Longitudinal Changes of Spinal Appearance Questionnaire and SRS-22 Questionnaire Domain Scores on Surgical Adolescent Idiopathic Scoliosis Patients before and after 2 Years of Operation

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ABSTRACT

Background: Both Scoliosis Research Society-22 questionnaire (SRS-22) and Spinal Appearance Questionnaire (SAQ) are well-established disease-specific patient-reported outcome questionnaires on adolescent idiopathic scoliosis (AIS). Our severe AIS patients were administered both questionnaires before and after surgery. The use of SRS-22 on surgical cases was well documented, however, SAQ which focused on patients' perceptions of spinal appearance, was merely reported. This study summarized the longitudinal changes of SAQ and SRS-22 domain scores in surgical AIS patients from preoperative to 2 years after surgery.

Materials and methods: All surgical AIS patients operated on in the year 2014 to 2016 were recruited. They completed both questionnaires at (1) before surgery ("Pre-op"), (2) immediately before hospital discharge ("Post-op"), (3) 1 year after surgery ("Post-op 1 year"), and (4) 2 years after surgery ("Post-op 2 years").

Results: There were 135 severe AIS patients recruited in this study, of which 74.1% were females, and the mean age at operation was 15.97. All SAQ domains were increasing (improving) until 2 years after surgery. Curve and prominence scored the highest among the nine domains across four time points. Significant increases were observed in "Trunk shift", "Shoulders", "Prominence", "Curve", and "General".

Conclusion: Improvements in appearance after surgery responded differently from function, pain, and other factors immediately after surgery. Patients' appearance perception was continuously improving after surgery despite function, pain, and mental were dropped then recovered in the next 2 years. Using SAQ in conjunction with SRS-22 in health-related quality of life (HRQOL)-related studies on AIS patients greatly improves and complements the interpretations on patients' appearance which endeavors further research on cognitive behavior in AIS patients after years of surgery in long-term follow-up studies.

Keywords: Adolescent idiopathic scoliosis, Longitudinal, Quality of life, Scoliosis Research Society-22 questionnaire, Spinal Appearance Questionnaire, Surgery.

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INTRODUCTION

The use and value of the patient-reported outcome (PRO) to improve patients' satisfaction and care are well established.[1,2] Longitudinal changes of health-related quality of life (HRQOL) before and after surgery in severe adolescent idiopathic scoliosis (AIS) patients become an increasing concern, both female and male, as a result of increasing patients' awareness and the popularity of social media. Scoliosis Research Society-22 questionnaire (SRS-22) is a well-established disease-specific HRQOL PRO instrument and the use of SRS-22 on surgical cases is also well reported.[3,4] However, the Spinal Appearance Questionnaire (SAQ), another disease-specific PRO instrument paying much attention to the perceptions of spinal appearance, was a nice complementary tool to SRS-22 despite less attention had been made.

Using SAQ and SRS-22 to measure the longitudinal changes of HRQOL, particularly on patients' perception of their spinal deformity's appearance, of severe AIS patients before and after surgery was important but had not yet been reported. Only five questions in SRS-22 described the patients' spinal appearance did not provide enough information, especially in adolescents who were concerned about their appearance most.[5] The 20-item SAQ was originally developed based on the Walter Reed Visual Assessment Scale and modified by Sanders et al.[6] Spinal

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Appearance Questionnaire assessed AIS patients' perceptions of spinal appearance using drawings and questions. Spinal Appearance Questionnaire scales were further modified by Carreon et al. to access a patient's perception of several aspects of the spinal deformity based on a pictorial scale.[2,6–8] Spinal Appearance Questionnaire was proved to be reliable, valid, responsive, and was applicable over all Lenke types.[2,7,8]

In our institute, both questionnaires were administered by every surgical AIS patient before and follow-ups after surgery.

Longitudinal changes of SRS-22 and SAQ domain score across the surgical treatment have yet to be discussed. Surprisingly, no study was found even under cross-sectional design. Those found focused on questionnaire evaluations. Spinal Appearance Questionnaire was found to have a greater correlation to curve magnitude than the SRS-22 appearance and total scores.[8] Another study measuring the reliability and validity of SAQ and Trunk Appearance Perception Scale (TAPS) concluded that further research would be helpful to combine different measures for refining medical diagnosis and better understand patients' needs.[9] None reported longitudinal changes of SAQ domain scores before and after surgery. This study summarized the longitudinal changes of SAQ and SRS-22 domain scores in surgical AIS patients from preoperative to 2 years after surgery.

MATERIALS AND METHODS

Study Design

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

Subject Recruitment and Longitudinal Follow-up

All severely suffering AIS patients (major Cobb angle ≥ 50) and operated on in the year 2014–2016 were recruited from our specialized clinic in a tertiary hospital. 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 both SAQ and SRS-22 questionnaire at four time points: (1) before surgery (time point "Pre-op"), (2) immediately before hospital discharge ("Post-op"), (3) 1 year after surgery ("Post-op 1 year"), and (4) 2 years after surgery ("Post-op 2 years"). Both questionnaires were completed through an electronic portal.[10]

SAQ

The original hardcopy format had been transformed to an electronic format. 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. Spinal Appearance Questionnaire was well-validated and had been adapted to different languages.[11–16] Our system provided both English[6] and Traditional Chinese[11] languages for patients to choose to answer the questions. Spinal Appearance Questionnaire 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 to 5) with higher scores showing worsening deformity. Spinal Appearance Questionnaire consisted of nine domains (General, Curve, Prominence, Trunk shift, Waist, Shoulders, Kyphosis, Chest, and Surgical scar) and provided more detail than SRS appearance domain and explanation of spinal deformity's concerns and improvements. Spinal Appearance Questionnaire demonstrated good outcome, good reliability, and strong evidence and excellent responsiveness to surgical correction. For easier understanding of the magnitude of severity, the scores were transformed to show a better appearance with higher scores. The domain scores were calculated by averaging the sums for all the items in the corresponding domains.

SRS-22

The original version is copyright by the Scoliosis Research Society.[17] Scoliosis Research Society-22 questionnaire is a scoliosis-specific HRQOL questionnaire consisting of 22 items and five domains (Function, Pain, Self-image, Mental, and Satisfaction). Each domain score ranged from 1 to 5, with higher scores indicating better outcomes. Again, our system provided both English[4] and Traditional Chinese[18] languages for patients to choose from. The logistics and workflow were documented elsewhere.[19,20]

Statistical Analysis

Demographic characteristics were described using mean $\pm$ SD or number (percentage) where appropriate. Mean SAQ and SRS-22 domain scores from the four time points were tabulated, as well as the numbers of months between time points. A component matrix in terms of factor loadings, communalities, and eigenvalues from factor analysis based on principal component analysis with orthogonal rotation was tabulated. Data distribution of the two composite indexes was demonstrated by descriptive statistics and reliability analysis. Data analysis was carried out using IBM SPSS 26.0 (Armonk, New York). A two-sided p value ≤ 0.05 was considered statistically significant.

RESULTS

Demographic Characteristics and Surgical Information of the 135 Severe AIS Patients (Tables 1 and 2)

The demographic characteristics were tabulated in Table 1. Cobb's angle of the major curve was 60° and the majority (93.9%) was right-sided (Table 2). The lowest instrumented vertebra at the major curve was 50 (37.0%) at T10, 39 (28.9%) at T12, and 46 (34.1%) at L2. Twenty percent ($N = 27$) of patients fused 4 levels and 7 or more levels fused in 34 (25.2%) patients.O

Longitudinal SRS-22 and SAQ Domain Scores along with the Four Visits (Figs 1 and 2, Table 3)

OAll SAQ domain scores were basically kept increasing (improving) throughout the study. Curve and prominence always scored higher than the other domains and they shared similar trends across the four time points. Both increased sharply after surgery from "Pre-op" to "Post-op" and were still increasing slowly until "Post-op 2 years". Significant increases were observed between "Pre-op" and the other 3 time points (overall $p < 0.01$). Trunk shift and shoulders showed similar trends and statistical significances at lower score range (from 4.24 at Pre-op in shoulder to 5.75 at Post-op 2 years in

Table 1: Demographic characteristics of the 135 AIS patients in this study [mean $\pm$ SD (range) or N (%) where appropriate]

Demographic variable	Mean $\pm$ SD or N (%)
Age at operation	15.97 $\pm$ 2.43
Gender	
Male	35 (25.9)
Female	100 (74.1)
Years since surgery	1.15 $\pm$ 0.66
Number of fused levels	11.42 $\pm$ 2.36

Table 2: Surgical information of the 135 severe AIS patients

Surgical information	Curve 1	Curve 2	Curve 3
Cobb angle (Mean ± SD [Median])	39.42 ± 14.49 [37]	59.97 ± 13.52 [60]	42.28 ± 16.48 [43]
(Min, Max)	(12, 68)	(33, 106)	(8, 76)
Side			
Left	40 (90.5)	3 (6.1)	41 (93.1)
Right	4 (9.5)	44 (93.9)	3 (6.9)
Number of fused levels			
4	15 (34.1)	0	12 (27.2)
5	29 (65.9)	0	16 (36.4)
6	0	13 (27.7)	16 (36.4)
≥7	0	34 (72.3)	0
Lowest instrumented vertebra (LIV)			
T1–T10	42 (95.5)	8 (17.6)	0
T11–L2	2 (4.5)	36 (76.5)	1 (3.3)
L3–S1	0	3 (5.9)	43 (96.7)

SD, standard deviation
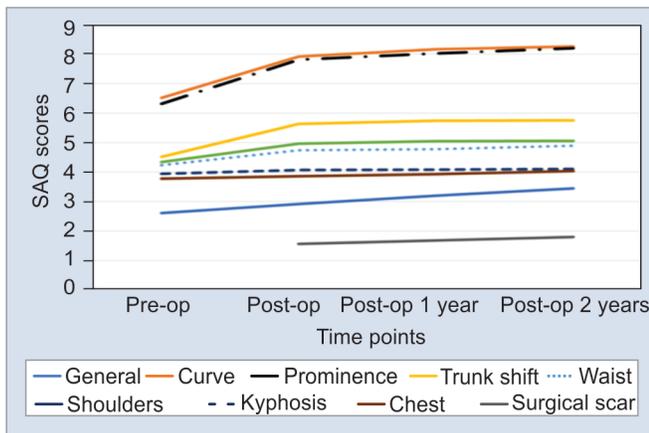
Fig. 1: Longitudinal changes of SAQ domain scores before and after surgery in the 135 severe AIS patients. SAQ, Scoliosis Appearance Questionnaire; AIS, Adolescent Idiopathic Scoliosis

trunk shift). General scores were steadily and slowly increasing [from 2.61 (Pre-op) to 3.44 (Post-op)], and scores significantly increased between Pre-op and Post-op 1 year ($p = 0.04$), and Pre-op and Post-op 2 years ($p = 0.02$). No significant difference was found in Waist, Kyphosis, Chest, and Surgical scar (Post-op, Post-op 1 year, and Post-op 2 years only).

In SRS-22, longitudinal changes in function and pain scores followed similar trends. Both dropped after surgery and gradually returned through the first year than the second year after surgery back to preoperative level. *Post hoc* Bonferroni corrections showed significant differences were found in both between "Post-op" and the other three time points (both $p < 0.01$) (Table 3). Self-image was gradually increasing from "Pre-op" to "Post-op 2 years", with significant differences found between "Pre-op" and "Post-op 1 year" and "Pre-op" and "Post-op 2 years" (both $p < 0.01$). Mental and satisfaction showed increasing trends 2 years after surgery, despite not showing any statistical significance. Mean scores basically followed the trends observed in "Function" and "Pain" and so as the comparisons which showed statistical differences ($p < 0.01$).

Mean SAQ domain scores were generally increasing (better) after surgery, and in SRS-22 the domain scores were increasing since

hospital discharge after dropping at "post-op" (Table 2). Further data descriptions on the data were beyond the scope of this study.

DISCUSSION

Scoliosis Research Society-22 questionnaire is a well-established scoliosis-specific HRQOL instrument and the use of SRS-22 on surgical cases is also well reported.[3,4] That is different in SAQ in which longitudinal changes have not yet been documented. Our severe AIS patients completed both SAQ and SRS-22 at every clinic visit, and longitudinal SAQ scores for postoperative patients had not been reported elsewhere. This study aimed to report concurrent longitudinal SAQ and SRS-22 domain scores of operated severe AIS patients. All SAQ domains increased from Pre-op to Post-op for 2 years. Curve, prominence, and trunk shift scores started the highest among the nine domains, and were significantly raising at Post-op, and kept increasing despite slowly at Post-op 1 year and Post-op 2 years. Trunk shift showed a similar trend at lower scores. Surgical scar scored the lowest without significant improvements. In SRS-22, the longitudinal changes in domains basically follow the reported articles: (1) Function and Pain dropped hugely, (2) Mental also dropped to a certain extent, and (3) Self-image and Satisfaction were continuously increasing.

This study reported the longitudinal characteristics of concurrent SAQ and SRS-22 domain scores before and after spinal correction. Studies using SAQ as the major PRO instrument are scarce. A Polish perspective study monitoring the changes in the impression of spinal deformity of 36 AIS females undergoing the Cheneau brace treatment concluded prominence (head-chest-hips line) was reversely correlated with trunk rotation and the situation was even worst in AIS females treated conservatively.[21] A study utilizing two questions concerning breast/chest wall asymmetry from SAQ to examine the perceptions of breast asymmetry on AIS patients after spinal fusion.[22] Breast asymmetry was reported improvements after surgery despite expected.[22] Moreover, the study design followed a before-after comparative approach (before-2 years postoperation in this study) which always missed the changes in between. Our results showed noticeable improvements in curve, prominence, and trunk shift from patients' perception which was closely related to breast symmetry.

Table 3: Longitudinal SRS-22 and SAQ domain scores along with the 4 visits ($N = 135$)

Time point	Pre-op	Post-op	Post-op 1 year	Post-op 2 years	p value
Number of months between visits			0.39 ± 0.26	1.49 ± 0.30	
(Mean $\pm$ SD; Min, Max)			(0.10–1.00)	(1.01–2.00)	
SAQ					
General	$2.61 \pm 1.24^{a,b}$	2.91 ± 1.81	3.20 ± 1.60^a	3.44 ± 1.57^b	0.03
Curve	$6.52 \pm 1.39^{c,d,e}$	7.92 ± 1.75^c	8.17 ± 1.01^d	8.27 ± 1.03^e	<0.01
Prominence	$6.32 \pm 1.52^{f,g,h}$	7.82 ± 1.11^f	8.03 ± 0.82^g	8.21 ± 0.88^h	<0.01
Trunk shift	$4.51 \pm 1.71^{i,j,k}$	5.64 ± 1.30^i	5.74 ± 0.92^j	5.75 ± 1.18^k	<0.01
Waist	4.24 ± 1.12	4.74 ± 1.24	4.78 ± 1.31	4.90 ± 1.22	0.64
Shoulders	$4.34 \pm 1.70^{l,m,n}$	4.96 ± 1.48^l	5.05 ± 1.61^m	5.06 ± 1.33^n	0.02
Kyphosis	3.94 ± 1.85	4.07 ± 1.13	4.08 ± 1.14	4.10 ± 1.28	0.78
Chest	3.77 ± 1.50	3.85 ± 1.40	3.93 ± 1.64	4.03 ± 1.55	0.57
Surgical scar	–	1.56 ± 0.15	1.68 ± 0.19	1.79 ± 0.50	0.22
SRS-22					
Function	4.43 ± 0.56^i	$3.57 \pm 0.68^{i,ii,iii}$	4.08 ± 0.52^{ii}	4.43 ± 0.52^{iii}	<0.01
Pain	4.35 ± 0.56^{iv}	$3.52 \pm 0.69^{iv,v,vi}$	4.06 ± 0.58^v	4.39 ± 0.63^{vi}	<0.01
Self-image	$3.39 \pm 0.75^{vii,viii}$	3.73 ± 0.48	3.92 ± 0.52^{vii}	4.08 ± 0.52^{viii}	<0.01
Mental	4.03 ± 0.56	3.81 ± 0.59	4.08 ± 0.54	4.19 ± 0.69	0.18
Satisfaction	4.00 ± 0.74	4.00 ± 0.78	4.34 ± 0.65	4.23 ± 0.65	0.17
Mean	4.04 ± 0.44^{ix}	$3.73 \pm 0.44^{ix,x,xi}$	4.09 ± 0.40^x	4.26 ± 0.50^{xi}	<0.01

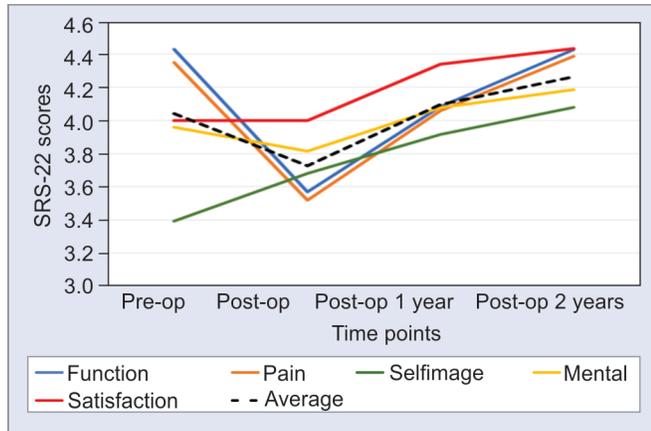–: Not recorded before surgery
a to n: $p < 0.05$
i to xi: $p < 0.05$
Scale:
For SAQ, the score ranges from 0 to 10
For SRS-22, the score ranges from 0 to 5

Fig. 2: Longitudinal changes of SRS-22 domain scores before and after surgery in the 135 severe AIS patients. SRS-22, Scoliosis Research Society-22 questionnaire; AIS, Adolescent Idiopathic Scoliosis

Improvements in appearance after surgery reacted quite differently from function, pain, and other factors immediately after surgery. Patients' appearance perception was continuously improving after surgery despite function, pain, and mental were dropped then recovered in the next 2 years. A Polish study group first adapted the SAQ to Polish cultural settings and validated,[23] followed by a cross-sectional study of 41 pairs of parents and female patients with AIS looking for patient–parent agreements on perceptions of appearance using SAQ in patients and adapted SAQ-patient form in parents reviewed the relationship between age and patient–parent differences in General domain.[24] The retrospective

analysis in Texas comparing breast/chest symmetry in severe AIS patients before and after surgery referenced before is the only time-dependent analysis we could find.[22] The novelty of this study is to provide statistical supports on the observations, which have been well recognized awaiting evidences. Using SAQ in conjunction with SRS-22 in HRQOL-related studies on AIS patients greatly improves and complements the interpretations on patients' appearance which endeavors further research on cognitive behavior in AIS patients after years of surgery in long-term follow-up studies.

Scoliosis Research Society-22 questionnaire and SAQ were well-established and well-accepted PRO measures in AIS patients. Scoliosis Research Society-22 questionnaire and SAQ measure different HRQOL approaches. We adopted both questionnaires to quantify the quality of life of surgical AIS patients. A follow-up study applying both SAQ and SRS-22 on AIS bracing patients would tell us whether putting on a brace actually influence the patients' perception of appearance. A longer long-term postoperative follow-up of AIS patients is needed to look for any noticeable and persistent changes of patients' appearance, say a decade or longer after surgery. Moreover, a parent version of SAQ is also recommended to develop to rate any change in appearance from parents/legal guardians or caretakers. Development of composite indexes simplifying the interpretation when administering both SAQ and SRS-22 to patients using factor analysis would be favorable.

Limitations

There are limitations to the current study. The small number of participants in this study may affect the data generalizability of the results. The retrospective nature of the study inevitably inherited the recall and information bias. The same design can be employed

in different centers to increase the sample size. A similar study carrying out on non-scoliotic patients and healthy subjects would be another direction. Future validation studies looking for floor and ceiling effects and minimal clinically important difference (MCID) will be required before the instrument's use in severe AIS patients. Moreover, this would also be interesting to carry out similar research on parents or legal guardians/caretakers and look for any difference with the outcomes from patients.

CONCLUSION

Longitudinal changes of SRS-22 and SAQ scores in severe AIS patients across the surgical treatment have yet to be discussed. Improvements in appearance after surgery responded differently from function, pain, and other domains after surgery. Patients' appearance perception was continuously improving after surgery despite function, pain, and mental were dropped then recovered in the next 2 years. Using SAQ in conjunction with SRS-22 in HRQOL-related studies on AIS patients greatly improves and complements the interpretations on patients' appearance which endeavors further research on cognitive behavior in AIS patients after years of surgery in long-term follow-up studies. Long-term follow-up studies applying both SAQ and SRS-22 on AIS bracing patients would warrant any noticeable and persistent changes in patients' appearance. A parent version of SAQ as well as the development of composite indexes simplifying the interpretation would be recommended.

PATIENT DECLARATION STATEMENT

"The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed."

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