ARAŞTIRMA MAKALESİ / *RESEARCH ARTICLE*

Sacroiliac Joint Variations on Magnetic Resonance Imaging in Patients with Low Back Pain

Bel Ağrısı Olan Hastalarda Manyetik Rezonans Görüntülemede Sakroiliak Eklem Varyasyonları

Aysu Basak Ozbalci

Department of Radiology, Ondokuz Mayıs University Faculty of Medicine, Samsun, Türkiye

ABSTRACT

Aim: *To investigate the frequency of anatomical variations on the sacroiliac joint (SIJ) and reveal their clinical importance by distinguishing the findings that mimic sacroiliitis in patients referred to magnetic resonance imaging (MRI) for low back pain.*

Material and Method: *This retrospective study included all SIJ MRI examinations performed in our hospital with patients ≥18 and <65 years of age for 24 months. According to the Assessment of Spondyloarthritis International Society (ASAS) criteria, data collection consisted of the patients' age at the imaging time, gender, and the presence of active and chronic sacroiliitis. Lumbosacral transitional vertebra (LSTV) was classified according to the Castellvi classification system. Moreover, all images were assessed for the presence of major sacroiliac joint variations described in the literature. Structural and edematous changes were also noted.*

Results: *1020 MRI examinations were included, and SIJ variations were identified in 323 of them. The frequency order of anatomical variants of SIJs are as follows: 1) LSTV (114 patients, 12.2%), 2) Accessory sacroiliac joint (80 patients, 7.8%), 3) Iliosacral complex (66 patients, 6.4%), 4) Sacral defect (61 patients, 5.9%), and 5) Isolated synostosis (2 patients, 0.2%). Structural and edematous findings were frequently observed in LSTV and accessory SIJ.*

Conclusion: *We conclude that the lumbosacral transition segments and various anatomical SIJ variations are common in the low back pain population, especially in women. Moreover, these variations may be associated with degenerative and edematous signal intensity changes that mimic sacroiliitis.*

Key words: *magnetic resonance imaging; sacroiliac joint; anatomy; low back pain*

ÖZET

Amaç: *Bu çalışmada, bel ağrısı nedeniyle Manyetik Rezonans Görüntüleme (MRG)'ye başvuran hastalarda sakroiliyak eklemin (SİE) anatomik varyasyonlarının sıklığını araştırmak ve sakroiliiti taklit eden bulguları ayırt ederek klinik önemini ortaya koymak amaçlanmıştır.*

Materyal ve Metot: *Çalışmamızda, 24 ay boyunca ≥18 ve <65 yaş arasındaki tüm olguların SIE MRG'leri retrospektif olarak değerlendirildi. Uluslararası Spondiloartrit Değerlendirmesi Derneği (ASAS) kriterlerine göre olguların verileri, görüntüleme sırasındaki yaşı, cinsiyeti, aktif ve kronik sakroiliit varlığı açısından analiz edildi. Tüm görüntüler Lumbosakral transizyonel vertebra (LSTV) varlığı ve major sakroiliak eklem varyasyonları açısından Castellvi sınıflandırma sistemi ile literatürde belirtilen kriterlere göre kategorize edilerek bu varyasyonlara eşlik eden yapısal ve ödematöz değişiklikler kaydedildi.*

Bulgular: *Çalışmaya dahil edilen 1020 MRG'nin 323'ünde SİE varyasyonları tespit edildi. SİE'lerin anatomik varyasyonlarının sıklık sırası şu şekildedir: 1) LSTV (114 hasta, %12,2), 2) Aksesuar sakroiliak eklem (80 hasta, %7,8), 3) İliyosakral kompleks (66 hasta, %6,4), 4) Sakral defekt (61 hasta, %5,9) ve 5) İzole sinostoz (2 hasta, %0,2). Ayrıca LSTV ve aksesuar SİE varyasyonuna, yapısal ve ödematöz bulgular sıklıkla eşlik ediyordu.*

Sonuç: *Bel ağrısı şikayeti ile başvuran ve SİE MRG planlanan özellikle kadın hastalarda, lumbosakral transizyonel vertebra ve sakroiliak eklem anatomik varyasyonları sıklıkla karşımıza çıkmaktadır. Ayrıca bu varyasyonlar, sakroiliiti taklit eden dejeneratif ve ödematöz sinyal değişikliklerine de yol açabileceğinden her zaman göz önünde bulundurulmalıdır.*

Anahtar kelimeler: *manyetik rezonans görüntüleme; sakroiliak eklem; anatomi; bel ağrısı*

Introduction

Spondyloarthritis (SpA) refers to a group of chronic inflammatory rheumatic diseases characterized by enthesitis and arthritis that commonly affect the axial skeleton[1–3]. Sacroiliac joint (SIJ) involvement in imaging (sacroiliitis) is part of the diagnostic algorithm for axial SpA, and it has been a crucial criterion according to the Assessment of Spondyloarthritis International Society (ASAS) classification since 2009[4]. Therefore, the SIJ's magnetic resonance

İletişim/Contact: *Aysu Başak Özbalcı, Ondokuz Mayıs University Faculty of Medicine, Department of Radiology, 55139 Samsun, Türkiye* • ***Tel:*** *0362 312 19 19* • ***E-mail:*** *aysu.basak@yahoo.com* • ***Geliş/Received:*** *12.11.2021* • ***Kabul/Accepted:*** *07.05.2022*

ORCID: *Aysu Başak Özbalcı, 0000-0001-9974-5974*

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imaging (MRI) has become the preferred imaging method because it reveals active inflammatory lesions in the early period before radiographic findings begin.

Although MRI is increasingly used to diagnose inflammatory back pain such as SpA and nonspecific low back pain (LBP), there are some uncertainties regarding the diagnostic value of degenerative and SpA-related MRI findings[5,6]. Therefore, more research is needed to expand the knowledge of pathoanatomical changes seen in MRI and to increase diagnostic accuracy in LBP.

However, in clinical practice, anatomical variations involving the ligamentous and cartilaginous parts of the SIJ make it challenging to evaluate. In SIJ MRI, findings such as bone marrow edema (BME) and sclerosis, which are signs of sacroiliitis, are also encountered in normal anatomical variations and degenerative processes. These variations and associated changes have previously been identified in some CT and MRI studies[7–11]. However, we believe they have not yet been studied in MRI with a large patient population.

Therefore, the primary purpose of this study is to investigate the frequency of normal anatomical variations and to reveal their importance by distinguishing the findings that mimic sacroiliitis in patients referred to MRI for LBP.

Materials and Methods

All consecutive MRI examinations of the SIJ patients aged 18–65 years performed due to LBP in our institution, a tertiary medical center, were evaluated between January 2018 and December 2019. One thousand three hundred and seventy (1370) consecutive MRI examinations were performed during the study period. Among those, we excluded patients with poor image quality and a history of metastasis, bone tumor, septic arthritis, or surgery. We also excluded patients whose information (such as age, gender, and final diagnosis before or after the MRI examination) could not be accessed. Consequently, 1020 patients (mean age 40.51±11.94, range 18–65) were enrolled in the study. There were 735 women (72.1%) and 285 men (27.9%).

Our study used classical sequences – paracoronal T1-weighted (T1W), short tau inversion recovery (STIR) images, and axial STIR images – for the SIJ scanning protocol. After intravenous gadolinium (Gd) contrast administration, the examination with contrast-enhanced (CE), fat-saturated axial, and paracoronal T1W sequences is completed. Examinations were conducted with the patient in the supine position using 1.5T or 3T magnets from manufacturers that use high-resolution body phased-array coil.

An experienced musculoskeletal radiologist reviewed all images. The images were assessed for the presence of structural and active sacroiliitis findings befitting the ASAS definition[4]. The morphologic features of sacroiliitis were assessed on axial STIR images and T1-weighted, fat-saturated images after administration of contrast material. At least two different locations of the SIJ of a characteristic BME must be identified to diagnose axial SpA. In the case of unilocular BME, this finding had to be present in at least two consecutive slices to meet the diagnostic criteria for axial SpA.

Major SIJ variations evaluated in addition to sacroiliitis according to the criteria described in the literature[12] are as follows:

- Accessory Sacroiliac Joint: A false joint between the sacral and iliac components, usually located at the S2 level in the dorsal part of the true synovial.
- Iliosacral Complex: An iliac protrusion placed in a complementary sacral recess in the posterolateral portion of the SIJ from the first sacral foramen level to the second sacral foramen.
- Sacral Defect: A round sacral defect in the posterior part of the sacrum unrelated to the presence of the opposite iliac defect in the axial plane.
- Transitional Vertebra: LSTV evaluation was based on the iliolumbar ligament, and the ligament-adherent vertebra was considered L5. Patients with and without dysplasia in the transverse process were classified according to the Castellvi radiographic classification system[13].

Laterality (unilateral or bilateral), associated structural and edematous changes in the bony surfaces, and the accompanying vascular structures to these variations were evaluated when one of the previous variations was observed.

The study data were evaluated using SPSS for Windows 15.0 software (SPSS Inc. Chicago, IL). The conformity of the variables to normal distribution was assessed visually (histogram and possibility graphs) and with analytical methods (Kolmogorov-Smirnov/Shapiro-Wilks tests). The Chi-square test (Fisher's Exact test) and Student's t-test were used for values conforming to the normal distribution. However, for values not conforming to the normal distribution, the Mann-Whitney U test $p<0.05$ was considered significant.

Results

Of 1020 patients, 88 had active sacroiliitis, 56 had chronic sacroiliitis, and 42 had signs of active and chronic sacroiliitis. We detected anatomical variation in 323 of 1020 patients who had SIJ MRI. The frequency order of anatomical variants of SIJs are as follows: 1) LSTV (114 patients, 12.2%), 2) Accessory sacroiliac joint (80 patients, 7.8%), 3) Iliosacral complex (66 patients, 6.4%) 4) Sacral defect (61 patients, 5.9%), and 5) Isolated synostosis (2 patients, 0.2%) (Table 1).

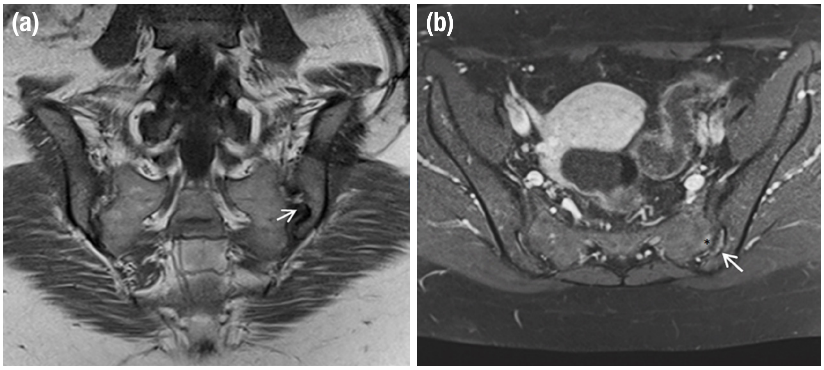

Figure 1. a, b. *Left accessory SIJ (arrows) was observed on paracoronal T1-weighted **(a)** and contrast-enhanced fat-saturated T1-weighted **(b)** axial images. Bone marrow edema at the sacral side and minimal sclerosis were seen in the left SIJ (asterisk).*

One hundred fourteen patients, 90 (78.9%) female, and 24 (21.0%) male, were classified as positive for LSTV. According to sacralisation classification, the most common anatomical variant was Castellvi Type Ia (3.8%), followed by Type Ib (2.5%). There were no statistically significant differences between men and women who had LSTV (p: 0.986). In addition, there was no significant correlation between the transitional vertebra and active or chronic sacroiliitis (p: 0.471).

Accessory SIJ was the second most common anatomical variant identified in 80 (12.2%) patients, 48 (60%) unilateral, and 32 (40%) bilateral. The joint is between the iliac and the sacral articular surfaces at the posterior portion of the SIJ, from the first to the second sacral foramen (Fig. 1). Accessory SIJ was also best detected in axial images, while LSTV and iliosacral complex were best seen in coronal images. Sacral defects were visualized in both axial and coronal images. Isolated synostosis was observed in only two of our cases, which were visualized in both axial and coronal images.

Thirty-two of 80 patients with accessory SIJ, 31 of 61 patients with sacral defects, and 37 of 66 patients with iliosacral complexes were bilateral. Bilateral status did not have a significant relationship with gender.

All the variations were more common in women but were not statistically significant compared with the male group. Only the incidence of sacral defects was significantly higher in males (p: 0.001) (Table 2).

Structural signal intensity changes – including subchondral sclerosis, subchondral cysts, osteophytes, and fatty deposition – were depicted in patients with LSTV and accessory SIJ. The most common structural signal intensities we detected were subchondral cysts and fatty deposits, as in 25 of 114 LSTV patients and 16 of 80 accessory SIJ patients.

We observed BME in 20 of 80 patients with accessory SIJ and 7 of 114 patients with LSTV (Fig. 2). However, compared with the association of sacroiliitis, there were no significant relationships (Table 3). Among the LSTV subgroups, the most common subgroup we observed with BME was Type 2a.

Table 1. *SIJ anatomical variations: prevalence, laterality, and associated changes*

	Variations (n: 323)	Laterality (n: 150)	BME (n: 27)	Structural changes (n: 41)	Prominent vascular (n: 52)
LSTV	114 (12.2%)	50 (33.3%)	7 (25.9%)	25 (60.1%)	0
Accesory SIJ	80 (7.8%)	32 (21.3%)	20 (74.1%)	16 (39.0%)	0
Iliosacral complex	66 (6.4%)	37 (24.6%)	0	0	20 (38.5%)
Sacral defect	61 (5.9%)	31 (20.6%)	0	0	32 (61.5%)
Synostosis	2 (0.2%)	0	0	0	0

Table 2. *Comparison of sacroiliac joint variations according to gender and age*

		Sex		Age	
		Female (%)	p^1	Median (Q1-Q3)	p^2
LSTV	+ (n: 114)	78.6%	0.096	40 (31–50)	0.373
	- (n: 906)	71.2%		43 (32–51)	
Accesory SIJ	+ (n: 80)	63.8%	0.092	40 (31–50)	0.493
	- (n: 940)	72.8%		38 (30–48)	
Iliosacral complex	+ (n: 66)	66.7%	0.192	40 (31–50)	0.648
	- (n: 954)	72.4%		39 (32–50)	
Sacral defect	+ (n: 61)	54.1%	**0.001**	37 (24–48)	0.093
	- (n: 952)	73.2%		41 (20–50)	

[1]Chi-Square analysis. [2]Mann-Whitney U analysis.

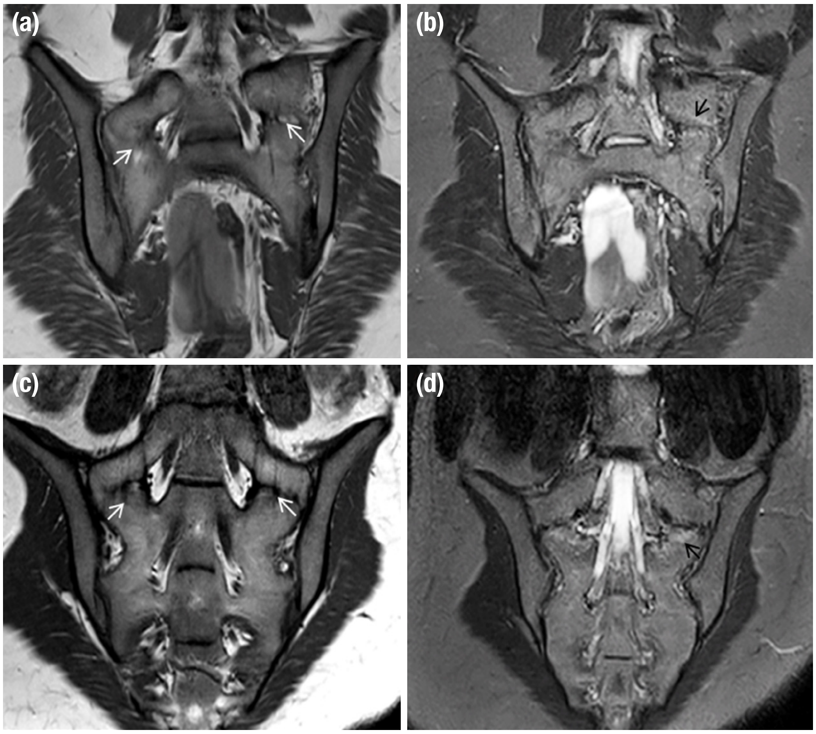

Figure 2. a–d. *Magnetic resonance imaging of SIJ demonstrates Castellvi type IV* ***(a)*** *and type IIB* ***(c)*** *sacralizations (white arrows) on paracoronal T1-weighted images. Contrast-enhanced fat-saturated T1-weighted images* ***(b, d)*** *demonstrate bone marrow edema at both sides of sacralization (black arrows).*

Accompanying prominent vascular structures occurred in 52 (41%) of the 127 patients with sacral defects and iliosacral complexes (Fig. 3).

Discussion

Since sacroiliitis is a hallmark of active SpA, according to the ASAS classification, MRI has become a crucial imaging biomarker of SpA for diagnosing and evaluating inflammation in patients with early disease[14]. However, it is important to know the common anatomical variations of the SIJ, as they can lead to diagnostic misinterpretation. Hence, we assessed the prevalence of anatomical variations on SIJ MRI in patients with LBP and highlighted their associations with sacroiliitis, gender, age, BME, and other structural changes.

Table 3. *Comparison of the BME according to the sacroiliitis and its correlation to LSTV and Accessory SIJ*

		BME +	BME -	Statistics	p
LSTV (+) (n: 114)	Sacroiliitis +	% 12.5 (n: 1)	% 16.0 (n: 17)	χ^2: 0.070	0.791
	Sacroiliitis -	% 87.5 (n: 7)	% 84.0 (n: 89)		
Accessory SIJ (+) (n: 80)	Sacroiliitis +	% 15.0 (n: 3)	% 16.7 (n: 10)	χ^2: 0.031	0.861
	Sacroiliitis -	% 85.0 (n: 10)	% 83.3 (n: 50)		

Column proportions are shown –Chi-square and Fisher's exact test used for analysis.

Only a few studies have reported the prevalence of MRI findings of anatomical variations on SIJ[11,15], but our study has the highest number of patients. We investigated anatomical variations in 323 patients among a total of 1020 aged 18–65 years.

LSTV was identified in 12.2% of our patients, and it was the most common variation. Castellvi et al.[13] reported a 30% prevalence in the LBP population and noted higher rates for Type IV, IIIB, and Type II. Their largest cohorts came from Type II (38.3%), whereas ours largely came from Type I (IA and IB) (57%). Reddy Ravikantha et al.[15] found the prevalence of LSTV to be 26.8% in their study with 500 patients, and their most common subgroup was Type IA (7.6%), as in our study.

Although LSTV was reported predominantly in men in the literature, there was no statistically significant difference between men and women who had LSTV in our study, as in Reddy Ravikantha et al.[15].

An MRI study conducted by Rafei et al.[11] provided the following results: "Accessory SIJ" in 17 (11%), "iliosacral

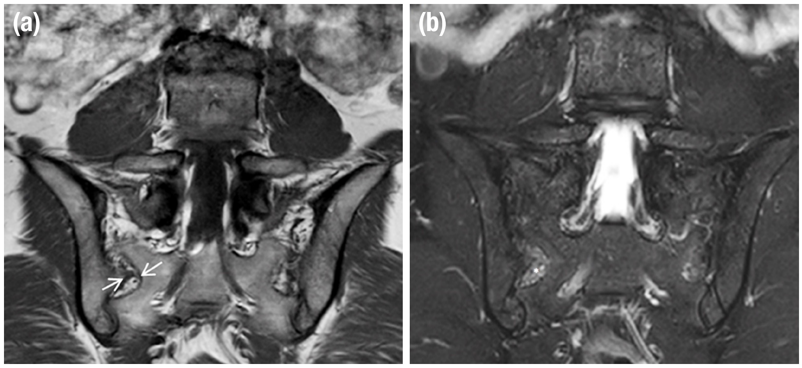

Figure 3. a, b. *Iliosacral complex on the right side on MRI. Paracoronal T1W image **(a)** showed protrusion of the ilium and concave depression of the sacrum on the opposite (arrows). This region's vascular structures (asterisks) may mimic enthesitis on T1W FS post-contrast axial images **(b)**.*

complex" in 18 (11%), "sacral defects" in 21 (13%), and "synostosis" in one (0.6%). In our study, however, accessory SIJ was the most common anatomical variation (7.8%, n=80), followed by the iliosacral complex (6.4% ; n=66), sacral defect (5.9%, n=61), and synostosis (0.2%, n=2).

Accessory SIJ is considered the most common variant, with a reported prevalence of 3.6–50%, and is also the most prone to degenerative changes and the most symptomatic[16–18]. One study reported that 64% (65/102) of the cases presenting with both LBP and degenerative changes were present[10].

In the current study among accessory SIJ patients, we found the prevalence of structural signal intensity changes, including subchondral cysts and fatty deposits, to be 20% and the prevalence of edematous changes as 25%. From experience, structural and degenerative changes resulting from anatomic variations in SIJ MRI can cause diagnostic misinterpretation. It is mostly associated with mechanical changes and should not be interpreted as sacroiliitis, especially in coronal images. Therefore, it will be useful to evaluate axial sequences for the diagnosis of accessory SIJ. Although Eno et al.[19] found a relationship between SIJ degeneration and age in asymptomatic adults, no statistically significant difference was found between structural changes and age in our study.

In our reported 80 accessory SIJ patients, 20 (25%) cases demonstrated BME as a high signal on STIR images: four cases were bilateral, and 16 were unilateral. At the same time, 7 (6.1%) of 114 patients with LSTV were accompanied by BME. In light of the literature, the prevalence of LSTV in patients seeking care for LBP varies between 4.6% and 35.6% [20]. The prevalence of LSTV was 12.2% in our study, in which all patients had symptoms of LBP.

We did not find a statistically significant relationship between BME and the presence of sacroiliitis in either accessory SIJ and LSTV patients. LBP in the presence of an LSTV was initially noted by Mario Bertolotti in 1917 and termed "Bertolotti's Syndrome."

Quinlan et al.[21] found the prevalence of Bertolotti's syndrome to be 4.6% in the general population and 11.4% in patients under 30 years of age. Mahato et al.[22] also stated that the degeneration of abnormal articulation between the LSTV and the sacrum might lead to LBP. Although it has not been fully revealed yet, it is thought that LBP that develops due to this syndrome has various etiologies and arises from different locations.

In patients with LSTV, we also demonstrated that accompanying degenerative findings and BME can cause biomechanical alterations independent of sacroiliitis and associated with LBP. In our experience, we think the prevalence we detected may reflect the real situation encountered in routine clinical practice, as only symptomatic patients require SIJ MRI.

Iliosacral complex and semicircular defects, which are anatomical variants seen in the ligamentous part of the SIJ, were not associated with any degenerative changes in our study since they do not have facing bony surfaces. We found their prevalence similar to previous CT studies[8,10].

Prassopoulos et al.[10] reported that these anatomical variants were more common in women and were not associated with age or body mass index. Similarly, in our study, they were observed more frequently in women.

Since the transitional zone between the cartilaginous and ligamentous part of the sacroiliac joint is rich in vessels[12,23], it should be kept in mind that the evident vascular structures in this area, especially in coronal images, may mimic enthesitis. It should always be evaluated with axial images to avoid this potential pitfall.

We found only two synostoses partially involving SIJ in our study. As these variations mimic ankylosis, it is essential to demonstrate that the remaining parts of the bilateral joints are free of structural and edematous damage. Our findings were similar to those of the other two previous studies demonstrating synostosis[11,24].

Our study has some limitations. First, its retrospective design entails selection bias. However, the widespread use of MRI in our country and the ease of patients' access to health services at the university hospital level make our study group close to setting an example to determine the true prevalence of anatomical variations. Second, referring only symptomatic patients for whom the diagnosis was unavailable for SIJ MRI examination by clinicians may mean that asymptomatic variations and their definitive diagnosis were not included in this study. Thus, no definitive interpretation can be made about the true incidence of BME. The follow-up period of the patients in our study was not long enough; however, the purpose of our study was not to evaluate the true prevalence of sacroiliitis but to increase the awareness of radiologists of SIJ variations in daily practice. Finally, although the number of cases in this series is small, to our knowledge, this study is the most comprehensive published series of sacroiliac joint anatomical variations, focusing solely on MRI features.

SIJ variations have an MRI prevalence of approximately 31.6% in the target population. Based on our data, we conclude that LSTV and several anatomical SIJ variations are common in the LBP population, especially in females. These variations may be associated with degenerative and edematous signal intensity changes mimicking sacroiliitis. Therefore, radiologists should be aware of these anatomical variations when analyzing the SIJ MR images of a patient with low back pain.

Ethical Approval

This study was conducted in compliance with the ethical principles according to the Declaration of Helsinki, and the local Institutional Review Board approved it.

Patients' Consent

As this study was retrospective, the patients' consent was waived.

Conflict of Interest

The author declared no conflict of interest.

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