

# What Kinds of Cosmetic Appearances were Improved after Scoliosis Surgery in Adolescent Idiopathic Patients? A Longitudinal Long-term Postoperative 7-year Study Using Spinal Appearance Questionnaire

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## ABSTRACT

**Background and aim:** The primary purpose of spinal corrective surgery is to prevent scoliosis progression by spinal fusion at the regions of involvement. Patients would like to see corrections on their trunk appearance along with the spinal correction. Long-term longitudinal follow-up of cosmetic trunk appearance in surgical adolescent idiopathic scoliosis (AIS) patients using solely an appearance-specific questionnaire has not yet been reported.

**Materials and methods:** All severe AIS patients operated on from the year 2014–2016 were recruited. They completed a spinal appearance questionnaire (SAQ) at a time point from <1 year to 6–7 years after surgery (7 time points). Spinal appearance questionnaire domain scores from the 7 time points were compared using ANOVA with multiple comparison corrections.

**Results:** There were 76 severe AIS patients were recruited, of which 74.1% were females, and the mean age at operation was 15.97. Mean “General”, “Waist”, and “Chest” SAQ domain scores were consistently scored high across the 7 time points. The “surgical scars” domain consistently scored the lowest among the nine SAQ domains. Female patients observed significantly better mean “Curve” and “Trunk shift” domain scores at 4–6 years compared with <2 years despite none found in male patients.

**Conclusion:** Postoperative AIS patients were highly satisfied with their general appearance, waist, and chest 7 years after surgery. “Surgical scars” was persistently the least satisfied domain across the 7 years after surgery. Gender difference existed of which female patients felt significantly better on their “curves” and “trunk shift” after 4 years of surgery but the significance was not found in male patients.

**Keywords:** Adolescent idiopathic scoliosis, Appearance, Cosmetic, Longitudinal, Spinal appearance questionnaire, Surgery.

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## INTRODUCTION

Adolescent idiopathic scoliosis (AIS) is a three-dimensional deformity presenting with back deformity, a rib hump, and/or shoulder asymmetry.<sup>1</sup> Adolescent idiopathic scoliosis patients of major Cobb angle  $\geq 60^\circ$  require spinal surgical correction. The primary purpose of spinal corrective surgery is to prevent scoliosis progression by achieving a spinal fusion of the regions of the spine that are involved in the curve.<sup>2</sup> On patients' perspective, they would like to see their trunk or cosmetic appearances improved after surgery. These kinds of “outlook improvements” are hugely concerned by surgical patients, although no specific and objective discussion evaluating their long-term changes in appearances after surgery has been reported. “Appearance” or similar terms might appear in different questionnaires, these tools are non-appearance specific which lacks a comprehensive reflection of cosmetic appearance from patients who underwent spinal correction surgery, even though the questionnaires are scoliosis-specific.

The number of studies on health-related quality of life (HRQOL) of surgical AIS patients after surgery has been increasing due to the increase in patient's awareness of their well-being after surgery, as a result of the popularity of social media. This leads to the development of different kinds of patient-reported outcome questionnaires or tools, of which some of them are disease-specific and some of them are for a non-specific purpose (e.g., Short Form-36<sup>3</sup>). Scoliosis Research Society-22 (SRS-22) and spinal

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**Conflict of interest:** None

appearance questionnaire (SAQ) are well-known scoliosis-specific questionnaires both aiming for the health issues related to idiopathic scoliosis.<sup>4</sup> Spinal Appearance Questionnaire was modified by Sanders et al. from the Walter Reed Visual Assessment Scale to access a patient's perception of several aspects of the spinal deformity based on a pictorial scale.<sup>5–8</sup> Spinal appearance questionnaire was proved to be reliable, valid, and responsive.<sup>5–7</sup>

Long-term follow-up of patients' perceptions of their cosmetic appearance has not yet been discussed. The shoulder balance of AIS patients who underwent surgery was changed from left

down to left up [reflected by the changes in T1 Tilt (medial shoulder) and clavicular angles (lateral shoulder)], in associated with significant improvements in "Function" and "Self-image" after surgery in particular in female Lenke 2 patients regardless of age.<sup>9</sup> Self-image after the operation was associated with better curve flexibility, of which larger Cobb angle was related to less curve flexibility.<sup>10</sup> Authors recommended operating severe AIS patients when their curve flexibility was still good to gain a better chance of self-image.<sup>10</sup> Degree of curve correction after surgery and preoperative highest Cobb angle were significant predictors of "Function", "Self-image", and "Satisfaction with management".<sup>11</sup> Self-image was persistently and significantly lower than other domain scores in surgical AIS patients after 30 years of follow-up.<sup>12</sup> The HRQOL of a specific group of AIS patients who came across both bracing and surgery were also discussed.<sup>13</sup> Self-image can only represent and explain a part of "appearance". It is necessary to use a specific assessment tool to reflect a complete picture of patients' appearance. The SAQ is the most appropriate patient-reported outcome tool paying much attention to the perceptions of spinal appearance. Comparing to SRS-22, SAQ was found to have a greater correlation to curve magnitude than the SRS-22 appearance and total scores.<sup>5</sup>

Searching for a single or combinations of the keyword(s) "Spinal Appearance Questionnaire", "SAQ", "longitudinal", "long-term", and "follow-up" returned none. In our institute, every surgical patient was invited to fill out SAQ at every postoperative clinic follow-up. This study reported the long-term longitudinal changes of SAQ domain scores in surgical AIS patients. Gender difference on their perceptions of cosmetic appearance was also explored.

## MATERIALS AND METHODS

### Study Design

This is a retrospective long-term longitudinal follow-up study on severe AIS patients who underwent surgery.

### Subject Recruitment and Longitudinal Follow-up

All severely suffering AIS patients (major Cobb angle  $\geq 50$ ) and operated on between the years 2014 and 2016 were recruited from our specialized clinic in a tertiary hospital. Ethical approval was obtained from the local ethics review board (Research Ethics Committee approval number: 2019.213). Informed consent was obtained from all individual participants included in this study. The inclusion criteria were: (1) patients 10 years of age or above, and (2) idiopathic scoliosis planned for surgery. The following exclusion criteria were applied in patient selection: (1) non-AIS, (2) any congenital orthopedic disorder, and (3) any neurophysiological defect. Patients filled out SAQ at 7 time points: (1) postoperative (postoperative) <1 year, (2) postoperative 1–2 years, (3) postoperative 2–3 years, (4) postoperative 3–4 years, (5) postoperative 4–5 years, (6) postoperative 5–6 years, and (7) postoperative 6–7 years. The SAQ was completed through an electronic portal.<sup>14</sup>

### Spinal Appearance Questionnaire

The layout and contents in the electronic format were exactly the same as in the original format without any alternation, except answering the questions by tapping the mobile devices instead of writing on pieces of paper. The SAQ was well-validated and had been adapted to different languages.<sup>15–20</sup> Our system provided both English<sup>8</sup> and Traditional Chinese<sup>15</sup> languages and patients could

choose their preferred language. The SAQ contained two main sections: (1) standardized drawing illustrating increasing severity according to various components of spinal deformity and (2) textual questions rating dissatisfaction on an abnormal appearance on the spinal deformity. Patients selected one of five options (scored 1–5) with higher scores showing worsening deformity. The SAQ consisted of nine domains (General, Curve, Prominence, Trunk shift, Waist, Shoulders, Kyphosis, Chest, and Surgical scar) and provided more detail than the SRS appearance domain and explanation of spinal deformity's concerns and improvements. The SAQ demonstrated good outcome, good reliability, and strong evidence and excellent responsiveness to surgical correction.

### Data Collection

Demographical variables and surgical characteristics were collected through electronic records. The nine SAQ domain scores were calculated using the standard scoring algorithm.<sup>8</sup> Mean total score was also calculated being the mean sum of all nine mean domain scores. The domain scores were calculated by averaging the sums for all the items in the corresponding domains. For easier understanding of the magnitude of severity, the scores were transformed to show a better appearance with higher scores.

### Data Analysis

Demographic characteristics were described using mean  $\pm$  SD or number (percentage) where appropriate. Mean SAQ domain scores from the 7 time points were tabulated, as well as the numbers of years since surgery. Longitudinal SAQ domain scores were analyzed using ANOVA. *Post hoc* Bonferroni correction analyzes were carried out to look for any significant difference in multiple comparisons. Line charts on individual longitudinal average SAQ scores were plotted. Data analyzes were carried out using IBM SPSS 26.0 (Armonk, New York). A two-sided *p* value  $\leq 0.05$  was considered statistically significant.

## RESULTS

Of the 76 cases, there were 62 (81.6%) females and 14 (18.4%) males, with a mean age of 17.52. The demographic characteristics were tabulated in Tables 1A and 1B. The mean major preoperative Cobb angle was 68.62. The average postoperative Cobb angle is 20.43° and postoperative spinal correction is 71% (Table 2).

### Overall Comparisons

The nine mean SAQ domain scores across the 7 time points were summarized in Table 3 and Figure 1. Mean numbers of years in individual follow-up periods were shown as well. Generally speaking, the nine overall mean scores were increasing along the 7 years of follow-up. Moreover, the nine domains could be classified into three groups based on the mean values. The mean scores ranged from 0 to 10, and patients scored high (over 7) in "General", "Waist", and "Chest". "Shoulders" scored a mean of 5.64 at <1 year and gradually increased to 6.67 at 6–7 years. "Curve", "Prominence", "Trunk shift", "Kyphosis", and "Surgical scar" scored <4 at <1 year and were gradually increasing also. Results from ANOVA showed statistical significances were found in "Curve" and "Trunk shift". Comparisons of mean values among the time points further showed that mean "Curve" score at 5–6 years was significantly higher than the scores at <1 year (4.83 vs 2.91, *p* = 0.01), 1–2 years (4.83 vs 2.84, *p* < 0.01), and 2–3 years (3.36 vs 2.91, *p* = 0.02). In "Trunk shift", there was no statistical significance when inter-time point comparisons applied.

**Table 1A:** Demographic characteristics of the 76 patients (numeric)

Demographic characteristics	Mean $\pm$ SD (range)
Age at operation	17.52 $\pm$ 5.14 (12, 37)
BMI	18.92 $\pm$ 2.97 (10.85, 28.34)
Pre-operative body height (cm)	158.29 $\pm$ 8.39 (135.50, 185.40)
Pre-operative body weight (kg)	47.46 $\pm$ 8.43 (25.50, 72.10)
Pre-operative armspan (cm)	161.15 $\pm$ 10.14 (134.00, 185.00)
Pre-operative sitting height (cm)	83.20 $\pm$ 4.08 (73.00, 97.00)

**Table 1B:** Demographic characteristics of the 76 patients (categorical)

Variables	N (%)
Sex	
Male	14 (18.4)
Female	62 (81.6)
BMI	
Underweight	36 (47.4)
Normal	34 (44.7)
Overweight and obese	6 (7.9)
Lenke staging	
1	17 (22.4)
2	33 (43.4)
3	13 (17.1)
4	5 (6.6)
5	2 (2.6)
6	6 (7.9)
Number of levels	
$\leq 10$	15 (19.7)
11	9 (11.8)
12	18 (23.7)
13	20 (26.3)
14	8 (10.5)
15	6 (7.9)

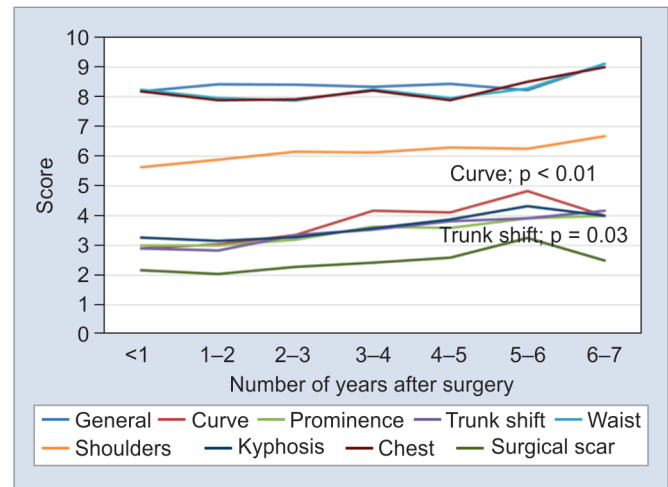
## Comparisons by Gender

### Male Patients

In male patients, the trends of different SAQ domain scores were a mix, which was quite different from the overall comparisons. "General", "Waist", and "Chest" still scored high, and even "Waist" and "Chest" scored 10 (highest score) at the 6–7 years. "Shoulders"

**Table 2:** Surgical information

Surgical and clinical details and measurements	Curve 1	Curve 2	Curve 3
Pre-operative Cobb	35.58 $\pm$ 12.91	68.62 $\pm$ 13.89	41.89 $\pm$ 15.87
Post-operative Cobb (latest visit)	20.26 $\pm$ 9.85	20.43 $\pm$ 9.25	14.40 $\pm$ 9.16
% Cobb correction (%)	43.92 $\pm$ 20.38	70.56 $\pm$ 10.94	66.01 $\pm$ 18.21



**Fig. 1:** Longitudinal SAQ domain scores until postoperative 7 years. SAQ: spinal appearance questionnaire

**Table 3:** Longitudinal SAQ domain scores of the 76 surgical patients until postoperative 7 years

Domain scores	Number of years after surgery							p value
	<1	1–2	2–3	3–4	4–5	5–6	6–7	
Mean years after surgery	0.59	1.42	2.30	3.23	4.13	5.10	6.13	
SAQ								
General	8.18 $\pm$ 2.00	8.42 $\pm$ 1.59	8.40 $\pm$ 1.33	8.33 $\pm$ 1.36	8.43 $\pm$ 1.05	8.22 $\pm$ 1.28	9.11 $\pm$ 0.34	0.91
Curve	2.91 $\pm$ 1.04 <sup>a</sup>	3.05 $\pm$ 1.03 <sup>b</sup>	3.36 $\pm$ 1.25 <sup>c</sup>	4.17 $\pm$ 1.55	4.12 $\pm$ 1.11	4.83 $\pm$ 1.34 <sup>a,b,c</sup>	4.00 $\pm$ 0.00	<0.01*
Prominence	3.00 $\pm$ 0.89	3.00 $\pm$ 0.82	3.20 $\pm$ 1.04	3.63 $\pm$ 1.21	3.59 $\pm$ 1.23	3.92 $\pm$ 1.16	4.00 $\pm$ 0.63	0.09
Trunk shift	2.91 $\pm$ 1.30	2.84 $\pm$ 1.01	3.36 $\pm$ 1.04	3.54 $\pm$ 1.14	3.82 $\pm$ 1.07	3.92 $\pm$ 1.44	4.17 $\pm$ 0.75	0.03*
Waist	8.24 $\pm$ 2.59	7.96 $\pm$ 2.92	7.87 $\pm$ 2.54	8.25 $\pm$ 2.34	7.96 $\pm$ 2.36	8.28 $\pm$ 1.94	9.11 $\pm$ 1.61	0.96
Shoulders	5.64 $\pm$ 1.43	5.89 $\pm$ 1.79	6.16 $\pm$ 1.34	6.13 $\pm$ 1.23	6.29 $\pm$ 1.31	6.25 $\pm$ 1.22	6.67 $\pm$ 0.52	0.78
Kyphosis	3.27 $\pm$ 1.35	3.16 $\pm$ 1.21	3.28 $\pm$ 1.28	3.58 $\pm$ 1.56	3.88 $\pm$ 1.50	4.33 $\pm$ 0.78	4.00 $\pm$ 0.00	0.16
Chest	8.18 $\pm$ 2.56	7.89 $\pm$ 3.13	7.92 $\pm$ 2.74	8.21 $\pm$ 2.50	7.88 $\pm$ 2.34	8.50 $\pm$ 1.88	9.00 $\pm$ 1.67	0.96
Surgical scar	2.18 $\pm$ 1.08	2.05 $\pm$ 0.91	2.28 $\pm$ 1.37	2.42 $\pm$ 1.18	2.59 $\pm$ 1.42	3.25 $\pm$ 1.14	2.50 $\pm$ 1.38	0.22
Total	42.33 $\pm$ 9.78	42.23 $\pm$ 9.12	43.55 $\pm$ 7.83	45.83 $\pm$ 8.75	45.98 $\pm$ 9.38	48.25 $\pm$ 7.50	50.06 $\pm$ 3.28	0.24

SAQ, spinal appearance questionnaire

\*p < 0.05

a, b, c: post hoc Bonferroni multiple comparisons p < 0.05

Scale: Every SAQ domain score ranges from 0 to 10

**Table 4:** Longitudinal SAQ domain scores of the patients until postoperative 7 years (male patients only)

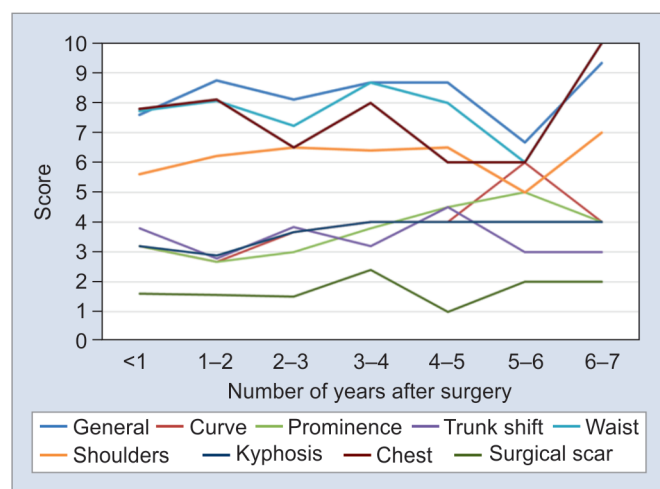
Domain scores	Number of years after surgery							p value
	<1	1–2	2–3	3–4	4–5	5–6	6–7	
SAQ								
General	7.60 ± 2.52	8.74 ± 1.84	8.11 ± 1.49	8.67 ± 1.05	8.67 ± 0.00	6.67 ± 0.00	9.33 ± 0.00	0.81
Curve	3.20 ± 1.10	2.67 ± 1.00	3.67 ± 1.51	4.00 ± 2.00	4.00 ± 0.00	6.00 ± 0.00	4.00 ± 0.00	0.27
Prominence	3.20 ± 1.10	2.67 ± 0.87	3.00 ± 1.10	3.80 ± 1.48	4.50 ± 2.12	5.00 ± 0.00	4.00 ± 0.00	0.25
Trunk shift	3.80 ± 1.48	2.78 ± 1.09	3.83 ± 1.17	3.20 ± 0.84	4.50 ± 0.71	3.00 ± 0.00	3.00 ± 0.00	0.41
Waist	7.73 ± 3.29	8.07 ± 3.32	7.22 ± 2.99	8.67 ± 1.25	8.00 ± 2.83	6.00 ± 0.00	10.00 ± 0.00	0.94
Shoulders	5.60 ± 2.07	6.22 ± 1.79	6.50 ± 1.22	6.40 ± 0.89	6.50 ± 2.12	5.00 ± 0.00	7.00 ± 0.00	0.93
Kyphosis	3.20 ± 1.79	2.89 ± 1.45	3.67 ± 1.51	4.00 ± 2.00	4.00 ± 2.83	4.00 ± 0.00	4.00 ± 0.00	0.90
Chest	7.80 ± 3.35	8.11 ± 3.48	6.50 ± 3.45	8.00 ± 2.45	6.00 ± 0.00	6.00 ± 0.00	10.00 ± 0.00	0.88
Surgical scar	1.60 ± 0.55	1.56 ± 0.53	1.50 ± 0.55	2.40 ± 0.89	1.00 ± 0.00	2.00 ± 0.00	2.00 ± 0.00	0.14
Total	42.13 ± 14.20	42.15 ± 10.89	42.50 ± 8.38	46.73 ± 2.44	46.17 ± 10.61	41.67 ± 0.00	51.33 ± 0.00	0.95

SAQ, spinal appearance questionnaire

\* $p < 0.05$

a, b, c: *post hoc* Bonferroni multiple comparisons  $p < 0.05$

Scale: Every SAQ domain score ranges from 0 to 10



**Fig. 2:** Longitudinal SAQ domain scores until postoperative 7 years (male patients only). SAQ: spinal appearance questionnaire

scored 5.60 at <1 year and 7.00 at 6–7 years. “Curve”, “Prominence”, “Trunk shift”, “Kyphosis”, and “Surgical scar” scored lower than 4 at <1 year and most of them scored similarly across the time points. “Surgical scars”, in particular, scored consistently low and was also persistently the lowest among the nine SAQ domains. The next lowest at 6–7 years was trunk shift (Table 4 and Fig. 2).

### Female Patients

Spinal appearance questionnaire domain scores in female patients followed the trends as seen in overall comparisons. Mean “General”, “Waist”, and “Chest” domain scores maintained high compared with the other six domain scores. “Shoulders” scored a mean of 5.67 at <1 year and gradually increased to 6.60 at 6–7 years (i.e., scores were very similar in overall comparisons). “Curve”, “Prominence”, “Trunk shift”, “Kyphosis”, and “Surgical scar” scored similarly as in overall comparisons. Statistical significance was found in “Curve” and “Trunk shift”. In *post hoc* multiple comparisons, in the “Curve” domain, mean scores at 5–6 years were significantly higher than in

<1 year (4.73 vs 2.67,  $p = 0.03$ ) and in 2–3 years (4.73 vs 3.26,  $p = 0.05$ ). In “Trunk shift”, the mean domain scores were significantly higher between <1 and 5–6 years (2.17 vs 4.00,  $p = 0.03$ ), and between <1 and 6–7 years (2.17 vs 4.40,  $p = 0.03$ ) (Table 5 and Fig. 3).

Multiple correction comparisons of mean values among the time points further showed that mean “Curve” score at 5–6 years was significantly higher than the scores at <1 year (4.83 vs 2.91,  $p = 0.01$ ), 1–2 years (4.83 vs 2.84,  $p < 0.01$ ), and 2–3 years (3.36 vs 2.91,  $p = 0.02$ ). In “Trunk shift”, there was no statistical significance when inter-time point comparisons applied. “Surgical scar” still scored the lowest among the nine domains; however, all mean scores were higher than in male patients.

## DISCUSSION

Patients’ perceptions on cosmetic appearance in severely suffering AIS patients who underwent spinal correction surgery is one of the important outcomes after surgery, however, this topic has not yet been specifically discussed. Patient-oriented outcome tools used in different reports were non-specific which could not provide a true and complete picture of the trunk appearance after surgery and years after surgery. The patient’s appearance-disease-specific patient-reported outcome measure, SAQ, was used in this longitudinal follow-up study. Results showed that “General”, “Waist”, and “Chest” SAQ domain scores consistently obtained high scores in both overall and gender-specific comparisons. “Surgical scars” scored the lowest among the nine domain scores in overall and gender-specific comparisons. Statistical significance was found in “Curve” and “Trunk shift” in overall and female patients. In both domain scores, mean scores at 4–5 and 5–6 years were statistically higher than in <1 year.

The SAQ was the patient-reported outcome assessment tool in this study. Studies using SAQ as the major instrument are scarce. Moreover, none reported postsurgical appearance outcome when studies involved solely SAQ. Since the introduction of SAQ for more than a decade, studies involving SAQ are still focused on language translation, validation, and adaptation approach as well as playing a non-major role in determining the outcomes. Language translation and adaptation, validity, and reliability studies were carried out



**Table 5:** Longitudinal SAQ domain scores of the patients until postoperative 7 years (female patients only)

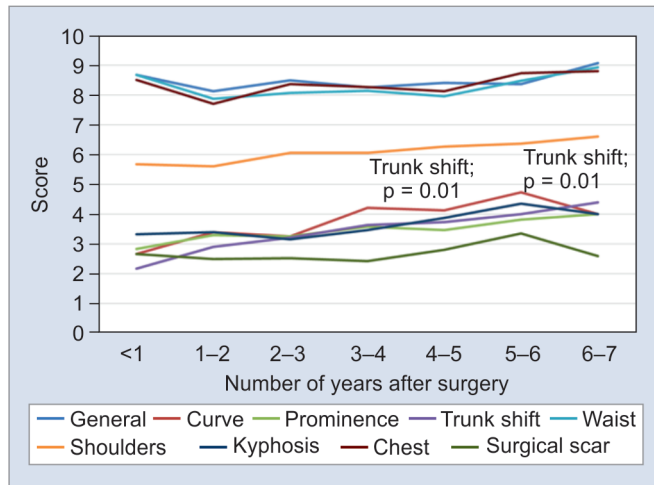
Domain scores	Number of years after surgery							p value
	<1	1–2	2–3	3–4	4–5	5–6	6–7	
SAQ								
General	8.67 ± 1.52	8.13 ± 1.36	8.49 ± 1.31	8.25 ± 1.44	8.40 ± 1.12	8.36 ± 1.24	9.07 ± 0.36	0.88
Curve	2.67 ± 1.03 <sup>1</sup>	3.40 ± 0.97	3.26 ± 1.19 <sup>2</sup>	4.21 ± 1.47	4.13 ± 1.19	4.73 ± 1.35 <sup>1,2</sup>	4.00 ± 0.00	0.01*
Prominence	2.83 ± 0.75	3.30 ± 0.67	3.26 ± 1.05	3.58 ± 1.17	3.47 ± 1.13	3.82 ± 1.17	4.00 ± 0.71	0.43
Trunk shift	2.17 ± 0.41 <sup>3,4</sup>	2.90 ± 0.99	3.21 ± 0.98	3.63 ± 1.21	3.73 ± 1.10	4.00 ± 1.48 <sup>3</sup>	4.40 ± 0.55 <sup>4</sup>	0.01*
Waist	8.67 ± 2.07	7.87 ± 2.68	8.07 ± 2.43	8.14 ± 2.57	7.96 ± 2.41	8.48 ± 1.89	8.93 ± 1.74	0.97
Shoulders	5.67 ± 0.82	5.60 ± 1.84	6.05 ± 1.39	6.05 ± 1.31	6.27 ± 1.28	6.36 ± 1.21	6.60 ± 0.55	0.75
Kyphosis	3.33 ± 1.03	3.40 ± 0.97	3.16 ± 1.21	3.47 ± 1.47	3.87 ± 1.41	4.36 ± 0.81	4.00 ± 0.00	0.19
Chest	8.50 ± 1.97	7.70 ± 2.95	8.37 ± 2.41	8.26 ± 2.58	8.13 ± 2.39	8.73 ± 1.79	8.80 ± 1.79	0.97
Surgical scar	2.67 ± 1.21	2.50 ± 0.97	2.53 ± 1.47	2.42 ± 1.26	2.80 ± 1.37	3.36 ± 1.12	2.60 ± 1.52	0.62
Total	42.50 ± 5.48	42.30 ± 7.80	43.88 ± 7.86	45.60 ± 9.81	45.96 ± 9.62	48.85 ± 7.56	49.80 ± 3.60	0.43

SAQ, spinal appearance questionnaire

\* $p < 0.05$

1, 2, 3, 4: *post hoc* Bonferroni multiple comparisons  $p < 0.05$

Scale: Every SAQ domain score ranges from 0 to 10



**Fig. 3:** Longitudinal SAQ domain scores until postoperative 7 years (female patients only). SAQ: spinal appearance questionnaire

in Turkey.<sup>21</sup> A validation study on a modified version of SAQ was carried out to increase its sensitivity and specificity on kyphosis.<sup>22</sup> In a Swedish study comparing trunk appearance in 1,416 patients with scoliosis and 272 subjects from the general population used the pictorial part of the SAQ.<sup>23</sup> Major results showed scoliosis patients paid much concern about their body appearance than normal individuals, and male and female AIS patients did not differ from each other on self-experienced trunk appearance.<sup>23</sup> However, the male and female patient groups in this study were mixed groups of AIS patients at different stages including bracing, pre- and post-surgery. The results showing no difference in their trunk appearance perception in this study are not comparable to the present study which compared between male and female patients after surgery. Moreover, the authors admitted that this was a limitation in this study. Another Scandinavian study assessed the psychosocial implications of AIS patients using two different types of brace, and SAQ was one of the assessment tools.<sup>24</sup> As a result, using SAQ in postoperative AIS patients was still rarely reported. Our study reports the patient's appearance outcomes up to 7 years

postoperatively. Further study describing the changes in SAQ domain scores in a specific group of AIS patients who came across both bracing and surgery would be very interesting to look at the domain changes in individuals who came through the two major interventions in AIS treatment history.

General impression, waist, and chest are found to be highly satisfied years after surgery. This is the novel finding in this study. In a cohort study carried out in California evaluating ethnic variation concerning appearance before and after surgery in AIS patients using SAQ, Asians were least concerned about domains including shoulders, hips, waist, ribs, and chest before surgery, on the contrary, just a minor proportion of patients concerned about their appearance after surgery.<sup>25</sup> This was a great contrast in the patient's appearance perception coming through surgery.<sup>25</sup> The data generalizability of the California study were limited by the admitted reasons, (1) The answers in the questions were condensed from a 5-point Likert scale to two to three categories, and (2) The identification of "Asians" in this study was not clear enough to distinguish American Asian from native Asians. Our patients paid much concern about their general impression, waist, and chest. The SAQ questionnaire used in our study is the unaltered original version. All our patients are from the same ethnic group. The mean age of our study is 17.52 which lies within the late adolescent stage. It is pretty obvious for both male and female patients to take much attention to their general impression, waist shape and balance, and chest-to-waist alignment. Surgeons are advised to plan ahead and take a balance between a successful spinal curve correction and cosmetic appearance.<sup>26</sup>

Curve and trunk shifts are kept improving over the 7 years. The greatest improvement (i.e., highest difference) happened between 4–6 and 2 years or fewer after surgery. A gender difference was found, of which female patients showed significant improvements but were not observed in male patients. A Polish study explored the perception of trunk deformity using the Polish version of SAQ in 40 female AIS patients who underwent surgical treatment and the results showed female postoperative patients rated important on the general, chest, surgical scar, symmetry of shoulders, and waist domains.<sup>27</sup> The design of our study was superior to the Polish study because we included male patients and the duration of

postoperative follow-up was much longer. The general pattern of changes in the nine mean domain scores across the 7 years of the follow-up period were similar while considering all patients and female patients only. This kind of gender difference is important for medical practitioners to cope with the differences in cosmetic needs between male and female patients.

While “surgical scar” always scored the least in both male and female patients, male patients consistently scored lower than the female counterparts across the 7 time points. This finding is out of the expectation to a certain extent because females are thought to take more care of their outlook. “Surgical scar” rated one of the most critical domains in a study involving 40 female Polish postsurgical AIS girls.<sup>27</sup> Medical professionals should pay more attention to the effect of the surgical scar, especially on male patients. Choosing an appropriate surgical approach provides a better chance to improve scar appearance.<sup>28</sup> An even longer follow-up study is recommended to observe any change in all domain scores, e.g., the 10th, 15th, and even  $\geq 20$ th years after surgery.

## LIMITATIONS OF THIS STUDY

There are limitations to the current study. The small number of participants in this study may affect the data generalizability. The retrospective nature of this study inherited the recall and information bias. The same study design can be employed in different centers to increase the sample size. Another point to note is that perception of appearance always adapts over time. Postoperative patients who are unsatisfied with the cosmetic appearance at the beginning might gradually accept the appearance, based on the fact that the patients realize this is a non-reversible fact (operated and instrumented) after a certain period of time postoperatively. This is a natural behavior of human beings. Therefore, the changes in SAQ domain scores over time should be considered as actual.

## CONCLUSION

Discussions on the long-term longitudinal self-assessed appearance changes in postoperative AIS patients have yet to be reported. Results using the disease-specific SAQ showed that the AIS patients were highly satisfied with their general appearance, waist, and chest after surgery, and remained high scores at their 6–7 years postoperatively. Surgical scars remained the lowest satisfied item among the nine domains. Female patients reported their spinal curves and trunk shift were significantly better after 4 years post-surgery, which explained gender differences existed. Extending the investigating period is recommended to look for any difference in trend in their cosmetic appearance domains.

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