

Determination of the relationship between radiographic parameters and patient-reported outcomes in Lenke type-1 adolescent idiopathic scoliosis

Lenke tip-1 adolesan idiyopatik skolyozda radyografik parametreler ile hasta tarafından bildirilen sonuçlar arasındaki ilişkinin belirlenmesi

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Posted date:14.02.2023

Acceptance date:01.03.2023

Abstract

Purpose: This study aims to examine sagittal alignment and spinopelvic parameters in patients with surgically treated Lenke type-1 AIS and to determine the relationship between radiographic outcomes and body image, self-esteem, disability and anxiety.

Materials and methods: Twenty-five patients who underwent posterior spinal fusion surgery and followed up for more than 1 years were evaluated (mean age 14.20 ± 1.63 years). Radiographic analysis of A/P and lateral full spine standing radiographs was carried out with the Surgimap software. The patient-reported outcomes were evaluated with Walter Reed Visual Assessment Scale, Rosenberg Self-Esteem Scale, Oswestry Disability Index and Beck Anxiety Inventory. Correlations between deformity measures and patient-reported outcomes were evaluated by the Pearson's correlation test.

Results: There was a significant decrease in Cobb angle, AVT, trunk shift, T1 tilt and pelvic incidence at early postoperative and final follow up compared with the preoperative measurement ($p < 0.005$). Oswestry disability index was moderately negatively correlated with major curve Cobb angle ($r = -0.545$, $p = 0.007$), and moderately positively correlated with pelvic tilt ($r = 0.478$, $p = 0.021$). There was no significant correlation between all other radiographic and patient reported outcomes ($p > 0.05$).

Conclusion: Patient-reported outcomes are important in terms of evaluating the physical and psychosocial effects of scoliosis-related deformity from the patient's perspective. However, low or no correlation was found between radiographic evaluation and patient-reported outcomes. This result indicates that objective and patient-reported results should be interpreted separately.

Key words: Scoliosis, patient reported outcome measures, surgery.

Arik I, Buker N, Savkin R, Ok N, Kiter AE. Determination of the relationship between radiographic parameters and patient-reported outcomes in Lenke type-1 adolescent idiopathic scoliosis. Pam Med J 2023;16:368-375.

Öz

Amaç: Bu çalışma, cerrahi olarak tedavi edilen Lenke tip-1 AIS'li hastalarda sagittal dizilim ve spinopelvik parametreleri incelemeyi ve radyografik sonuçlar ile vücut imajı, benlik saygısı, disabilite ve anksiyete arasındaki ilişkiyi belirlemeyi amaçlamaktadır.

Gereç ve yöntem: Posterior spinal füzyon cerrahisi uygulanan ve 1 yıldan fazla takip edilen 25 hasta (ortalama yaş $14,20 \pm 1,63$ yıl) retrospektif olarak değerlendirildi. A/P ve tam lateral omurga ayakta radyografilerin radyografik analizi Surgimap yazılımı ile yapıldı. Hasta tarafından bildirilen sonuçlar Walter Reed Görsel Değerlendirme Skalası, Rosenberg Benlik Saygısı Ölçeği, Oswestry Disabilite İndeksi ve Beck Anksiyete Envanteri ile değerlendirildi. Deformite ölçümleri ile hasta tarafından bildirilen sonuçlar arasındaki korelasyonlar Pearson korelasyon testi ile incelendi.

Bulgular: Erken postoperatif ve son takip değerlendirmelerinde Cobb açısı, AVT, gövde kayması, T1 tilt ve pelvik insidansta ameliyat öncesi ölçüme göre anlamlı azalma vardı ($p < 0,005$). Oswestry disabilite indeksi, majör eğri Cobb açısı ile orta derecede negatif korelasyon ($r = -0,545$, $p = 0,007$), pelvik tilt ile orta derecede pozitif korelasyon gösterdi ($r = 0,478$, $p = 0,021$). Diğer tüm radyografik ve hasta tarafından bildirilen sonuçlar arasında anlamlı bir ilişki yoktu ($p > 0,05$).

Sonuç: Hasta tarafından bildirilen sonuçlar, skolyoza bağlı deformitenin fiziksel ve psikososyal etkilerinin hasta açısından değerlendirilmesi için önemlidir. Ancak, radyografik değerlendirme ile hasta tarafından bildirilen sonuçlar arasında düşük korelasyon bulundu veya hiç korelasyon bulunmadı. Bu sonuç, objektif ve hasta tarafından bildirilen sonuçların ayrı ayrı yorumlanması gerektiğini göstermektedir.

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Anahtar kelimeler: Skolyoz, hasta tarafından raporlanan sonuç ölçütleri, cerrahi.

Arik İ, Bükler N, Şavkın R, Ök N, Kırer AE. Lenke tip-1 adolesan idiyopatik skolyozda radyografik parametreler ile hasta tarafından bildirilen sonuçlar arasındaki ilişkinin belirlenmesi. Pam Tıp Derg 2023;16:368-375.

Introduction

Adolescent idiopathic scoliosis (AIS) is a three-dimensional spinal deformity that shows changes in the axial rotations of the vertebrae and pelvis in the coronal and sagittal planes, with a prevalence of 0.47-5.2% [1, 2]. The relationship between sagittal pelvic parameters and thoracic hypokyphosis and lumbar lordosis requires the evaluation of sagittal and spinopelvic parameters as well as coronal in AIS [3, 4].

In recent years, although remarkable advances have been made in the treatment of AIS in the correction of spinal deformity psychosocial problems may persist even after surgical correction [5, 6]. Quality of life can be affected by physical symptoms such as back pain, psychosocial problems such as low self-esteem and negative body image [7, 8]. Especially aesthetic concerns are given more importance nowadays than in the past decades [9]. Improvements in radiographic deformities, general cosmetic status, and self-perception of health of patients are expected to be closely related [10]. However, the finding of a poor correlation between the radiographic and self-reported findings is challenging in the sense that it leads to the misinterpretation of the physical and functional outcomes [11, 12].

A limited number of studies have investigated psychosocial variables such as body image, self-esteem, and anxiety in surgically treated AIS patients [13-15]. However, the relationship between radiographic and physical/psychosocial patient-reported variables has not been clarified yet. This study aims to examine sagittal alignment and spinopelvic parameters in patients with surgically treated Lenke type-1 AIS and to determine the relationship between radiographic outcomes and body image, self-esteem, disability and anxiety.

Materials and methods

Study design and participants

This single-center, retrospective cohort study carried out in a university hospital. Patients who

underwent surgery for AIS between 2008 and 2015 were screened. This study was approved by Pamukkale University, Non-Invasive Clinical Research Ethics Committee, and written informed consent was obtained from legal guardians.

The inclusion criteria were as follows: ages between 10 to 16, diagnosed with Lenke type-1 AIS, underwent posterior spinal fusion surgery by the same experienced orthopedic surgeon (AEK) and team, at least 1-year follow-up. Exclusion criteria were as follows: revision surgery, previous spinal infection, luminal pathologies as detected by magnetic resonance imaging, neurological, muscular, or rheumatic diseases, and lack of postoperative follow-up examinations.

In the present study, data of 71 patients with AIS were scanned through the hospital registry system. 46 patients were excluded from the study: Lenke type 2-6 (n=9), revision surgery (n=4), previous spinal infections (n=3), luminal pathologies as detected by magnetic resonance imaging (n=5), neurological, muscular, or rheumatic diseases (n=6), incomplete data (n=12), and inability to maintain contact because of a change in telephone number (n=7). The final study sample consisted of 25 patients.

Measurements

Data were obtained from the hospital information management system and patients' medical records. Demographic variables, clinical characteristics, and operative findings of the patients were recorded.

Radiological evaluations

All radiographic measurements (EIDOS 3000 Multifunctional Radiographic Unit Mecall s.r.l. X-Ray Equipment Lissone Milan-Italy) were analyzed using the image archiving and communication system and the measurements were performed using the Surgimap software (Nemaris Inc., New York, USA). Standing full-length anteroposterior and lateral radiographs were taken before surgery, early postoperative period and at the last follow-up. The coronal

Cobb angle, apical vertebral translation (AVT), trunk shift, T1 and L4 tilt, pelvic tilt, pelvic incidence, sacral slope, lumbar lordosis, thoracic kyphosis, sagittal and coronal balance were measured by the same investigator (IA).

Patient-reported outcomes

Walter Reed Visual Assessment Scale [16], Rosenberg Self-Esteem Scale [17], Oswestry Disability Index [18] and Beck Anxiety Inventory measurements [19], which were filled in at the last follow-up under the supervision of a physiotherapist (RS, NB), were obtained from patient records.

Walter Reed Visual Assessment The subjective perception of the deformity is evaluated with a group of figures representing the seven aspects of the deformity. Total score ranges from 0 to 35, with higher scores indicating maximum deformity [16].

The Rosenberg Self-Esteem Scale is a 10-item scale that measures overall feelings about self-esteem. Total score ranges from 0 to 30, with higher scores indicate higher self-esteem [17].

Oswestry Disability index is most widely used condition-specific outcome measures used in the assessment of spinal conditions. It consists of 10 items that examine how much the pain affects patients' ability to manage everyday life. The final score ranges from 0-100, and higher scores represents higher disability [18].

The Beck Anxiety Inventory measures the severity of anxiety symptoms and consists of 21 items. The total score ranges from 0 to 63, and higher scores indicate higher anxiety. Scores above 15 are considered a clinical cutoff and the scale interpreted as follows: minimal (1–5 points), mild (6–15), moderate (16–30) and severe (31–63) anxiety [19].

Statistical analysis

IBM SPSS Statistics for Windows version 24.0 software (IBM Corp., Armonk, NY, USA) was used for data analysis. Continuous variables were defined by mean±standard deviation, minimum and maximum values and categorical variable values as absolute numbers and percentages. Data distribution was evaluated using the Shapiro-Wilk test. Radiographic outcomes were evaluated by repeated-measures ANOVA. Relationship between the last follow up radiographic measurements and patient-reported outcomes were evaluated with Pearson's correlation coefficient. Statistical significance was set at $p \leq 0.05$.

Results

A total of 25 patients (24 female and 1 male; mean age 14.20 ± 1.63 years) participated in the study. The mean last follow-up period of the patients was 39.08 ± 19.88 months. Distribution of Risser stages was as follows: 6 patients were classified as having grade 1; 4 as grade 2, 4 as grade 3, 7 as grade 4 and 4 as grade 5 (Table 1).

Table 1. Demographic and clinical characteristics of the study group

	Mean±SD
Age (year)	14.20±1.63
Follow up (month)	39.08±19.88
	n (%)
Gender	
Female	24 (96)
Male	1 (4)
Risser stage	
1	6 (24)
2	4 (16)
3	4 (16)
4	7 (28)
5	4 (16)

SD, standard deviation, n, number; %, percent

Radiographic measurement outcomes are shown in Table 2. Cobb angle was 48.16 ± 9.21 before surgery, 13.08 ± 6.41 in the early postoperative period, 14.88 ± 4.96 at the last follow-up. There was a significant decrease in Cobb angle, AVT, trunk shift, T1 tilt and pelvic incidence at early postoperative and final follow up compared with the preoperative measurement ($p < 0.005$).

Patient-reported outcomes scores are presented in Table 3. Walter Reed Visual Assessment Scale score was 10.14 ± 3.15 , Rosenberg Self-esteem Scale was 41.74 ± 10.71 ,

Oswestry Functional Disability Scale was 9.61 ± 8.49 and Beck Anxiety Inventory was 10.32 ± 10.18 .

The relationship between the last follow-up radiographic measurements and patient-reported outcomes were presented in Table 4. Oswestry disability index was moderately negatively correlated with major curve Cobb angle ($r = -0.545$, $p = 0.007$), and moderately positively correlated with pelvic tilt ($r = 0.478$, $p = 0.021$). There was no significant correlation between all other radiographic and patient reported outcomes ($p > 0.05$) (Table 4).

Table 2. Radiographic measurement outcomes

	Before surgery	Early postoperative	Last follow-up	f	p value
Deformity measures					
Major curve Cobb angle (degree)	48.16±9.21	13.08±6.41	14.88±4.96	390.573	<0.001 ^{1-2, 1-3}
AVT (mm)	24.78±32.04	-1.57±13.11	-0.53±12.95	17.612	<0.001 ^{1-2, 1-3}
Trunk shift (cm)	6.70±17.97	-9.27±12.53	-8.54±9.61	15.233	0.001 ^{1-2, 1-3}
T1 tilt (degrees)	-0.32±5.87	2.92±4.05	3.47±4.08	7.891	0.001 ^{1-2, 1-3}
L4 tilt (degrees)	-4.55±9.23	-2.66±5.66	-3.43±6.84	1.189	0.307
Pelvic parameters					
Pelvic tilt	10.76±5.67	8.96±5.87	7.80±5.52	4.655	0.019 ¹⁻³
Pelvic incidence	48.24±8.96	45.28±7.29	44.08±7.59	8.787	0.002 ^{1-2, 1-3}
Sacral slope	37.48±5.13	35.88±4.91	36.32±4.71	3.230	0.052
Spinal parameters					
Lumbar lordosis (degrees)	47.30± 7.12	49.53±10.28	50.92±8.00	1.446	0.246
Thoracic kyphosis (degrees)	28.62±10.91	31.92±5.94	30.28±6.48	1.417	0.252
Sagittal balance (mm)	-25.53±27.00	-22.58±36.84	-31.25±35.84	0.509	0.605
Coronal balance (mm)	-10.51±16.79	-10.95±15.74	-8.90±12.40	0.192	0.826

AVT, apical vertebral translation; ¹⁻², Before surgery vs Early postoperative; ¹⁻³, Before surgery vs Last follow-up

Table 3. Patient-reported outcomes

	Patients (n=25)	
	Min-Max	Mean±SD
Walter Reed Visual Assessment Scale	7-16	10.14±3.15
Rosenberg Self-esteem Scale	8-30	20.87±5.35
Oswestry Functional Disability Scale	0-30	9.61±8.49
Beck Anxiety Inventory	0-34	10.32±10.18

AVT, apical vertebral translation

Table 4. Relationship between the last follow up radiographic measurements and patient-reported outcomes

	Walter Reed visual assessment scale		Rosenberg self-esteem scale		Oswestry disability index		Beck anxiety inventory	
	r	p	r	p	r	p	r	p
Deformity measures								
Major curve Cobb angle (degrees)	0.219	0.328	0.267	0.219	-0.545	0.007	-0.285	0.198
AVT (mm)	0.238	0.285	-0.097	0.661	-0.067	0.761	-0.105	0.641
Trunk shift (cm)	-0.059	0.793	0.026	0.905	0.229	0.292	0.002	0.993
T1 tilt (degrees)	0.085	0.706	-0.116	0.599	0.068	0.760	-0.065	0.774
L4 tilt (degrees)	-0.015	0.947	0.069	0.756	-0.221	0.311	-0.197	0.378
Pelvic parameters								
Pelvic tilt	0.249	0.263	-0.077	0.726	0.478	0.021	0.045	0.842
Pelvic incidence	-0.016	0.945	-0.027	0.902	0.380	0.074	0.067	0.767
Sacral slope	-0.288	0.194	0.001	0.995	0.068	0.758	0.057	0.801
Spinal parameters								
Lumbar lordosis (degrees)	-0.139	0.538	0.091	0.681	0.036	0.871	-0.004	0.988
Thoracic kyphosis (degrees)	-0.010	0.966	0.085	0.700	-0.201	0.357	0.087	0.700
Sagittal balance (mm)	-0.025	0.911	0.053	0.811	0.201	0.359	0.028	0.901
Coronal balance (mm)	0.222	0.320	-0.125	0.570	0.077	0.727	-0.004	0.986

AVT, apical vertebral translation

Discussion

This study was planned to examine the sagittal alignment and spinopelvic parameters in patients with surgically treated Lenke type-1 AIS and to determine the relationship between radiographic and patient-reported outcomes. A significant improvement was found in Cobb angle, AVT, trunk deviation, T1 and L4 tilt, pelvic incidence in the early postoperative and last follow-up. Although there was a moderate relationship between the Oswestry disability index and Cobb angle and pelvic tilt at the last follow-up, there was no significant relationship between all other radiographic measurements and body image, self-esteem, disability, and anxiety outcomes.

The spine is a complex structure that is balanced by multiple forces in the sagittal and coronal vertical axis, and proper alignment of the spine and pelvis, including appropriate physiological sagittal curves, is important to maintain as stable posture and balance as possible [20, 21]. Surgical correction aims to correct postural imbalances in the coronal and sagittal planes. Understanding spinopelvic parameters in AIS is important for preoperative planning and minimizing degenerative changes in the long term [21]. In this study, we found that the mean of the main curve Cobb thoracic angle decreased by 33.28 at the last follow-up

compared to the preoperative period, and from mean of pelvic parameter there is a decrease of pelvic tilt by 2.96, of pelvic incidence by 4.16 and of sacral slope by 1.16.

Low self-esteem and deterioration in perceived body image are often associated with physical disorders and can have emotional and psychological effects in individuals [22]. In particular, patients with AIS tend to worry that their bodies will become more and more different from normal/ordinary individuals as the disease progresses. In addition, factors such as dissatisfaction with physical appearance, low body image, lack of self-confidence, pessimism, anxiety may cause deterioration in social adaptability and isolation [23]. Corrective surgeries can improve body image, self-esteem, life satisfaction and quality of life in patients with AIS [23-26]. We found that patients with Lenke type-1 AIS had good perceived body image, high self-esteem, and mild anxiety after surgical correction. This may be due to the improvement in the physical appearance of the patients with an average 3-year follow-up, resulting in an increase in their ability to tolerate and manage psychosocial stressors. In the early period of AIS surgery, there may be a decrease in the tendency to participate in physical activity due to fear of injury [27]. However, we found that patients had minimal disability in the late

postoperative period. A detailed examination of the Oswestry disability index scores revealed that only 3 patients (12%) had moderate disability. All the other patients were at a level at which no treatment was indicated except for the recommendations to lifting, sitting and exercise. Our study results revealed that back pain after scoliosis surgery can generally be mild and may not cause disability in most patients.

The primary clinical assessment and management of AIS is based on radiographic measurements. In recent years, disease-specific and patient-reported outcomes have become an important tool to measure the impact of scoliosis on patient health. However, questionnaires developed to assess patients' subjective perceptions of their spinal deformities had low or no correlation with radiological findings [12, 28-31]. In our study, except for a moderate relationship between Oswestry disability index and Cobb angle and pelvic tilt, there was no significant relationship between all other radiographic measurements and patient-reported scales. Therefore, we think that radiographic and clinical outcome data should be analyzed and interpreted separately when evaluating postoperative outcomes.

Some limitations might be considered when interpreting the findings of this study. The small number of patients in this retrospective study may have resulted in low statistical significance. Due to the lack of preoperative patient-reported outcomes, we could not determine the effect of surgery on these outcomes. Another limitation was that the study results could not be generalized to other curve patterns. Further studies can be performed in a larger sample with different curve patterns and preoperative measurements. Since the main purpose of surgery is to correct curvature and restore spinal balance, surgeons tend to evaluate clinical results radiologically. However, our study results showed low or no correlation between self-reported outcomes such as adolescent body image, self-esteem, disability, and anxiety, and radiographic outcomes. In this sense, it can be a guide in terms of revealing the necessity of comprehensive clinical evaluation after surgery in patients with AIS.

In conclusion, significant improvements were detected in the postoperative radiographic evaluation of patients with Lenke type 1 AIS who underwent posterior corrective surgery. However, low or no correlation was found between radiographic evaluation and patient-reported outcomes. Patient-reported outcomes are important in terms of evaluating the physical and psychosocial effects of scoliosis-related deformity from the patient's perspective. However, the lack of correlation with radiographic data indicates that the results should be interpreted separately.

Conflict of interest: No conflict of interest was declared by the authors.

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Ethics committee approval: This study was approved by Pamukkale University, Non-Invasive Clinical Research Ethics Committee with the decision numbered 60116787-020/13061 on 16.08.2016.

Authors' contributions

Surgical and Medical Practices: I.A., N.O. and A.E.K., Concept: I.A., N.B., R.S., N.O. and A.E.K., Design: I.A., N.B., N.O. and A.E.K., Data Collection or Processing: I.A. and R.S., Analysis or Interpretation: I.A., N.B., R.S. and A.E.K., Literature Search: I.A., N.B., R.S. and N.O., Writing: I.A., N.B. and R.S.