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Clinical and radiological outcomes of sacroiliac joint ankylosis in radiographic axial spondyloarthritis

Radyografik aksiyel spondiloartritte sakroiliak eklem ankilozunun klinik ve radyolojik sonuçları

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Abstract

Objective: To compare the clinical, functional, and radiological features of patients with radiographic axial spondyloarthritis (r-AxSpA) according to the presence of sacroiliac joint (SIJ) ankylosis.

Methods: This retrospective study included 290 patients fulfilling the modified New York criteria for ankylosing spondylitis. SIJ ankylosis was defined on pelvic radiographs as unilateral or bilateral grade 4 sacroiliitis. Patients with unilateral and bilateral ankylosis were initially analysed together as the overall ankylosis group and compared with patients without ankylosis; subsequently, a separate subgroup analysis was performed focusing exclusively on patients with bilateral ankylosis. Clinical, functional, radiographic, and treatment-related characteristics were compared between groups.

Results: Among 290 patients, 30 (10.3%) had unilateral and 101 (34.8%) had bilateral sacroiliac ankylosis. Compared with patients without ankylosis, patients with sacroiliac ankylosis showed a male predominance, longer symptom and disease duration, and higher rates of smoking, alcohol consumption, hip involvement, sacral enthesitis, and syndesmophytes. Human leukocyte antigen B27 positivity was increased in patients with sacroiliac ankylosis overall but was not significantly associated in the bilateral ankylosis group. Symptom and disease duration were positively correlated with Bath Ankylosing Spondylitis Metrology Index and modified Stoke Ankylosing Spondylitis Spinal Score (mSASSS), whereas spinal mobility measures were negatively correlated, with stronger associations observed in the bilateral ankylosis group. In multivariable models, total mSASSS and hip involvement were independently associated with bilateral sacroiliac ankylosis.

Conclusion: SIJ ankylosis, particularly when bilateral, is associated with more extensive structural damage and impaired spinal mobility in r-AxSpA.

Keywords: Radiographic axial spondyloarthritis, sacroiliac joint ankylosis, structural damage, spinal mobility, BASMI, mSASSS

Özet

Amaç: Radyografik aksiyel spondiloartrit (r-AxSpA) hastalarında sakroiliak eklem (SİE) ankilozu varlığına göre klinik, fonksiyonel ve radyolojik özellikleri karşılaştırmaktır.

Yöntem: Bu retrospektif çalışmaya, modifiye New York kriterlerine göre ankilozan spondilit tanısı almış 290 hasta dahil edildi. SİE ankilozu, pelvis grafilerinde unilateral veya bilateral evre 4 sakroiliit olarak tanımlandı. Unilateral ve bilateral ankilozu olan hastalar başlangıçta birlikte değerlendirilerek ankilozu olmayan hastalarla karşılaştırıldı; ardından yalnızca bilateral ankilozu olan hastalara yönelik alt grup analizi yapıldı. Klinik, fonksiyonel, radyografik ve tedaviye ilişkin özellikler gruplar arasında karşılaştırıldı. Spinal Mobilite Bath Ankilozan Spondilit Metrologi İndeksi (BASMI) ile, yapısal hasar ise modifiye Stoke Ankilozan Spondilit Omurga Skoru (mSASSS) kullanılarak değerlendirildi.

Bulgular: Hastaların 30'unda (%10,3) unilateral, 101'inde (%34,8) bilateral sakroiliak ankiloz saptandı. Sakroiliak ankilozu olan hastalarda (unilateral veya bilateral, n=131) erkek cinsiyet predominansı, daha uzun semptom ve hastalık süresi ile sigara ve alkol kullanımı, kalça tutulumu, sakral entezit ve sindesmofit sıklığı daha yüksekti. İnsan lökosit antijeni B27 pozitifliği genel olarak ankiloz grubunda daha yüksek olmakla birlikte, bilateral ankiloz ile anlamlı bir ilişki göstermedi. Semptom ve hastalık süresi BASMI ve mSASSS ile pozitif korelasyon gösterirken, spinal mobilite ölçümleri negatif korelasyon gösterdi; bu ilişkiler bilateral ankiloz grubunda daha belirgindi. Çok değişkenli analizlerde toplam mSASSS ve kalça tutulumu, sakroiliak ankiloz ile bağımsız olarak ilişkili bulundu.

Sonuç: SİE ankilozu, özellikle bilateral olduğunda, r-AxSpA'da daha yaygın yapısal hasar ve belirgin spinal mobilite kısıtlılığı ile ilişkilidir.

Anahtar Kelimeler: Radyografik aksiyel spondiloartrit, sakroiliak eklem ankilozu, yapısal hasar, spinal mobilite, BASMI, mSASSS

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Introduction

Radiographic axial spondyloarthritis (r-AxSpA) is a chronic inflammatory rheumatic disease characterized by inflammation of the sacroiliac joints (SIJs) and spine, leading to new bone formation, ankylosis, and progressive loss of mobility.[1] The SIJs are the earliest and most characteristic sites of involvement, and radiographic sacroiliitis remains central to the diagnosis of ankylosing spondylitis (AS), as established in the modified New York (mNY) criteria.[2]

Structural damage in r-AxSpA has been widely evaluated using scoring methods such as the modified Stoke Ankylosing Spondylitis Spinal Score (mSASSS), which quantifies vertebral changes in the cervical and lumbar spine.[3] Radiographic progression, especially syndesmophyte formation, is one of the strongest determinants of functional decline and reduced spinal mobility in axSpA, as demonstrated in large prospective cohorts.[4,5] However, while spinal damage has been extensively studied, the implications of SIJ ankylosis itself remain less well explored.

SIJ ankylosis, defined as complete fusion of the joint, represents a late and irreversible stage of sacroiliitis. Although some studies suggest that SIJ damage is associated with disease severity and functional impairment, its independent contribution compared with spinal changes is not fully understood.[5]

In addition, a recent multicentre study from the TReasure cohort reported that advanced structural phenotypes such as bamboo spine were independently associated with male sex, higher body mass index (BMI), hip arthritis, and entheseal involvement.[6] These findings highlight the complex interplay between pelvic structural damage and spinal new bone formation, further supporting the need to understand the specific clinical implications of SIJ ankylosis. Furthermore, little is known about how unilateral versus bilateral SIJ ankylosis differentially impacts structural damage, clinical features, and treatment patterns in AS.

Given the central role of the SIJs in disease initiation and progression, clarifying the clinical, functional, and radiological implications of SIJ ankylosis may provide important insights for disease monitoring and risk stratification. Therefore, this study aimed to compare the demographic, clinical, functional, and radiological characteristics of r-AxSpA patients with and without sacroiliac ankylosis, with particular attention to bilateral involvement.

Materials and Methods

This retrospective cross-sectional study included patients diagnosed with AS according to the mNY criteria.[2] Medical records from three tertiary rheumatology centers were systematically reviewed between January 2025 and April 2025. Pelvic and spinal radiographs were generally obtained during the same clinical visit as part of routine care. Only patients with both pelvic and spinal radiographs acquired within the preceding 12 months were included; when obtained at different visits, the interval did not exceed 12 months. Patients with incomplete radiographic or clinical data were excluded. A total of 290 patients with complete datasets were included in the final analysis.

Radiographic Assessment

SIJ ankylosis was defined radiographically as unilateral or bilateral grade 4 sacroiliitis on conventional pelvic radiographs, in accordance with the mNY criteria.[2] Any ankylosis was defined as grade 4 involvement in at least one SIJ (unilateral or bilateral total ankylosis), and bilateral total ankylosis required grade 4 sacroiliitis in both joints. According to the mNY criteria, grade 3 sacroiliitis was characterized by erosions, sclerosis, joint space widening or narrowing, or partial ankylosis, and grade 4 indicated total ankylosis. Sacroiliitis was assessed separately for the right and left SIJs; patients with a maximum sacroiliitis grade of 3 across both joints were classified in the without ankylosis group and were not included in any ankylosis group. Two primary comparisons were performed: (1) patients with any ankylosis (unilateral or bilateral) versus those without ankylosis, and (2) patients with bilateral ankylosis versus those without ankylosis, excluding unilateral cases.

Spinal structural damage was evaluated using the mSASSS, which assesses vertebral squaring, erosions, syndesmophytes, and ankylosis in the cervical and lumbar regions (3). Hip involvement was graded according to the Bath Ankylosing Spondylitis Radiology Index for the hip (BASRI-hip), providing a standardized measure of radiographic damage.[7] A BASRI-hip score ≥2 was considered indicative of hip involvement. Total hip replacement was also recorded and classified as hip involvement. Additional radiographic features, including pubic symphysis involvement and sacral enthesitis, were also documented based on expert radiological review. Pubic symphysis involvement (symphysitis) was defined as the presence of subchondral sclerosis, erosions, joint-space irregularity or partial/complete ankylosis of the symphysis pubis on anteroposterior pelvic radiographs. Sacral enthesitis was defined as cortical irregularity, erosions, subchondral sclerosis or bony proliferation at the sacral entheseal sites visible on pelvic radiographs.

All radiographs were independently evaluated by two rheumatologists (GA and HC) with expertise in axSpA imaging, who worked in a tertiary referral spondyloarthritis clinic with regular exposure to the assessment of SIJ and spinal radiographs. Intra-rater reliability was excellent [intraclass correlation coefficient (ICC)=0.83 and 0.88], and inter-rater reliability was similarly high (ICC=0.85), demonstrating robust consistency in both SIJ grading and mSASSS scoring.

Clinical and Functional Assessments

Collected data included age, sex, BMI, symptom duration, disease duration, human leukocyte antigen B27 (HLA-B27) status, smoking and alcohol use, and the presence of comorbidities. Extra-articular manifestations, including uveitis, inflammatory bowel disease (IBD), and psoriasis, were recorded, along with peripheral features such as enthesitis, peripheral arthritis, and dactylitis.

Treatment history was assessed, including prior and current use of non-steroidal anti-inflammatory drugs (NSAIDs), conventional synthetic disease-modifying antirheumatic drugs (DMARDs); methotrexate (MTX), sulfasalazine, and biological or targeted synthetic DMARDs (b/tsDMARDs), in accordance with international recommendations.[8]

Functional status was evaluated using the Bath Ankylosing Spondylitis Radiology Index (BASMI), which comprises measurements of cervical rotation, tragus-to-wall distance, lateral lumbar flexion, intermalleolar distance, and the modified Schober test.[9] All clinical and functional assessments were performed at the patients' most recent clinical visit.

Ethics Approval

The study protocol was approved by the Clinical Research Ethics Committee of Uşak University Faculty of Medicine (approval no: 630-630-28; date: 10.04.2025). Informed consent was waived due to the retrospective design and anonymized data.

Statistical Analysis

All analyses were performed using SPSS software version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were reported as mean ± standard deviation or median and interquartile range for continuous variables and as frequencies and percentages for categorical variables. Comparisons between groups were conducted using the chi-square test for categorical variables, the independent samples t-test for normally distributed continuous variables, and the Mann-Whitney U test for skewed data. Correlation analyses were performed using Spearman's rank correlation coefficients. A p-value of <0.05 was considered statistically significant. Variables associated with sacroiliac ankylosis were analysed using multivariable logistic regression.

Results

Demographic and Clinical Characteristics (Any Ankylosis vs. Non-ankylosis)

Among the 290 patients with AS, 131 had SIJ ankylosis (unilateral or bilateral), while 159 had no ankylosis. Patients with ankylosis were significantly more often male (80.2% vs. 56.0%, $p<0.001$) and older (45.9±10.2 vs. 40.5±10.3 years, $p<0.001$). They also had longer symptom duration (median 20 vs. 12 years, $p<0.001$) and disease duration (median 14 vs. 8 years, $p<0.001$). Smoking, alcohol consumption, and HLA-B27 positivity were more frequent in the ankylosis group. No significant differences were observed in BMI, enthesitis, uveitis, peripheral arthritis, psoriasis, IBD, or NSAID use. Use of MTX and biologic therapy were higher among patients with ankylosis (Table 1).

Functional and Radiographic Findings (Any Ankylosis vs. Non-ankylosis)

Among the 290 patients included in the study, the distribution of sacroiliitis grades differed between the right and left SIJs. For the right SIJ, grade 1 was observed in 1 patient (0.3%), grade 2 in 55 patients (19.0%), grade 3 in 115 patients (39.7%), and grade 4 in 119 patients (41.0%). For the left SIJ, grade 1 was present in 12 patients (4.1%), grade 2 in 61 patients (21.0%), grade 3 in 106 patients (36.6%), and grade 4 in 111 patients (38.3%).

Patients with ankylosis demonstrated significantly worse functional outcomes, with higher BASMI scores (4.38±2.28 vs. 2.42±1.51, $p=0.002$) and reduced spinal mobility in all domains, including cervical rotation, lumbar flexion, intermalleolar distance, tragus-to-wall distance, and modified Schöber test (all $p<0.01$). Radiographically, they had higher rates of syndesmophytes (cervical: 55.8% vs. 19.0%; lumbar: 55.0% vs. 21.7%), hip involvement (62.6% vs. 25.2%, $p<0.001$), sacral enthesitis (34.4% vs. 13.8%), and symphysitis (21.4% vs. 6.3%). The median total mSASSS score was significantly higher in the ankylosis group (5 vs. 1, $p<0.001$) (Table 2). Total hip replacement was observed in 11 patients in the ankylosis group.

Multivariable Analysis for Any SIJ Ankylosis

In the multivariable logistic regression model, higher structural damage and hip involvement were independently associated with SIJ ankylosis. Total mSASSS remained a robust predictor, with each unit increase conferring higher odds of SIJ ankylosis. Hip involvement was also independently associated with the presence of ankylosis. HLA-B27 positivity showed a borderline association but did not reach statistical significance in the adjusted model. Age, sex, smoking status, disease duration, and biologic therapy were not independently associated with any SIJ ankylosis (Table 3).

Demographic and Clinical Characteristics (Bilateral Ankylosis vs. Non-Ankylosis)

In the subgroup analysis restricted to bilateral SIJ ankylosis ($n=101$), differences were even more pronounced. Male predominance (83.2% vs. 58.2%, $p<0.001$), older age (46.4±9.6 vs. 41.1±10.6 years, $p<0.001$), smoking (79.2% vs. 64.6%, $p=0.008$), and alcohol consumption (25% vs. 13.8%, $p=0.018$). HLA-B27 positivity was also higher (73.4% vs. 59.7%), although the

difference was not statistically significant (p=0.058). Symptom duration and disease duration were longer. Methotrexate and biologic therapy use were higher in the bilateral ankylosis group. Other variables, including BMI, enthesitis, uveitis, peripheral arthritis, psoriasis, and IBD showed no significant differences (Table 4).

Functional and Radiographic Findings (Bilateral Ankylosis vs. Non-ankylosis)

Bilateral ankylosis was associated with markedly impaired spinal mobility, reflected in higher BASMI scores (4.8±2.26 vs. 2.45±1.48, p<0.001) and worse performance in all mobility measures. Radiographic damage was greater in the bilateral ankylosis group, with higher frequencies of cervical

Table 1. Comparison of demographic, clinical, and treatment characteristics between patients with and without any SIJ ankylosis (unilateral or bilateral)

Variables	With ankylosis (n=131)	Without ankylosis (n=159)	p-value
Sex, male, n (%)	105 (80)	89 (56)	**<0.001**
Age, years, mean (SD)	46 (10)	41 (10)	**<0.001**
Ever smoker, n (%)	105 (80)	97 (61)	**<0.001**
Alcohol consumption, n (%)	32 (25)	19 (12)	**0.005**
Symptom duration, years, median (IQR)	20 (9)	12 (8)	**<0.001**
Disease duration, years, median (IQR)	14 (9)	8 (6)	**<0.001**
HLA-B27 positive, n/N (%)	61/84 (73)	66/114 (58)	**0.03**
BMI, kg/m², mean (SD)	27 (4.7)	26 (4.3)	0.88
History of enthesitis, n (%)	54 (41)	75 (47)	0.31
History of uveitis, n (%)	26 (20)	23 (15)	0.22
History of psoriasis, n (%)	7 (5.4)	17 (10)	0.13
History of IBD, n (%)	10 (7.6)	8 (5.0)	0.47
History of peripheral arthritis, n (%)	46 (35)	50 (31)	0.51
Current NSAID use, n (%)	77 (59)	93 (59)	0.96
SSZ use, ever, n (%)	77 (59)	77 (48)	0.08
MTX use, ever, n (%)	36 (28)	26 (16)	**0.02**
Biologic therapy, n (%)	114 (87)	111 (70)	**<0.001**

Percentages were calculated based on available data. N reflects the number of patients with available data for each variable. BMI: Body mass index, HLA: Human leukocyte antigen, IQR: Interquartile range, MTX: Methotrexate, NSAID: Non-steroidal anti-inflammatory drug, SD: Standard deviation, SIJ: Sacroiliac joint, SSZ: Sulfasalazine

Table 2. Comparison of functional parameters and radiographic findings between patients with and without any SIJ ankylosis (unilateral or bilateral)

Variables	With ankylosis (n=131)	Without ankylosis (n=159)	p-value
BASMI total score, mean (SD)	4.4 (2.3)	2.4 (1.5)	**0.002**
Cervical rotation, mean (SD)	52 (22)	67 (18)	**<0.001**
Tragus-to-wall distance, cm, mean (SD)	19 (6.4)	15 (3.4)	**0.004**
Lateral lumbar flexion, cm, mean (SD)	12 (12)	20 (19)	**<0.001**
Intermalleolar distance, cm, mean (SD)	89 (24)	100 (18)	**<0.001**
Modified Schober test, cm, mean (SD)	3.3 (2.0)	5.0 (2.1)	**<0.001**
Cervical syndesmophyte, n (%)	72 (56)	30 (19)	**<0.001**
Lumbar syndesmophyte, n (%)	71 (55)	34 (22)	**<0.001**
Sacral enthesitis, n (%)	45 (34)	21 (13)	**<0.001**
Symphysitis, n (%)	28 (21)	10 (6)	**<0.001**
Hip involvement, n (%)	82 (63)	39 (25)	**<0.001**
Cervical mSASSS, median (IQR)	4 (10)	0 (1)	**0.001**
Lumbar mSASSS, median (IQR)	1 (2)	0 (1)	**0.02**
Total mSASSS, median (IQR)	5 (11)	1 (2)	**<0.001**

BASMI: Bath ankylosing spondylitis metrology index, IQR: Interquartile range, mSASSS: Modified stoke ankylosing spondylitis spinal score, SD: Standard deviation, SIJ: Sacroiliac joint

syndesmophytes (58.6% vs. 23.4%), lumbar syndesmophytes (67.6% vs. 32.0%), sacral enthesitis (32.7% vs. 17.5%), symphysitis (21.8% vs. 8.5%), and hip involvement (66.3% vs. 28.6%) (all p≤0.003). Median total mSASSS was also higher (5 vs. 1, p<0.001) (Table 5). Total hip replacement was observed in 10 patients in the bilateral ankylosis group.

Multivariable Analysis for Bilateral SIJ Ankylosis

In the model evaluating bilateral SIJ ankylosis, disease duration and total mSASSS emerged as independent predictors. Longer disease duration modestly increased the likelihood of bilateral ankylosis, while higher total mSASSS [odds ratio (OR): 1.075, 95% confidence interval (CI): 1.023-1.130; p=0.004] remained strongly associated with its presence. Hip involvement was the strongest independent factor, conferring approximately three-fold increase in odds (OR: 2.904, 95% CI: 1.100-7.666; p=0.031). Other demographic and clinical variables, including age, sex, smoking history, and HLA-B27, were not independently associated with bilateral ankylosis in the adjusted model (Table 6).

To account for the potential confounding effect of disease duration, additional stratified analyses were performed based on the median disease duration of the cohort (10 years). Within both duration strata (<10 and ≥10 years), patients with bilateral SIJ ankylosis consistently demonstrated worse functional outcomes, reduced spinal mobility, and higher structural damage compared to those without ankylosis. These findings remained consistent across both clinical and radiographic parameters (Supplementary Tables 1 and 2).

Correlation Analyses

Correlation analysis demonstrated that longer symptom and disease duration were positively correlated with functional limitation (BASMI) and radiographic damage (mSASSS).

Table 3. Multivariable logistic regression analysis for any SIJ ankylosis (unilateral or bilateral)

Variable	OR	CI lower	CI upper	p-value
Age	0.985	0.929	1.045	0.62
Male sex	2.597	0.760	8.876	0.13
Disease duration	1.084	0.992	1.185	0.07
Ever smoker	1.789	0.604	5.297	0.29
HLA-B27	2.991	0.971	9.209	0.06
Total mSASSS	1.075	1.023	1.130	**0.004**
Hip involvement	2.904	1.100	7.666	**0.03**

CI: Confidence interval, HLA-B27: Human leukocyte antigen B27, mSASSS: Modified Stoke Ankylosing Spondylitis Spine Score, OR: Odds ratio, SIJ: Sacroiliac joint

Table 4. Comparison of demographic, clinical, and treatment characteristics between patients with and without bilateral SIJ ankylosis

Variables	With ankylosis (n=101)	Without ankylosis (n=189)	p-value
Sex, male, n (%)	84 (83)	110 (58)	**<0.001**
Age, years, mean (SD)	46 (9.6)	41 (11)	**<0.001**
Ever smoker, n (%)	80 (79)	122 (65)	**0.01**
Alcohol consumption, n (%)	25 (25)	26 (14)	**0.02**
Symptom duration, years, median (IQR)	21 (9)	13 (9)	**<0.001**
Disease duration, years, median (IQR)	15 (9)	9 (7)	**<0.001**
HLA-B27 positive, n/N (%)	47/64 (73)	80/134 (60)	0.06
BMI, kg/m², mean (SD)	27 (4.6)	26 (4.3)	0.86
History of enthesitis, n (%)	43 (43)	86 (46)	0.63
History of uveitis, n (%)	19 (19)	30 (16)	0.53
History of psoriasis, n (%)	6 (6.0)	18 (9.5)	0.37
History of IBD, n (%)	7 (6.9)	11 (5.8)	0.80
History of peripheral arthritis, n (%)	31 (31)	65 (34)	0.52
Current NSAID use, n (%)	60 (59)	110 (58)	0.84
SSZ use, ever, n (%)	56 (55)	98 (52)	0.56
MTX use, ever, n (%)	26 (26)	36 (19)	0.19
Biologic therapy, n (%)	85 (84)	140 (74)	**0.05**

Percentages were calculated based on available data. N reflects the number of patients with available data for each variable. BMI: Body mass index, HLA: Human leukocyte antigen, IQR: Interquartile range, MTX: Methotrexate, NSAID: Non-steroidal anti-inflammatory drug, SD: Standard deviation, SSZ: Sulfasalazine

Table 5. Comparison of functional parameters and radiographic findings between patients with and without bilateral SIJ ankylosis			
Variables	**With ankylosis (n=101)**	**Without ankylosis (n=189)**	**p-value**
BASMI total score, mean (SD)	4.8 (2.3)	2.5 (1.5)	**<0.001**
Cervical rotation, mean (SD)	48 (22)	67 (18)	**<0.001**
Tragus-to-wall distance, cm, mean (SD)	19 (6.9)	15 (3.7)	**<0.001**
Lateral lumbar flexion, cm, mean (SD)	11 (12)	19 (17)	**0.004**
Intermalleolar distance, cm, mean (SD)	89 (23)	99 (19)	**0.002**
Modified Schober test, cm, mean (SD)	3.3 (2.0)	5.0 (2.1)	**<0.001**
Cervical syndesmophyte, n (%)	58 (59)	44 (23)	**<0.001**
Lumbar syndesmophyte, n (%)	71 (68)	58 (32)	**<0.001**
Sacral enthesitis, n (%)	33 (33)	33 (18)	**0.003**
Symphysitis, n (%)	22 (22)	16 (9)	**0.001**
Hip involvement, n (%)	67 (66)	54 (29)	**<0.001**
Cervical mSASSS, median (IQR)	4 (10)	0 (1)	**<0.001**
Lumbar mSASSS, median (IQR)	1 (2)	0 (1)	**<0.001**
Total mSASSS, median (IQR)	5 (11)	1 (2)	**<0.001**
BASMI: Bath ankylosing spondylitis metrology index, IQR: Interquartile range, mSASSS: Modified stoke ankylosing spondylitis spine score, SD: Standard deviation, SIJ: Sacroiliac joint			

Table 6. Multivariable logistic regression analysis for bilateral SIJ ankylosis				
Variable	**OR**	**CI lower**	**CI upper**	**p-value**
Age	0.995	0.935	1.058	0.86
Male sex	2.056	0.577	7.328	0.27
Disease duration	1.088	1.002	1.181	**0.04**
Ever smoker	1.331	0.433	4.088	0.62
HLA-B27	2.444	0.734	8.144	0.15
Total mSASSS	1.044	1.006	1.084	**0.02**
Hip involvement	3.208	1.189	8.653	**0.02**
CI: Confidence interval, HLA-B27: Human leukocyte antigen B27, mSASSS: Modified stoke ankylosing spondylitis spine score, OR: Odds ratio, SIJ: Sacroiliac joint				

Conversely, spinal mobility measures such as cervical rotation, lumbar flexion, intermalleolar distance, tragus-to-wall distance, and the Schober test showed significant negative correlations with both BASMI and mSASSS. These associations were more pronounced in the bilateral ankylosis subgroup, where the correlation between BASMI and mSASSS reached moderate strength ($\rho=0.50$, $p<0.001$) (Figure 1).

Discussion

In this retrospective study of 290 patients with r-axSpA, we found that SIJ ankylosis is closely associated with more advanced structural damage, worse spinal mobility, and greater functional impairment. Patients with ankylosis particularly those with bilateral fusion were more often male, had longer symptom and disease durations, and more frequently exhibited smoking, HLA-B27 positivity, hip involvement, sacral enthesitis, and syndesmophytes. These findings suggest that SIJ ankylosis reflects a more severe, structurally progressive phenotype within r-AxSpA.

Although SIJ involvement is recognized as a hallmark of axSpA, only a limited number of studies have evaluated the specific consequences of SIJ disease itself. Earlier research has largely focused on radiographic sacroiliitis grading rather than complete fusion, and the prognostic relevance of ankylosis has remained insufficiently characterised.

Our findings are supported in part by previous work showing that structural damage in the SIJ contributes to functional impairment in axSpA. Protopopov et al.[10] demonstrated in a longitudinal cohort of 210 patients that radiographic sacroiliitis severity (SIJ sum-score) was independently associated with small but statistically significant worsening in BASFI and BASMI, even after adjustment for disease activity and spinal structural damage. These results indicate that SIJ damage plays a role in functional limitation beyond spinal involvement. However, their analysis focused on the full spectrum of radiographic sacroiliitis grades and did not specifically address complete ankylosis or distinguish between unilateral and bilateral fusion. In contrast, our study extends this evidence by showing that SIJ ankylosis

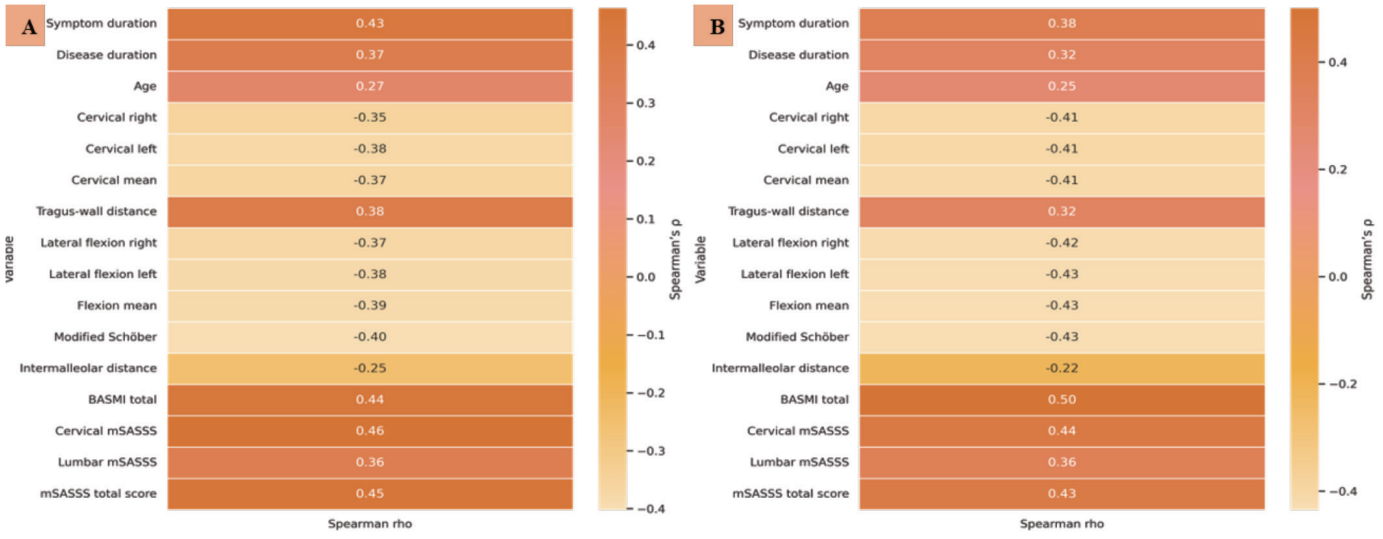

Figure 1. Spearman correlation heatmaps of demographic, functional, and radiographic variables in ankylosing spondylitis

Panel A: Overall ankylosis group. Panel B: Bilateral ankylosis subgroup.
Positive correlations (orange) indicate that longer disease duration is associated with higher BASMI and mSASSS scores, whereas negative correlations (lighter shades) reflect reduced spinal mobility with increasing structural damage.
BASMI: Bath ankylosing spondylitis metrology index, mSASSS: Modified stoke ankylosing spondylitis spinal score

particularly bilateral ankylosis represents the most advanced structural phenotype and is associated with the greatest mobility limitation and radiographic burden.

However, prior studies did not differentiate unilateral versus bilateral ankylosis or comprehensively evaluate their associations with syndesmophytes, hip involvement, and detailed mobility indices. Our findings extend this literature by showing that bilateral ankylosis is associated with the most profound mobility limitations, higher mSASSS scores, and widespread pelvic and spinal structural changes, highlighting the clinical relevance of distinguishing the degree of SIJ fusion.

In our cohort, sacroiliac ankylosis was markedly more frequent in male patients. Similarly, a computed tomography-based population study reported male sex as an independent risk factor for spontaneous SIJ ankylosis even in non-inflammatory settings.[11] This parallel finding suggests that sex-related predisposition may influence both inflammatory and degenerative pathways leading to SIJ ankylosis.

The relationship between SIJ ankylosis and spinal structural damage is particularly notable. Patients with ankylosis had significantly higher rates of cervical and lumbar syndesmophytes and bridging lesions, suggesting parallel progression of pelvic and spinal new bone formation. These associations were strongest in the bilateral subgroup, supporting the concept that complete SIJ fusion represents a late and advanced stage of axial structural progression. The strong correlations between disease duration, BASMI, and mSASSS further reinforce the cumulative nature of radiographic damage in axSpA. To further explore whether these findings were solely driven by disease duration, we performed additional stratified analyses based on the median disease duration of the cohort (10 years). Notably, the differences in functional impairment, spinal mobility, and structural damage between patients with and without bilateral SIJ ankylosis persisted within both duration strata. These findings suggest that SIJ ankylosis is not merely a reflection of longer disease duration, but rather represents a distinct structural phenotype associated with more severe clinical and radiographic involvement. A recent multicentre Turkish cohort similarly reported that advanced spinal ankylosis (bamboo spine) clustered with hip involvement, higher BMI, and entheseal disease, further supporting the parallel progression of pelvic and spinal structural damage.[6]

Long-term prospective data from the OASIS cohort demonstrated that radiographic progression in axSpA continues over several decades and follows an approximately linear trajectory, with new syndesmophytes developing in more than half of patients over 12 years.[5] These findings emphasize that structural damage in axSpA is a cumulative and ongoing process. In this context, SIJ ankylosis in our cohort likely represents the extreme end of this structural continuum, supported by the markedly higher mSASSS values, widespread syndesmophytes, hip involvement, and impaired mobility observed in patients with bilateral fusion.

Our findings regarding the strong association between SIJ ankylosis and hip involvement are consistent with recent evidence from orthopaedic cohorts. In a study of patients with AS, Ido et al.[12] demonstrated that SIJ fusion was an independent risk factor for radiographic hip involvement. Their analysis suggested that reduced spinopelvic mobility and increased mechanical

stress on adjacent joints may contribute to hip pathology. These results align with our observation that patients with sacroiliac ankylosis particularly those with bilateral fusion had markedly higher rates of hip involvement, supporting the concept that SIJ fusion reflects a more severe structural phenotype affecting both the pelvis and the spine. Similarly, sacral enthesitis and pubic symphysis involvement clustered in the ankylosis group, reflecting more diffuse pelvic structural pathology.

Inflammation is generally regarded as a contributing factor in the development of structural damage in axSpA; however, the relationship between inflammatory activity and ankylosis remains complex. Ankylosis reflects cumulative structural change over time and may not correspond directly to inflammatory activity measured at a single time point. As this study was cross-sectional and did not include baseline or longitudinal inflammatory assessments, we were unable to examine this association in detail. Further longitudinal investigations would be needed to better clarify this relationship.

Study Limitations

This study benefits from a relatively large sample size, standardized radiographic evaluation using validated scoring systems, and detailed assessment of spinal mobility. A key strength is the distinction between unilateral and bilateral sacroiliac ankylosis, which has been minimally addressed in previous research but appears clinically important. However, several limitations should be acknowledged. The retrospective and cross-sectional design precludes causal inference and does not permit direct evaluation of structural progression over time. Moreover, the lack of longitudinal baseline data limits assessment of the temporal relationship between disease duration, cumulative structural damage, and the development of SIJ ankylosis. Similarly, the absence of baseline and longitudinal inflammatory assessments restricts evaluation of the potential contribution of cumulative inflammatory burden to structural damage. In addition, patient-reported outcomes were not included, limiting a comprehensive understanding of the broader functional and patient-perceived impact of the disease. Nevertheless, the objective measures used BASMI and mSASSS offer a robust evaluation of functional and structural burden.

Conclusion

SIJ ankylosis is a clinically meaningful marker of advanced disease in r-AxSpA. Patients with ankylosis especially those with bilateral fusion demonstrated more extensive structural damage, greater pelvic and spinal involvement, and significantly impaired spinal mobility. Recognising SIJ ankylosis in routine clinical practice may help identify patients with a more progressive disease phenotype.

Ethics

Ethics Committee Approval: The study protocol was approved by the Clinical Research Ethics Committee of Uşak University Faculty of Medicine (approval no: 630-630-28; date: 10.04.2025).

Informed Consent: Informed consent was waived due to the retrospective design and anonymized data.

Footnotes

Authorship Contributions

Surgical and Medical Practices: H.C., M.K., G.A., Concept: H.C., M.K., G.A., Design: H.C., M.K., G.A., Data Collection and Processing: H.C., M.K., G.A., Analysis or Interpretation: H.C., M.K., G.A., Literature Search: H.C., M.K., G.A., Writing: H.C., M.K., G.A.

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