Irish Journal of Medical Science (1971 -)
https://doi.org/10.1007/s11845-023-03563-8

ORIGINAL ARTICLE

The effect of spinal range of motion on functional balance, quality of life, and perception of appearance in adolescent idiopathic scoliosis after posterior spinal fusion surgery

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Received: 26 September 2023 / Accepted: 30 October 2023

Abstract

Objective Spinal fusion, which is widely used in the surgical treatment of adolescent idiopathic scoliosis (AIS), limits the movements of the vertebral column. In this study, it was aimed to investigate the relationship between spinal mobility in the postoperative period with functional balance, quality of life, and perception of appearance in individuals with AIS.

Methods Thirty patients with AIS who underwent posterior spinal fusion surgery 1 to 3 years ago were included in the study. A universal goniometer was used to measure a spinal range of motion (ROM), functional reach test for functional balance, Scoliosis Research Society-30 (SRS-30) for quality of life, and Spinal Appearance Questionnaire (SAQ) for perception of appearance.

Results Surgical fusion length was significantly correlated with movements in the sagittal and transverse planes ($r = -0.383$–$[-0.608]$; $p = <0.001$–0.037). Except for spinal left rotation, there was a significant positive correlation between functional balance level and ROM results ($r = 0.374$–0.523; $p = 0.003$–0.42). The SRS-30 total score correlated significantly with all other ROM measures except for rotations ($r = 0.434$–0.574; $p = 0.00$–0.016). SAQ total data correlated significantly with all ROM measurements ($r = -0.553$–$[-0.395]$; $p = 0.002$–0.031).

Conclusions In AIS, limitation of movement in the coronal, sagittal, and transverse planes is observed after fusion surgery. Spinal ROM is affected by the level of fusion performed at surgery. Postoperative spinal limitation of motion adversely affected functional balance, quality of life, and perception of appearance. We believe that comprehensive rehabilitation approaches that improve postoperative range of motion and increase functionality are important for optimal postoperative recovery.

Keywords Adolescent · Quality of life · Range of motion · Scoliosis

Introduction

Adolescent idiopathic scoliosis (AIS) is a complex and three-dimensional structural deformity of the spine that occurs from the age of 10 to the completion of skeletal maturity [1]. In the treatment of severe curvature, surgical treatment is aimed at stopping the progression of the curvature, correcting the deformity, and obtaining a balanced spine in the coronal and sagittal planes [2]. The posterior spinal fusion and instrumentation (PSFI) technique has become the standard in the surgical treatment of AIS and is the most common surgical approach [3].

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Published online: 09 November 2023

In PSFI surgery, the spine is fused with screws and rods to transform the relevant segment into a fixed column that does not move, and in this way, asymmetric growth is controlled [4]. However, this process limits the physiological movements of the spine and reduces the normal range of motion of the trunk [5]. Severe scoliotic curves already present before surgery can interfere with normal spinal biomechanics, resulting in poor range of motion. These processes can lead to other functional problems, early-onset back pain, and disc degeneration [6, 7]. Therefore, knowing the variables associated with the range of motion (ROM) of the spine in the postoperative period is necessary to prevent secondary problems that may develop and to improve the postoperative process.

AIS patients with surgical indication may face balance and gait problems in addition to spinal muscle activation imbalance as the severity of the curvature increases [8, 9]. However, as the severity of curvature increases in these cases, their body image perception is negatively affected, and this reduces their quality of life [10–12]. Although these problems that existed in the preoperative period are likely to improve after surgical correction, movement restrictions that may occur in the postoperative period may affect this in the opposite direction.

Although studies evaluating the postoperative spinal ROM of individuals with AIS are frequently encountered in the literature, the variables accompanying decreased ROM after PSFI surgery have not been adequately investigated. In this study, we aimed to investigate the effect of spinal ROM after surgery on functional balance, quality of life, and appearance perception in patients with AIS.

Methods

In this observational cross-sectional study, diagnoses of adolescent idiopathic scoliosis, who came to Prof. Dr. Süleyman Yalçın city hospital and Emsey hospital for routine control after scoliosis surgery between July 2021 and November 2022, were included. The research was carried out in accordance with the Declaration of Helsinki and with the approval of the Haliç University Non-Invasive Ethics Committee (June 2021/130). Written informed consent was obtained from all participants or their parents who agreed and volunteered to participate in the study. Cases over the age of 10, diagnosed with AIS, operated with the PSFI technique at least 1 year and at most 3 years ago were included in the study. Previously undergoing a different spine surgery, advanced neuromuscular, rheumatological, orthopedic diagnosis accompanying scoliosis, presence of congenital deformity, and cases with a psychiatric disorder record were excluded from the study.

Demographic and clinical characteristics of patients were recorded. The magnitude of the curve was measured using the Cobb method on the participants' spine radiographs taken on the same day. The Cobb angle is the standard and valid unit of measurement used to grade the angle of the scoliotic curvature in the coronal plane [13].

In the present study, a long-arm universal goniometer (Baseline® Stainless, Roeselare, Belgium) designed for the spine was used to measure spinal ROM. For the measurement of flexion and extension, the subjects were standing and turned sideways, after the pivot point was kept in the center of the lumbosacral joint and the fixed arm was parallel to the midline of the femur, the movable arm followed the axillary line. For lateral flexion, the subjects stood and their back turned; after keeping the pivot point in the center of the lumbosacral joint and the fixed arm parallel to the ground, the movable arm followed C7 and other spinous processes. For rotation, participants sat in a chair with their knees fixed to the wall to prevent movement of the pelvis and lower extremities. After keeping the pivot point at the midpoint of the head and the fixed arm parallel to the ground, the movable arm followed the head and trunk. All goniometric measurements were repeated three times by the same investigator, and the mean of the three angles was recorded [14, 15].

The functional reach test is one of the valid clinical tests used in the evaluation of functional balance. In our study, the patient flexed his arm near the wall to 90° while standing sideways to the wall, and the tip of the third finger was marked on the wall. In this position, the patient reached as far as possible without raising his heels, the last point reached by the third finger was marked, and the difference between the two marks was recorded in centimeters (cm). Three trials were performed and the last two trials were averaged [16]. To evaluate the quality of life of the participants, the Scoliosis Research Society Questionnaire-30 (SRS-30), which consists of questions specific to the problems experienced by patients with scoliosis and was updated for patients who underwent surgical treatment, was used. The validated scale has five subgroups: pain, function, image, mental health, and satisfaction. As the scores obtained from the scale increase, the quality of life also increases [17]. For the perception of appearance, the Spinal Appearance Questionnaire (SAQ), a valid and reliable questionnaire that evaluates the perception of cosmetic deformity in scoliosis with visual and written explanations in detail, was used. The scale has two subgroups as "Appearance" and "Expectation". The higher the score obtained from the scale, the more negative the perception of the appearance by the patient and the higher the expectation from the appearance [18].

Statistical analysis

IBM Statistical Package for Social Sciences 24 (SPSS, Chicago, USA) statistical program was used for data analysis. Continuous variables were given as mean ± standard deviation, and qualitative variables were given as numbers and

percentages (%). It was determined that the data showed normal distribution with the Shapiro–Wilk test, and the relationship between the variables was evaluated with Pearson correlation analysis. Statistical significance was taken as $p < 0.05$ in all measurements.

Results

Thirty cases diagnosed with AIS were included in the study. The mean postoperative maximum Cobb angles were 11.13 ± 5.66, and fusion levels ranged from 6 to 15 vertebrae. The demographic and clinical characteristics of the subjects are presented in Table 1. The data on the participants' spinal range of motion, functional balance, quality of life, and perception of appearance are presented in Table 2.

Table 3 shows the correlations of spinal range of motion with fusion levels, functional balance, perception of appearance, and quality of life parameters. Surgical fusion length was significantly correlated with ROM values in the sagittal and transverse planes ($r = -0.383$–$[-0.608]$; $p = <0.001$–0.037). There was a positive significant correlation between functional balance level and ROM results except for left rotation ($r = 0.374$–0.523; $p = 0.003$–0.42). SAQ total mean score values correlated significantly with all ROM values ($r = -0.553$–$[-0.395]$; $p = 0.002$–0.031). However, the appearance subgroup score was only significantly associated with mean flexion values ($r = -0.488$; $p = 0.006$) and both side mean rotation values ($r = -0.427$; $p = 0.019$) angles. The expectation subgroup scores were correlated with all other ROM values except for left rotation values ($r = -0.560$–$[-0.390]$; $p = 0.001$–0.033). SRS-30 total score, pain, and function subgroups were significantly correlated with all other ROM measures except for rotation ($r = 0.415$–0.642; $p = <0.001$–0.022). The mental health subgroup was not associated with any measure of ROM ($p > 0.05$). Self-image subgroup was significantly associated with flexion ($r = 0.459$; $p = 0.011$), extension ($r = 0.514$; $p = 0.004$), and right lateral flexion ($r = 0.491$; $p = 0.006$). The satisfaction subgroup had a significant relationship only with the right ($r = 0.543$; $p = 0.002$) and left ($r = 0.386$; $p = 0.035$) rotation angles.

Table 1 Demographic and clinical characteristics of cases

Parameters	Mean ± SD or *n* (%)
Age (years)	17.5 ± 2.27
Sex (*n*)	
Female	22 (73.3%)
Male	8 (26.7%)
BMI (kg/m^2)	20.08 ± 2.75
Location of the apex	
Thoracal	15 (% 50)
Thoracolumbar	10 (% 33.3)
Lumbar	5 (%16.7)
Regularly exercise	
Yes	3 (% 10)
No	27 (% 90)
Bracing duration after surgery (month)	3.03 ± 1.92
Preoperative maximum cobb angle (°)	55.5 ± 12.1
Postoperative maximum cobb angle (°)	11.13 ± 5.66
Fusion level (*n*)	11.7 ± 2.49

SD standard deviation, *n* number of subjects, *BMI* body mass index

Table 2 Mean values of spinal range of motion, perception of appearance, and quality of life

Parameters	Mean ± SD
Spinal range of motion	
Flexion (°)	60.53 ± 13.25
Extension (°)	23.83 ± 6.43
Right lateral flexion (°)	19.33 ± 4.34
Left lateral flexion (°)	21.17 ± 4.49
Right rotation (°)	35.97 ± 10.73
Left rotation (°)	38.63 ± 10.59
Functional reach (cm)	32.83 ± 4.45
Perception of appearance—SAQ	
Total	29.17 ± 8.54
Appearance	17.13 ± 4.47
Expectation	12.03 ± 5.89
Quality of life—SRS30	
Total	19.86 ± 2.38
Pain	3.79 ± 0.72
Function/activity	3.96 ± 0.62
Mental health	3.46 ± 0.55
Self-image	4.17 ± 0.51
Satisfaction	4.46 ± 0.67

SD standard deviation, *SAQ* Spinal Appearance Questionnaire, *SRS-30* Scoliosis Research Society Questionnaire-30

Discussion

It was determined that the decrease in spinal ROM in almost all planes except for a few angles of rotation in individuals with AIS after PSFI surgery adversely affected functional balance, quality of life, and perception of appearance.

The spine is the central axis of trunk rotation over the pelvis that allows for both lateral flexion and flexion–extension. This three-dimensional biomechanics plays a critical role especially in the healthy maintenance of daily life activities. Scoliotic deformity can cause limitation by altering the normal movement of the spine and its orientation with the pelvis. Especially in severe scoliotic curves, there is a greater decrease in

Table 3 Correlations of spinal range of motion with fusion level, functional balance, perception of appearance, and quality of life

	Flexion (°)		Extension (°)		Right LF (°)		Left LF (°)		Right rotation (°)		Left rotation (°)	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Fusion level	−0.404	**0.027***	−0.502	**0.005***	−0.306	0.1	−0.183	0.332	−0.383	**0.037***	−0.608	**<0.001***
Functional Reach Test	0.374	**0.042***	0.523	**0.003***	0.469	**0.009***	0.392	**0.038***	0.405	**0.026***	0.167	0.376
SAQ—total	−0.547	**0.002***	−0.462	**0.01***	−0.516	**0.004***	−0.418	**0.021***	−0.553	**0.002***	−0.395	**0.031***
SAQ—appearance	−0.488	**0.006***	−0.231	0.22	−0.248	0.187	−0.285	0.127	−0.427	**0.019***	−0.427	**0.019***
SAQ—expectation	−0.422	**0.02***	−0.495	**0.005***	−0.560	**0.001***	−0.390	**0.033***	−0.478	**0.008***	−0.249	0.185
SRS30—total	0.574	**0.001***	0.547	**0.002***	0.562	**0.001***	0.434	**0.016***	0.27	0.149	0.332	0.073
SRS30—pain	0.642	**<0.001***	0.505	**0.004***	0.535	**0.002***	0.415	**0.022***	0.175	0.355	0.349	0.058
SRS30—function	0.495	**0.005***	0.584	**0.001***	0.518	**0.003***	0.430	**0.018***	0.234	0.213	0.296	0.113
SRS30—mental health	0.274	0.143	0.183	0.333	0.262	0.162	0.264	0.159	0.194	0.305	0.021	0.912
SRS30—self image	0.459	**0.011***	0.514	**0.004***	0.543	**0.002***	0.386	**0.035***	0.048	0.801	0.160	0.397
SRS30—satisfaction	0.313	0.092	0.310	0.095	0.315	0.09	0.201	0.287	0.375	**0.041***	0.403	**0.027***

SAQ Spinal Appearance Questionnaire, *SRS-30* Scoliosis Research Society Questionnaire-30, *r* Pearson analysis correlation coefficient
*statistically significant: $p < 0.05$

trunk movements [5, 6]. Information on the reduction in spinal mobility after surgery is generally based on experience rather than evidence, and it can be difficult to estimate how much motion may be lost [19]. In the post-surgical period, patients may fear movement and avoid trunk movements, which may lead to more limitations in spinal functions.

In a case–control study with a 20-year follow-up after surgery, spinal range of motion was found to be significantly reduced in the surgical treatment group compared to healthy controls. In this study, it was reported that total fusion length is a factor that negatively affects mobility [20]. In another study evaluating both coronal and sagittal movements 10 years after surgery, it was determined that the range of motion was significantly reduced in both planes. It was reported that the decrease in spinal mobility was greater as the fusion level extended further distally [21]. When the total spinal range of motion measurements of our participants was compared with the reference values [15], it was observed that spinal movements were restricted in all three planes in the postoperative period. In this study, we did not group the cases according to upper or lower instrumented vertebrae; we only noted the fusion length and looked for correlation. In our study, fusion length adversely affected the range of motion in all directions except left lateral flexion.

Balance problems in individuals with AIS may result from incorrect postural alignment of the body caused by scoliotic curvature. However, the existing literature is not consistent in this regard, probably due to parameters such as the type, location, and severity of the curve [22]. In addition, vestibular system problems, which are responsible for postural control and body balance, are also mentioned in the etiology of idiopathic scoliosis [23]. Although there are studies in the literature that deal with sagittal and coronal plane balance, especially on radiography, after surgical correction, as far as we know, there is no study evaluating the effect of spinal range of motion on functional balance after surgery. In our study, except for left rotation, all spinal limitation of motion negatively affected functional balance. This involvement may be due to the loss of postural control caused by both the severe scoliotic curvature in the preoperative period and the limitation of movement after surgery.

Fan et al. reported that flexion and extension range of motion of the spine did not affect the quality of life in the postoperative period. However, the researchers stated that the score of the function subgroup of SRS-22 (the original short version of SRS-30) may reflect loss of motion after vertebral fusion [24]. Sanchez-Raya et al., on the other hand, concluded that the restriction, which decreases as the fusion level extends distally, reduces the quality of life and causes an increase in perceived pain [25]. Conversely, one study reported that quality of life was not affected, despite the reduction in ROM after surgery [26]. Danielsson and Nachemson, in their long-follow-up study of 23 years after fusion surgery, showed that longer fusion levels and functional limitation in individuals with AIS cause more pain and more extensive degenerative disc changes [27]. Ohashi et al. determined that the decrease in lateral flexion 10 years after surgery was effective in the SRS-22 total score, pain, function, and satisfaction domains. They attributed the fact that forward flexion did not affect the quality of life, to the possibility that the joints of the lower extremities compensated for this movement [21]. In our study, we found that the restriction in the sagittal and coronal planes negatively affected the quality of life. Only mental health and satisfaction levels were not related. This result may be due to the multifactorial nature of adolescents' mental health and related subjective perceptions. In addition, the extreme limits of the rotation movement may not have affected the quality of life since they are not used very often in daily life.

Cosmetic perception of trunk deformity is a major concern in patients with scoliosis. It has been reported that individuals with AIS have more negative feelings about their body appearance than healthy control [28]. Although this perception improves with surgical correction, sometimes unrealistic expectations, psychosocial status, and correction losses may cause the negative perception to continue or worsen. Misterka et al. reported that one out of every three patients desired to be flatter in the postoperative period, 29% of them were uncomfortable with the rib protrusion, and 24% with the shoulder levels [29]. In a study conducted 21–41 years after surgery, significant loss of function and lower appearance image were reported in patients with AIS compared to healthy controls [30]. However, these results are variables associated with subgroups of quality of life. In our study, the total scores of the perception of appearance were negatively affected by the limitation of movement in all three planes. It is seen that this score is mostly due to the results belonging to the expectation subgroup. According to this result, the emotions and expectations of our participants regarding their spine appearance may be due to the negative perception of movement restriction.

Conclusions

In adolescent idiopathic scoliosis, limitation of movement in the coronal, sagittal, and transverse planes is observed after fusion surgery. The spinal range of motion is affected by the level of fusion performed at the surgery. Postoperative spinal limitation of motion adversely affected functional balance, quality of life, and external appearance perception. We believe that holistic rehabilitation approaches that improve postoperative range of motion and increase functionality are important for optimal postoperative recovery.

Availability of data and material The data that support the findings of this study are available upon request from the authors.

Declarations

Competing interests The authors declare no competing interests.

Scientific responsibility statement The authors declare that they are responsible for the all processes related to the scientific content, planning, and writing of this research.

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