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ORIGINAL INVESTIGATION / ÖZGÜN ARAŞTIRMA

Does the Choice of the Growth Potential Classification Affect the Non-surgical Treatment of the Adolescent Idiopathic Scoliosis?

Büyüme Potansiyelini Değerlendiren Sınıflandırma Seçimi Cerrahi Dışı Tedavi Edilen Adölosan İdiyopatik Skolyozluların Tedavisini Etkiler mi?

Ahmet Onur Akpolat[1], Onur Gültekin[1], Bekir Eray Kılınç[1], Ahmet Kocabıyık[1], Erkan Akgün[2], Esin Derin Çiçek[3], Mehmet Bülent Balioğlu[1]

[1]University of Health Sciences Turkey, Fatih Sultan Mehmet Training and Research Hospital, Clinic of Orthopaedics Surgery and Traumatology, İstanbul, Turkey
[2]Pursaklar Goverment Hospital, Ankara, Turkey
[3]University of Health Sciences Turkey, Fatih Sultan Mehmet Training and Research Hospital, Clinic of Radiology, İstanbul, Turkey

ABSTRACT

Objective: This study aimed to determine the progression parameters effect for miscorrelation between the Risser sign and the Sanders classification and the accuracy of the determined level of the skeletal maturation in patients with adolescent idiopathic scoliosis (AIS).

Method: Patients with AIS who were followed up with non-surgical treatment between March 2018 and August 2020 were included in the study. The parameters taken into consideration were age, sex, weight, height, body mass index percentile, menarche status in females, Risser sign and Sanders classifications stages, major Cobb angle, location of the apex of the major curve, and correlation of the Risser sign toward the Sanders classification.

Results: In total, 205 [126 (75.9%) females and 76 (24.1%) males] participants were included in the study. The rate of incorrect staging was 17.3% for the Risser sign toward the Sanders classification. Females were at a higher risk than males ($p < 0.05$). Patients who did not have their first menarche had a higher risk of miscorrelation for the Risser sign and Sanders classification ($p < 0.05$). Interobserver correlations were determined as A substantial correlation for the Risser sign and almost perfect correlation for Sanders classification (Risser $\kappa = 0.76$, Sanders $\kappa = 0.93$).

Conclusion: Miscorrelation of the two major growth potential classification systems should be considered to plan better non-surgical treatment.

Keywords: Adolescent idiopathic scoliosis, growth potential, risser sign, sanders classification, correlation

ÖZ

Amaç: Bu çalışmanın amacı, adölosan idiyopatik skolyoz (AİS) hastalarında Risser işareti ile Sanders sınıflandırması arasındaki uyumsuzluğun ilerleme parametrelerine olan etkisini ve iskelet olgunlaşma düzeyinin doğruluğunu belirlemektir.

Yöntem: Çalışmaya 2018 Mart ile 2020 Ağustos tarihleri arasında cerrahi dışı takip edilen AİS'li hastalar dahil edildi. Değerlendirme parametreleri yaş, cinsiyet, kilo, boy, vücut kitle indeksi, kadınlar için menarj durumu, Risser İşareti ve Sanders sınıflamasındaki evresi, majör cobb açısı, majör eğriliğin lokalizasyonu ve Risser işareti ile Sanders sınıflandırması arasındaki korelasyondur.

Bulgular: Çalışmaya 205 [126 (%75,9) kadın, 76 (%24,1) erkek] katılımcı dahil edildi. Risser İşareti ile Sanders sınıflamasın arasında ki korelasyona uymayan hasta oranı %17,3, olarak saptandı. Kadınlarda ve adet görmemiş kişilerde sınıflandırmalar arasında uyuşmazlık oranının daha yüksek düzeyde olduğu saptandı ($p < 0,05$). Gözlemciler arası korelasyon Risser İşareti için yüksek, Sander sınıflaması için neredeyse mükemmel olarak saptandı (Risser $\kappa = 0,76$, Sanders $\kappa = 0,93$)

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Address for Correspondence/Yazışma Adresi: Ahmet Onur Akpolat, University of Health Sciences Turkey, Fatih Sultan Mehmet Training and Research Hospital, Clinic of Orthopaedics Surgery and Traumatology, İstanbul, Turkey
E-mail: onurakpolat@hotmail.com **ORCID ID:** orcid.org/0000-0001-7773-5476

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Sonuç: Cerrahi dışı tedavi daha iyi planlamak için iki majör büyüme potansiyel sınıflama sistemin uyumsuzlukları dikkate alınmalıdır.

Anahtar kelimeler: Adölesan idiyopatik skolyoz, büyüme potansiyeli, risser işareti, sanders sınıflaması, korelasyon

INTRODUCTION

There is a close relationship between the growth potential and curvature progression in adolescent idiopathic scoliosis (AIS) [1]. Therefore, it is crucial to determine the growth potential, especially in planning the treatment of AIS [2,3]. Skeletal maturation classifications were prepared based on ossification centers [4-6] to determine the growth potential. The most popular systems to assess the growth potential are the Risser sign and Sanders classifications [5,6]. The Risser sign evaluates the development of the ossification center of the iliac crest apophysis in five stages [5]. By contrast, Sanders classification divides it into the eight phases according to the development of ossification centers in the metacarpals and phalanges [6].

In the literature, the miscorrelation between the Risser sign and Sanders classification patients with AIS was reported in a study only [7]. However, in that study, the other parameters of progression in patients with AIS were not evaluated [7].

Our hypothesis is the miscorrelation of the two-classification system may result in a false prediction of the growth potential of AIS to plan the correct treatment. These parameters should be taken into consideration to predict the curve progression.

The purpose of this study was to determine the progression parameters effect for miscorrelation between the Risser sign and the Sanders classification, the interobserver reliability of both classifications, and the accuracy of determining the level of skeletal maturation in patients with AIS that planned for the treatment.

METHOD

This retrospective and the single-center study were performed at Orthopedics and Traumatology clinic between March 2018 and August 2020. It was approved by the institutional review board (IRB number: 2019/4408) and was performed incongruent with the ethical principles of the Declaration of Helsinki. After approval of the IRB, informed consent was obtained from the guardians of all participants.

The study included patients with AIS aged 10-16 years who were within the limits of non-surgical treatment. The exclusion criteria of the study were history of the previous spine or hip surgery, congenital or syndromic concomitant disease, dental braces, non-idiopathic scoliosis, presence of malignancy or history of malignancy, presence of a metabolic or endocrinological disease, previous pelvic and hand injury, accompanying kyphosis deformity, and the time between scoliosis and hand radiography being longer than 4 weeks.

Age, sex, weight, height, body mass index (BMI) percentile (< 18.5, 18-24.9, and ≥ 25), menarche status in females (none, last 12 months, and >12 months), major Cobb angle, location of the apex of the major curve (thoracic, thoracolumbar junction, or lumbar), and correlation of Risser sign toward the Sanders classification of the patients were evaluated. The Risser-Sanders correlation scale developed by Vira et al. [8] was used to determine a false stage (Table 1) (Figure 1A, B, Figure 2A, B).

In the present study, the Risser sign and Sanders classification stages and major Cobb angles were determined by a senior author (> 25 years of specialized experience), a radiologist specialized in musculoskeletal conditions (> 15 years of specialized experience), an orthopedics and traumatology surgeon (> 5 years of experience), and a fellowship-trained spine surgeon (> 7 years of specialized experience).

The recorded evaluation parameters and the data obtained from the measurements were evaluated for statistical significance. In addition, the correlation and miscorrelation between the two-classification systems were further analyzed statistically.

Statistical Analysis

Descriptive statistics were presented with mean ± standard deviation values. The Kappa test was conducted to examine the consistency of the evaluation levels of four different evaluators in the study (0.01-0.20 as slight correlation, 0.21-0.40 as fair correlation, 0.41-0.60 as moderate correlation, 0.61-0.80 as substantial correlation, and 0.81-1.00 as almost perfect correlation). The chi-square and t-test were performed to examine the differences in patient characteristics according to the correlation level. In addition, repeated analysis of variance was used to analyze the evaluations of the evaluators among themselves. P values of < 0.05 were considered significant. SPSS version 25.0 was used for analysis.

Table 1. Correlation of sanders and risser stage during phases of bone growth			
Sanders stage	**Radiographic features**	**Risser stage**	**Radiographic features**
Juvenile slow (1)	Digital epiphyses are not covered	0	No ossification of the apophysis
Preadolescent slow (2)	All digital epiphyses are covered	0	No ossification of the apophysis
Adolescent rapid (early) (3)	Most digits are capped. 2nd-5th MC epiphyses are wider than metaphyses	0	Triradiate cartilage open (peak height velocity)
Adolescent rapid (late) (4)	Any of distal phalangeal physes are clearly beginning to close	0	Triradiate cartilage remains (open growth plates in the long bones)
Adolescent steady (early) (5)	All distal phalangeal physes are closed, while others are open	0	Triradiate cartilage closed (menarche in female patients)
Adolescent steady (late) (6)	Middle or proximal phalangeal physes are closing	≥1	Ossification of the iliac apophysis ranges from 25% to 75%
Early mature (7)	Only distal radial physis is open. MC physeal scars may be present	4	100% ossification of the iliac wing, with no fusion to iliac crest
Mature (8)	Distal radial physis is completely closed	5	Fusion of the iliac apophysis to the iliac crest (cessation of growth)

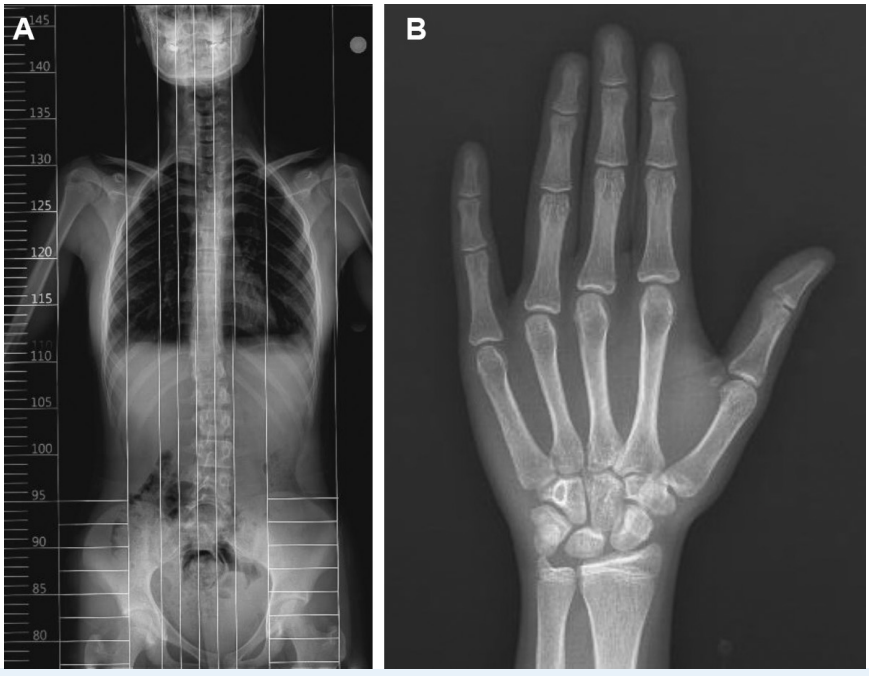

Figure 1A, B. Example of skeletal maturity mismatch between RS and SC: Risser 1 corresponding to Sanders 7

RESULTS

The sample size of patients included in the study provided a sampling power of 0.90. A total of 205 [126 (75.9%) females and 76 (24.1%) males] participants were included. The mean age was 13.81 ± 1.85 years. The demographic characteristics of the participants WAS detailed in Table 2.

The rate of incorrect staging was 17.3% between the Risser sign and Sanders classification stages. Age, height, weight, BMI, major curve angle, and apex location of the major curve were not associated with the miscorrelation of the Risser sign and Sanders classification stages. Females were at a higher risk of Risser sign and Sanders classification stage miscorrelation than males (17.3% vs. 9.6%; $p < 0.05$). In addition, patients who did not have their first menarche had a higher risk for miscorrelation of Risser sign and Sanders classification stage (36.1%, 19.1% vs. 18.6%; $p < 0.05$).

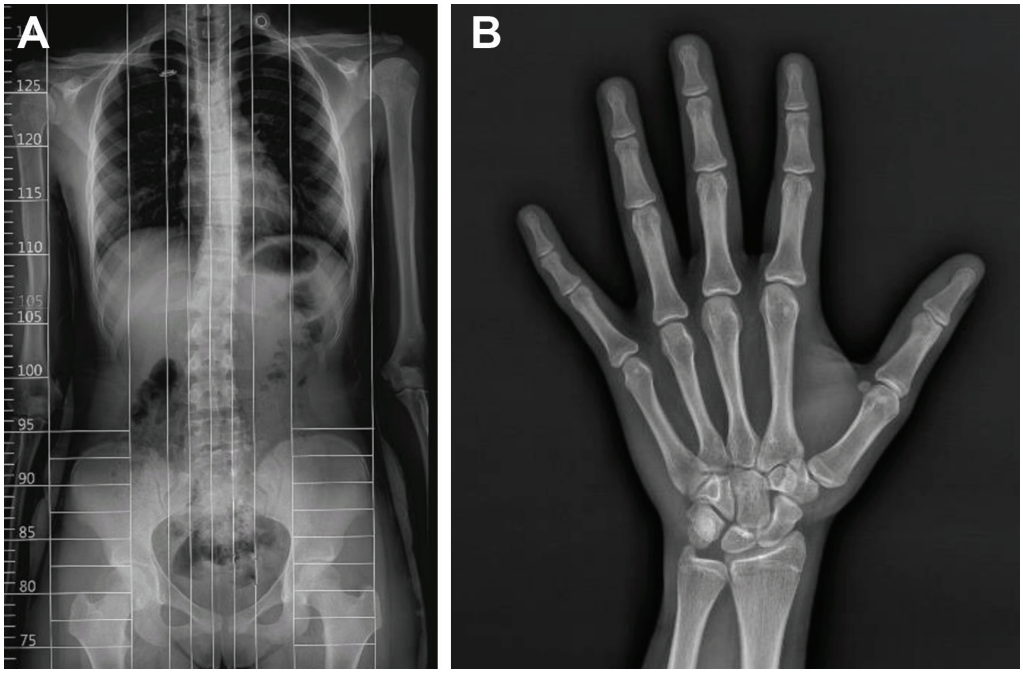

Figure 2A, B. Example of skeletal maturity match between RS and SC: Risser 4 corresponding to Sanders 7

Table 2. The demographic characteristics of the participants

		n (%)	Mean ± SD
Age			13.81 ± 1.85
Gender	Female	126 (75.9%)	
	Male	79 (24.1%)	
Height (cm)			161.97 ± 10.47
Weight (kg)			51.77 ±11.42
BMI			19.55 ± 3.03
BMI	< 18.5	41 (20.1%)	
	18.5-24.9	135 (65.8%)	
	>25	29 (14.1%)	
Menarche	None	72 (35.1%)	
	Last 12 month	68 (33.1%)	
	>12 ay	65 (31.7%)	
Major cobb			23.91 ± 11.42
Apex location of the major curve	Thoracic vertebrae (T1-T10)	91 (44.3%)	
	Thoracolumbar junction (T11-L1)	51 (24.8%)	
	Lumbar (L2-5) vertebrae	63 (30.8%)	

BMI: Body mass index, SD: Standard deviation

Interobserver correlations were determined as a substantial correlation for the Risser sign and an almost perfect correlation for Sanders classification (Risser K = 0.76, Sanders K = 0.93). In addition, the interobserver correlation of the Major Cobb angle was almost perfect (K = 0.89).

DISCUSSION

Our study reported a statistically significant difference between the two-growth maturation classification system that may occur in the false prediction of the treatment of the AIS patients.

Each classification developed to determine growth potential has its shortcomings. Risser sign [5], one of the first classifications, is still widely used in planning follow-up and treatment of AIS [9]. However, it also has serious limitations. First, it cannot distinguish the vast area of skeletal immaturity, consisting of periods before, during, and after peak growth velocity. Second, patients at each stage presumably have a different risk for curve progression [10,11]. Other shortcomings include that the Risser sign stage may change depending on the direction of the radiological image taken (anterior-posterior or posterior-anterior) [12] and differs between Europe and America [13,14]. The most important shortcoming of the Sanders classification is a longer learning curve [8,15].

When we considered studies evaluating the interobserver correlation between the Risser sign and Sanders classification in patients with AIS, Vira et al. [8] reported that both classifications had a moderate level of interobserver correlation and that the Sanders classification was more reliable. While Hammond et al. [16] reported that the interobserver correlation of the Risser sign was moderate, Sanders et al. [6] reported that the interobserver correlation of the Sanders classification they developed was considerably high. In all studies on the major Cobb angle, it was reported that the interobserver correlation is at a very high level [17-20]. Our study reported that our interobserver correlation was high, and our outcomes were accurate and are consistent with the literature.

There is a study in the literature that evaluates the correlation between the Risser sign and Sanders classifications. In their study, Minkara et al. [7] evaluated 165 patients with AIS. They were followed up non-surgically and showed that the male sex was in the risk group in correlation between classifications. Notably, our study showed that the risk group for correlation between Risser sign and Sanders classification was not the same.

Many studies in the literature have determined that the degree of the curvature at the time of diagnosis. Female sex, localization of the curvature (double curves and thoracic curve) [21,22] pre-menarche period, excess growth potential, and low skeletal maturation are risk factors in terms of the progression of the curvature [15,23,24]. In our study, the female sex and the pre-menarche period were risk factors in misinterpretation, indicating that more care should be taken in evaluating this patient group.

Study Limitations

There are some limitations to our study. First, this study was retrospective in nature. Although experienced evaluators were included in the study, the difference in experience could affect the results. Another limitation was that no control group was included in the study; however, this is not possible in practice.

CONCLUSION

Despite the miscorrelation of the growth potential classification system, evaluating more parameters to determine the growth potential of the patients with AIS may provide better planning of the non-surgical treatment.

Ethics Committee Approval: It was approved by the institutional review board (IRB number: 2019/4408) and was performed incongruent with the ethical principles of the Declaration of Helsinki.

Informed Consent: After approval of the IRB, informed consent was obtained from the guardians of all participants.

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

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Hasta Onayı: IRB'nin onayından sonra, tüm katılımcıların velilerinden bilgilendirilmiş onam alındı.

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