvement of Cobb's angle in the surgical group was better than that in the conservative group, indicating a reduction in the degree of kyphosis. This is because some subjects had rigid curves, Cobb's angles up to 60°, and their ages were around 18 years at the time of conservative treatment, and we did not assess patients' compliance with conservative treatment although compliance is an important factor for improvement.^{29,30)} Compliance with bracing treatment for female adolescents with adolescent idiopathic scoliosis (AIS) was evaluated to assess the correlation between compliance with conservative treatment in this group and improvement in the QOL in a study by Chan et al.²⁹⁾ Their results showed a significant correlation between compliance with and adherence to wearing a brace in conservative treatment and the improvement of patients' QOL

A cross-sectional study conducted in the USA determined the factors that could affect patients' compliance with brace treatment as a conservative option for adolescents with AIS. The results showed that there are many factors that affect patients' compliance with treatment, including the desire for the avoidance of surgical correction, prevention of disease progression, and prevention of

more back pain.³⁰⁾ Our study has some limitations, which include the fact that it was conducted in a single center, male: female ratio and comorbidities were not equal in both groups, compliance with conservative treatment was not assessed, and data were only collected at pre-treatment and final follow-up.

We found that surgical treatment outcome of Scheuermann's kyphosis in patients aged 10–18 years with curves between 50°–65°, as well as QOL scores, were better than those of conservative treatment in north Jordan. Surgical correction is also highly recommended for patients above the age of 16 years as most of the curves have low flexibility and compliance with conservative treatment is relatively low in this age group. Our findings can be used to counsel patients and their families on the clinical and functional benefits of surgical correction when indicated.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

ORCID

Ziad Ali Audat <https://orcid.org/0000-0003-0133-7716>
 Khalid Kheiralla <https://orcid.org/0000-0003-4504-4472>
 Bayan F Ababneh <https://orcid.org/0000-0002-6223-5599>
 Hisham Z. Aljamal <https://orcid.org/0000-0001-5151-4595>
 Jomana W. Alsulaiman <https://orcid.org/0000-0002-5858-0699>
 Yaman S Bataineh <https://orcid.org/0000-0002-1552-1517>
 Mohammad Gharaybeh <https://orcid.org/0000-0001-9780-7158>
 Abdarraahman Z Audat <https://orcid.org/0000-0002-6423-352X>

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