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CERVICAL ZYGAPOPHYSEAL JOINT INVOLVEMENT IS ASSOCIATED WITH RADIOGRAPHIC DAMAGE AND IMPAIRED SPINAL MOBILITY IN AXIAL SPONDYLOARTHRITIS

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Abstract

Aim: To evaluate the clinical, functional, and radiographic implications of cervical facet joint [zygapophyseal joint (ZJ)] involvement and ankylosis in patients with axial spondyloarthritis (axSpA).

Material and Methods: This retrospective study included 132 patients diagnosed with axSpA. Cervical ZJ involvement and ankylosis were assessed using the De Vlam scoring method. Patients were stratified according to ZJ involvement (score ≥1) and complete ankylosis (score =3). Clinical, functional, and radiographic parameters were compared between groups. Multivariate linear regression was performed to identify independent associated factors, of impaired cervical mobility, as measured by cervical rotation.

Results: ZJ involvement was observed in 24 patients (18.3%), and ankylosis was observed in 11 (8.4%). Patients with ZJ involvement had significantly higher Bath Ankylosing Spondylitis Metrology Index scores, reduced cervical rotation, greater tragus-to-wall distance, and elevated cervical and total modified Stoke Ankylosing Spondylitis Spinal Score (mSASSS). ZJ ankylosis was associated with male sex, hip involvement, cervical syndesmophytes, sacral enthesitis, and a higher prevalence of sacroiliac joint ankylosis. Notably, among patients with cervical ZJ involvement, 7/24 (29.2%; 5.3% of the overall cohort) had no anterior cervical damage (mSASSS=0). In multivariate analysis, both the De Vlam ZJ score (β=0.377, $p<0.001$) and cervical mSASSS (β=0.277, $p=0.012$) were independently associated with reduced cervical rotation.

Conclusion: Cervical ZJ involvement and ankylosis are associated with greater structural damage and reduced spinal mobility in axSpA. A subset of patients with ZJ ankylosis had no anterior cervical damage, highlighting the added diagnostic value of posterior structural assessment. Including posterior spinal evaluation may enhance functional assessment and improve prognostic accuracy.

Keywords: Axial spondyloarthritis, cervical spine, zygapophyseal joint, spinal mobility, functional limitation, radiographic damage

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INTRODUCTION

Facet joints, also known as zygapophyseal joints (ZJ), are diarthrodial joints that, along with intervertebral discs, contribute to articulation between adjacent vertebrae and play a crucial role in spinal biomechanics. These joints facilitate load transmission and limit excessive motion, thereby maintaining spinal stability and integrity. As true synovial joints lined with hyaline cartilage, ZJs are commonly affected in degenerative conditions such as spinal osteoarthritis, particularly involving the posterior vertebral column.

In patients with axial spondyloarthritis (axSpA), ZJ involvement is common, especially in the thoracic spine (1). Current data suggest that facet joints may be affected early in the disease course. Altered spinal biomechanics, often due to syndesmophytes at the same vertebral level, may contribute to the development of ZJ fusion. Cervical ZJ involvement can lead to restricted neck motion, significantly affecting patients' quality of life. Pain originating from ZJ can vary based on the level of involvement. Lesions at the C2-C4 levels may result in occipital headaches (2), while C4-C6 involvement may cause pain in the upper trapezius region (3), while C6-C7 involvement may lead to pain in the scapular area. Lumbar ZJ-related pain is often referred to the sacroiliac region, hips, and thighs (4). Clinically, ZJ pain may mimic inflammatory back pain, presenting with morning stiffness and post-inactivity stiffness.

The modified Stoke Ankylosing Spondylitis Spinal Score (mSASSS) is the most widely used method to assess structural spinal damage in axSpA, evaluating erosion, sclerosis, squaring, and ankylosis in 24 anterior vertebral corners from C2 to L5, on lateral radiographs, yielding a total score ranging from 0 to 72 (5). However, this method focuses exclusively on anterior vertebral corner changes, failing to assess posterior structures such as the facet joints. Investigating the relationship between ZJ damage and mSASSS may enhance our understanding of spinal biomechanics and damage progression in axSpA. While anterior vertebral scoring remains standard, recent computed tomography (CT) studies have emphasised the significance of posterior structural lesions. Tan et al. (6) reported that facet joint lesions—including ankylosis, erosion, and joint space narrowing—can be detected in both early and advanced axSpA stages, regardless of radiographic classification. Despite these insights, the role of posterior spinal structures such as the cervical facet joints in contributing to clinical disability remains underexplored.

Previous studies have shown that ZJ ankylosis often occurs in vertebral segments with syndesmophytes (6). Syndesmophytes and ZJ fusion have been associated with reduced spinal mobility, including limitations in modified Schober's test and lateral thoracolumbar flexion. Radiographic evaluation of cervical vertebrae has been shown to correlate with disease activity and functional impairment in axSpA. In the study by Berbel-Arcobé et al. (7), cervical spine involvement was observed in 53.2% of patients. Compared with those without cervical damage, patients with cervical spine involvement were more frequently male, were older, had a higher body mass index (BMI), and were more often smokers. Among these, 38.1% had ZJ fusion, and overall ZJ involvement was reported in 29.1% of the entire cohort, including 5.9% with isolated posterior involvement (7). This condition was also associated with higher disease activity, worse functional scores, and greater structural damage. However, the relationship between cervical ZJ involvement and radiographic scores or functional limitation has not been fully elucidated.

Clinical observations indicate that many axSpA patients exhibit restricted cervical mobility despite having no visible anterior radiographic lesions. This raises the possibility that posterior structures, especially the cervical ZJs, may contribute to spinal dysfunction. This study aimed to investigate the association of cervical ZJ involvement and ankylosis with radiographic spinal damage and functional impairment in axSpA, and to identify clinical associations of ZJ involvement.

MATERIAL AND METHODS

This retrospective cross-sectional study was conducted at the Rheumatology Department of a tertiary care center. Demographic and clinical data, including age, sex, symptom, and disease duration, smoking status, education level, *HLA-B27* status, medication history (conventional synthetic disease-modifying antirheumatic drugs and biologic disease-modifying antirheumatic drugs), comorbidities, and presence of extra-musculoskeletal manifestations (e.g., uveitis, psoriasis, and inflammatory bowel disease), were also collected. Medical records of patients diagnosed with axSpA based on the 2009 Assessment of SpondyloArthritis International Society criteria and/or ankylosing spondylitis (AS) based on the modified New York criteria were reviewed (8,9). Eligible patients were between 18 and 65 years old and had available cervical and lumbar spine radiographs. To preserve cohort homogeneity, patients with other SpA subtypes (e.g., psoriatic arthritis, reactive arthritis) were excluded, restricting the analysis to AS and non-radiographic axSpA. Additional exclusion criteria were spinal malignancy, spinal infections, prior spinal surgery, and poor-quality radiographs.

Radiographic evaluation was performed retrospectively. Cervical spine radiographs were assessed for ZJ involvement, including ankylosis, joint space narrowing, erosion, and sclerosis. Cervical

ZJ damage was scored using the De Vlam method, which evaluates each ZJ from C2 to C7 on a 0 to 3 scale, where 0 signifies normal, 1 signifies joint space narrowing, 2 signifies partial ankylosis, and 3 signifies complete ankylosis, with a maximum total score of 15 (10). Structural spinal damage was quantified using the mSASSS, based on lateral radiographs of 24 vertebral corners from C2 to L5 (total score range 0-72). Cervical spine radiographs were independently evaluated by two experienced rheumatologists both of whom had prior training in spinal radiographic scoring. To assess interobserver reliability, a subset of 30 randomly selected radiographs was independently scored by both raters. Interobserver reliability was quantified using Cohen's kappa and interpreted according to the Landis-Koch classification (0.61-0.80: substantial; 0.81-1.00: almost perfect). The agreement for detecting ZJ involvement (De Vlam ≥1) was κ=0.85 (almost perfect), and the agreement for ZJ ankylosis (score =3) was κ=0.88 (almost perfect). These findings support the reliability and reproducibility of posterior cervical scoring in this study. In this study, cervical ZJ involvement was defined as any pathological finding affecting the facet joints, corresponding to a De Vlam score of 1 or higher. This includes joint space narrowing, partial ankylosis, and complete ankylosis. For further analyses, ZJ ankylosis was considered a distinct subgroup and was defined strictly as complete joint fusion, corresponding to a De Vlam score of 3.

Disease activity was evaluated using the Bath Ankylosing Spondylitis Disease Activity Index, which comprises six questions assessing fatigue, spinal pain, joint pain and swelling, enthesitis, and the severity and duration of morning stiffness. Each item is rated on a 0-10 visual analogue scale, and the final score is calculated as the mean of these six items, with higher scores indicating more active disease (11). Health-related quality of life was measured using the Ankylosing Spondylitis Quality of Life (ASQoL) questionnaire, a disease-specific instrument consisting of 18 dichotomous items (yes/no) that assess the impact of axSpA on physical, emotional, and social functioning (12). The total score ranges from 0 to 18, with higher scores indicating poorer quality of life. Functional limitations were assessed using the Bath Ankylosing Spondylitis Functional Index (BASFI) and the Bath Ankylosing Spondylitis Metrology Index (BASMI). BASFI consists of ten questions rated on a visual analogue scale (0-10), and BASMI includes cervical rotation, tragus-to-wall distance, lateral lumbar flexion, modified Schober's test, and intermalleolar distance, with final scores for each measure averaged (12).

Statistical Analysis

Statistical analyses included parametric and non-parametric tests to compare patients with and without cervical ZJ involvement (defined as any score ≥1 on the De Vlam scale) and those with and without cervical ZJ ankylosis (defined as a score of 3). Comparisons included demographic characteristics, radiographic scores (mSASSS), and functional parameters (BASMI, BASFI). Normality was assessed using the Shapiro-Wilk test. Depending on distributional assumptions, continuous variables were analysed using Student's t-test or Mann-Whitney U test, while categorical variables were assessed using chi-square or Fisher's exact test. Multivariate linear regression was performed to identify independent predictors of cervical mobility, using cervical rotation as the dependent variable. Confidence intervals were calculated using a 95% level based on standard errors from the regression model. A two-tailed p-value <0.05 was considered statistically significant. All statistical analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA).

Ethics Approval

This retrospective study was approved by the Uşak University Non-Interventional Clinical Research Ethics Committee (approval number: 600-600-13, date: 20.03.2025). Written consent was not obtained due to the retrospective design of the study.

RESULTS

Out of 132 patients with axSpA, 24 (18.3%) had cervical facet joint (ZJ) involvement, defined as a De Vlam score ≥1, and 11 (8.4%) had ankylosis (score =3). Patients with ZJ involvement were slightly older (mean age: 44.0 vs. 39.1 years) and more often male (62.5% vs. 44.9%), although these differences were not statistically significant (Table 1). Symptom duration was also longer in the ZJ involvement group (median 10 vs. 8 years).

Patients with cervical ZJ involvement showed worse spinal mobility in unadjusted comparisons: BASMI 4.18 vs. 2.71 (p=0.002); cervical rotation 51.6 °C vs. 66.5 °C (mean difference -14.9 °C, p<0.001); tragus-to-wall distance 18.8 cm vs. 15.4 cm (p=0.001); and modified Schober 3.80 cm vs. 4.75 cm (p=0.019) (Table 2). In the ankylosis subgroup (De Vlam =3), decrements were larger: cervical rotation 43.9 °C vs. 65.4 °C (mean difference -21.5 °C, p<0.001) and BASMI 5.02 vs. 2.81 (p<0.001), with consistent differences across other mobility indices.

Structurally, cervical mSASSS was higher in patients with ZJ involvement (median 4 vs. 0), and cervical syndesmophytes were more common (62.5% vs. 14.2%). Hip involvement (41.7% vs. 18.7%) and sacroiliac ankylosis (37.5% vs. 9.3%) were also more frequent in this group. Although BASFI and ASQoL scores were numerically lower in patients with ZJ involvement, the differences were not statistically significant. Among patients with cervical ZJ involvement (De Vlam ≥1), 7/24 (29.2%) had a cervical mSASSS of 0, indicating no anterior cervical damage. This corresponds to 7/132 (5.3%) of the overall cohort. Within the ankylosis subset (De Vlam =3), 2/11 (18.2%) also had mSASSS=0 (2/132; 1.5% overall). Cervical facet joint ankylosis was present in 11 patients (8.4%), who had a longer symptom duration (median 16 vs. 7 years, p=0.107, not significant) and a significantly higher proportion of males (81.8% vs. 44.6%, p=0.018) (Table 3). These patients had significantly greater structural damage (median total mSASSS: 7.5 vs. 1) and reduced mobility (BASMI: 5.02 vs. 2.81; cervical rotation: 43.9 °C vs. 65.4 °C). Cervical syndesmophytes (81.9%) and hip involvement (54.5%) were particularly prominent in this subgroup (Table 4).

Spearman rank correlations showed that both the cervical facet (De Vlam ZJ) score and the cervical mSASSS were associated with several clinical/functional measures (Figure 1). Higher ZJ and mSASSS scores correlated with reduced cervical rotation (right: p=-0.23/-0.17, p=0.012/0.056; left: p=-0.24/-0.27, p=0.009/0.003; mean: p=-0.24/-0.23, p=0.008/0.010), greater tragus-to-wall distance (left: p=0.27/0.16, p=0.004/0.095), and lower modified Schober test (p=-0.16/-0.19, p=0.075/0.040). Correlations with lateral lumbar flexion were modest but significant in most comparisons (right: p=-0.18/-0.33, p=0.047/<0.001; left: p=-0.19/-0.40, p=0.040/<0.001). Intermalleolar distance showed small, non-significant associations (p=-0.05/-0.13, p>0.05).

Higher De Vlam ZJ scores [B=-2.397, 95% confidence interval (CI): -3.725 to -1.068, p<0.001] and cervical mSASSS scores (B=-1.007, 95% CI: -1.782 to -0.231, p=0.012) were independently associated with reduced cervical rotation in the multivariate

Table 1. Comparison of demographic, clinical, and treatment characteristics between axSpA patients with and without ZJ involvement (De Vlam score ≥1)

Variables	ZJ involvement (n=24)	No ZJ involvement (n=108)	p-value
Sex, male, n (%)	15 (62.5)	48 (44.4)	0.109
Age, years, mean ± SD	44.25±10.64	39.95±10.77	0.054
Smoker current, n (%)	10 (41.7)	46 (42.6)	0.934
Symptom duration, years, median (IQR)	10 (15)	8 (8)	0.754
Disease duration, years, median (IQR)	6 (7)	6 (10)	0.698
AxSpA type, r-axSpA, n (%)	14 (58.3)	63 (58.3)	0.820
HLA-B27 positive, n (%)	8 (44.4)	39 (50.6)	0.635
Spondlyloarthritis family history, n (%)	8 (33.3)	36 (33.6)	0.977
BMI, kg/m², mean ± SD	26.84±6.13	26.68±4.23	0.879
ESR mm/h, median (IQR)	8.5 (7)	8 (6)	0.256
History of enthesitis, n (%)	10 (41.7)	46 (42.6)	0.936
History of uveitis, n (%)	1 (4.2)	9 (8.3)	0.689
History of peripheral arthritis, n (%)	6 (25)	29 (26.9)	0.853
Psoriasis at baseline, n (%)	2 (4.5)	7 (9.3)	0.556
NSAID, current, n (%)	19 (79.2)	71 (65.7)	0.201
Biological therapy, n (%)	15 (62.5)	62 (57.4)	0.647
Comorbidity, at least one, n (%)	8 (33.3)	32 (29.6)	0.807
BASDAI, score, mean ± SD	3.76±2.03	4.43±2.36	0.111
BASFI, score, mean ± SD	3.40±1.69	2.75±2.45	0.823
ASQoL, score, mean ± SD	6.64±5.33	8.26±5.79	0.126

Data are presented as mean ± SD, median (IQR), or n (%).
axSpA: Axial spondyloarthritis, ZJ: Zygapophyseal joint, SD: Standard deviation, IQR: Interquartile range, BMI: Body mass index, ESR: Erythrocyte sedimentation rate, NSAID: Non-steroidal anti-inflammatory drug, BASDAI: Bath Ankylosing Spondylitis Disease Activity Index, BASFI: Bath Ankylosing Spondylitis Functional Index, ASQoL: Ankylosing Spondylitis Quality of Life, r-axSpA: Radiographic-axial spondyloarthritis

Table 2. Differences in functional measures and radiographic structural damage according to ZJ involvement (De Vlam score ≥1)

Variables	ZJ involvement (n=24)	No ZJ involvement (n=108)	p-value
BASMI total score, mean ± SD	4.18 (1.97)	2.71 (1.09)	**0.002**
Cervical rotation, mean ± SD	51.63 (19.9)	66.5 (14.9)	**<0.001**
Cervical rotation, right, mean ± SD, cm	51.70 (19.8)	64.75 (15.84)	**0.001**
Cervical rotation, left, mean ± SD, cm	51.05 (21.5)	67.75 (15.4)	**0.002**
Tragus-to-wall distance, mean ± SD, cm	18.80 (7.50)	15.4 (2.58)	**0.001**
Lateral lumbar flexion, right, mean ± SD, cm	13.55 (15.46)	19.72 (12.86)	0.086
Lateral lumbar flexion, left, mean ± SD, cm	12.96 (14.10)	18.87 (12.50)	**0.049**
Lateral lumbar flexion, mean ± SD, cm	13.40 (14.86)	19.56 (12.48)	0.086
Intermalleolar distance, mean ± SD, cm	96.6 (16.86)	102.18 (17.05)	0.111
Modified Schober's test, mean ± SD, cm	3.80 (2.22)	4.75 (1.59)	**0.019**
Sacroiliac ankylosis, n (%)	9 (37.5)	10 (9.3)	**<0.001**
Presence of cervical syndesmophyte, n (%)	14 (58.3)	15 (14)	**<0.001**
Presence of lumbar syndesmophyte, n (%)	7 (29.2)	13 (12.1)	**0.036**
Presence of symphysitis, n (%)	2 (8.3)	3 (2.8)	0.227
Sacral enthesitis, n (%)	5 (20.8)	10 (9.3)	0.148
Presence of hip involvement, n (%)	12 (50)	25 (23.1)	**0.008**
Cervical mSASSS, median (IQR)	4 (10)	0 (1)	**0.001**
Lumbar mSASSS, median (IQR)	1 (2)	0 (1)	**0.020**
Total mSASSS, median (IQR)	5 (11)	1 (2)	**<0.001**

Data are presented as mean ± SD, median (IQR), or n (%).
ZJ: Zygapophyseal joint, BASMI: Bath Ankylosing Spondylitis Metrology Index, SD: Standard deviation, mSASSS: Modified Stoke Ankylosing Spondylitis Spinal Score, IQR: Interquartile range

regression model (Table 5). Age, sex, and *HLA-B27* status were not found to be significant. Multicollinearity was not observed [variance inflation factors (VIFs) <1.4], supporting the independent contribution of posterior cervical damage to functional limitation in axSpA.

Binary ZJ involvement and ZJ ankylosis were not modeled multivariably due to limited events. These contrasts are presented as unadjusted mean differences.

DISCUSSION

This study highlights the clinical significance of cervical ZJ involvement in axSpA. We found that ZJ lesions were common and associated with impaired spinal mobility, supporting the notion that posterior spinal structures contribute substantially to functional limitation. Importantly, in multivariate regression, both the De Vlam ZJ score and cervical mSASSS were independently associated with reduced cervical rotation, indicating that posterior damage adds explanatory value beyond anterior vertebral scoring.

These findings support and extend previous reports on the clinical significance of cervical ZJ involvement in axSpA. In a 2024 study by Berbel-Arcobé et al. (7), cervical ZJ involvement was observed in 29.1% of patients, and ZJ fusion was present in 38.1% of those with cervical involvement. Notably, 20 patients (5.9% of the total cohort) exhibited isolated posterior involvement in the absence of anterior vertebral damage. Although the prevalence of ZJ ankylosis was lower in our cohort (8.4% vs. 20%), this difference may be attributed not only to a lower proportion of radiographic axSpA patients (58% vs. 91%) and a younger study population, but also to methodological differences, since Berbel-Arcobé et al. (7) reported ZJ fusion rates within the subgroup of patients with cervical involvement, whereas we reported prevalence across the entire cohort.

A meaningful subset lacked anterior cervical damage despite posterior ZJ lesions [7/24 (29.2%) within the ZJ-involvement group; 2/11 (18.2%) among those with complete ankylosis], supporting the added diagnostic value of posterior assessment. Compared with Berbel-Arcobé et al. (7), the overall proportion

Table 3. Comparison of demographic, clinical, and treatment characteristics between axSpA patients with and without cervical ZJ ankylosis (De Vlam score =3)

Variables	Facet joint ankylosis (n=11)	No ZJ ankylosis (n=121)	p-value
Sex, male, n (%)	9 (81.8)	54 (44.6)	**0.018**
Age, years, mean ± SD	44.82±10.8	39.98±10.81	0.158
Current smoker, n (%)	6 (54.5)	50 (41.3)	0.527
Smoker ever, n (%)	6 (54.5)	65 (54.2)	0.981
Symptom duration, years, median (IQR)	16 (14)	7 (8)	0.107
Disease duration, years, median (IQR)	8.5 (9)	6 (8)	0.414
AS type, r-axSpA, n (%)	9 (81.8)	68 (56.2)	0.120
HLA-B27 positive, n (%)	5 (62.5)	42 (48.3)	0.486
Spondlyloarthritis family history, n (%)	5 (45.5)	39 (32.5)	0.506
BMI, kg/m², mean ± SD	26.9±4.46	24.6±5.92	0.128
ESR mm/h, median (IQR)	10.5 (9)	8 (6)	0.117
CRP mg/L, median (IQR)	4.16 (9.01)	3.95 (6.13)	0.471
History of enthesitis, n (%)	2 (18.2)	54 (44.6)	0.116
History of peripheral arthritis, n (%)	2 (18.2)	32 (27.3)	0.727
History of uveitis, n (%)	1 (9.1)	9 (7.4)	0.595
Psoriasis at baseline, n (%)	2 (4.7)	29 (8.6)	0.556
NSAID, current, n (%)	8 (72.8)	82 (67.8)	1
Biological therapy, n (%)	9 (81.9)	68 (56.2)	0.120
Comorbidity, at least one, n (%)	2 (18.2)	38 (31.4)	0.503
BASDAI, score, mean ± SD	3.05±1.99	4.29±2.26	0.097
BASFI, score, mean ± SD	3.09±2.35	2.65±2.32	0.787
ASQoL, score, mean ± SD	6.33±6.46	7.79±5.62	0.460

Data are presented as mean ± SD, median (IQR), or n (%).
ZJ: Zygapophyseal joint, SD: Standard deviation, IQR: Interquartile range, BMI: Body mass index, ESR: Erythrocyte sedimentation rate, CRP: C-reactive protein, NSAID: Non-steroidal anti-inflammatory drug, ASQoL: Ankylosing Spondylitis Quality of Life, axSpA: Axial spondyloarthritis, AS: Ankylosing spondylitis, BASDAI: Bath Ankylosing Spondylitis Disease Activity Index, BASFI: Bath Ankylosing Spondylitis Functional Index, r-axSpA: Radiographic-axial spondyloarthritis

of isolated posterior involvement was similar (5.3% vs. 5.9%), whereas the proportion within the ZJ-involvement subgroup was higher in our cohort (29.2% vs. 20.2%).

Mechanistically, posterior element pathology at the cervical ZJs—capsular thickening/ossification, joint-space narrowing, and ankylosis—restricts segmental rotation and extension. Hypertrophy/ossification of adjacent posterior ligaments further stiffens the posterior column and alters load transfer, leading to global motion loss even when anterior vertebral corners are normal on mSASSS. Pain-related muscle guarding may additionally reduce active range. These mechanisms are consistent with imaging data showing co-occurrence of posterior and bridging lesions and with studies demonstrating that posterior scoring adds information beyond anterior-focused indices (6,10,13,14). In unadjusted comparisons, cervical ZJ involvement was associated with a 15 °C lower cervical rotation, and ZJ ankylosis with a 22 °C lower rotation, alongside higher BASMI scores. While Berbel-Arcobé et al. (7) reported associations with male sex, smoking, and elevated BMI; these variables were not significant in patients with overall ZJ involvement in our cohort. However, male sex was significantly more frequent in the ankylosis subgroup, suggesting a potential sex-related predisposition to more advanced posterior damage.

A key methodological distinction is that we conducted a multivariate regression analysis in which both the De Vlam ZJ score and cervical mSASSS were found to be independent predictors of reduced cervical rotation. Notably, despite the anatomical and pathological overlap between anterior and posterior lesions, no significant multicollinearity was detected (VIFs <1.4). This suggests that posterior structural changes,

Table 4. Differences in functional measures and radiographic structural damage according to the presence of cervical ZJ ankylosis (De Vlam score =3)

Variables	ZJ ankylosis (n=11)	No ZJ ankylosis (n=120)	p-value
BASMI total, mean ± SD	5.02 (2.51)	2.85 (1.83)	**<0.001**
Cervical rotation, mean ± SD	43.9 (17.88)	65.43 (15.76)	**<0.001**
Cervical rotation, right, mean ± SD	46.2 (17.99)	63.7 (16.62)	**0.002**
Cervical rotation, left, mean ± SD	43.95 (17.80)	64.9 (15.62)	**<0.001**
Tragus-to-wall distance, mean ± SD, cm	21.50 (9.79)	15.76 (2.74)	**<0.001**
Lateral lumbar flexion, right, mean ± SD, cm	16.20 (22.67)	18.17 (12.47)	0.659
Lateral lumbar flexion, left, mean ± SD, cm	15.55 (21.13)	17.96 (12.19)	0.577
Lateral lumbar flexion, mean ± SD, cm	15.87 (21.85)	18.52 (12.75)	0.642
Modified Schober's test, mean ± SD, cm	3.05 (2.77)	4.71 (1.58)	0.093
Intermalleolar distance, mean ± SD, cm	93.70 (20.55)	99.57 (17.36)	0.316
Sacroiliac ankylosis, n (%)	8 (72.7)	11 (9.1)	**<0.001**
Presence of cervical syndesmophyte, n (%)	8 (72.7)	21 (17.5)	**<0.001**
Presence of lumbar syndesmophyte, n (%)	3 (27.3)	17 (14.2)	0.372
Presence of symphysitis, n (%)	2 (18.2)	5 (4.1)	0.106
Sacral enthesitis, n (%)	4 (36.4)	11 (9.1)	**0.023**
Presence of hip involvement, n (%)	8 (72.7)	29 (24)	**0.001**
Cervical mSASSS, median (IQR)	7 (17)	0 (1)	**0.006**
Lumbar mSASSS, median (IQR)	0.5 (12)	0 (2)	0.412
Total mSASSS, median (IQR)	7.5 (29)	1 (3)	**0.012**

Data are presented as mean ± SD, median (IQR), or n (%).
ZJ: Zygapophyseal joint, BASMI: Bath Ankylosing Spondylitis Metrology Index, SD: Standard deviation, mSASSS: Modified Stoke Ankylosing Spondylitis Spinal Score, IQR: Interquartile range

primarily facet joint damage, provide additional explanatory value for cervical mobility impairment in axSpA, beyond what is captured by anterior vertebral scoring alone.

The frequent co-occurrence of syndesmophytes and ZJ ankylosis in our cohort (72.7% vs. 17.5%) aligns with findings from Tan et al. (6), who used thoracolumbar CT to demonstrate that ZJ ankylosis commonly occurs alongside vertebral bridging lesions. Although the cross-sectional nature of our study precludes inference of causality, the predominance of syndesmophytes in patients with ZJ fusion lends support to the hypothesis that anterior and posterior structural damage may develop in close association at the same levels.

The study findings are consistent with a large longitudinal analysis involving 1,106 AS patients, which found that cervical facet joint ankylosis occurred as frequently as bridging syndesmophytes (17.8% vs. 16.8%), and often coexisted (13.5%). That study also found that patients with ZJ ankylosis had a higher disease burden, including elevated cervical mSASSS, more severe sacroiliitis, increased hip involvement, and a greater frequency of uveitis (13). Consistently, in our cohort, ZJ ankylosis was associated with greater functional impairment, as evidenced by higher BASMI scores, reduced cervical rotation, and increased tragus-to-wall distance. In addition, patients with ZJ ankylosis showed more severe structural damage, including higher cervical and total mSASSS scores, and more frequent sacroiliac ankylosis, cervical syndesmophytes, hip involvement, and sacral enthesitis. Together, these findings highlight the importance of evaluating posterior spinal elements, which may reflect more extensive structural damage in axSpA.

Longitudinal data from the same cohort also demonstrated reciprocal changes between anterior and posterior lesions: patients with bridging syndesmophytes showed faster increases in cervical ZJ scores, while those with ZJ ankylosis exhibited more rapid progression in cervical mSASSS (13). Our cross-sectional findings, are consistent with this concept, especially in patients with functional limitation despite low mSASSS values, highlighting cases where posterior damage may precede or exceed anterior lesions.

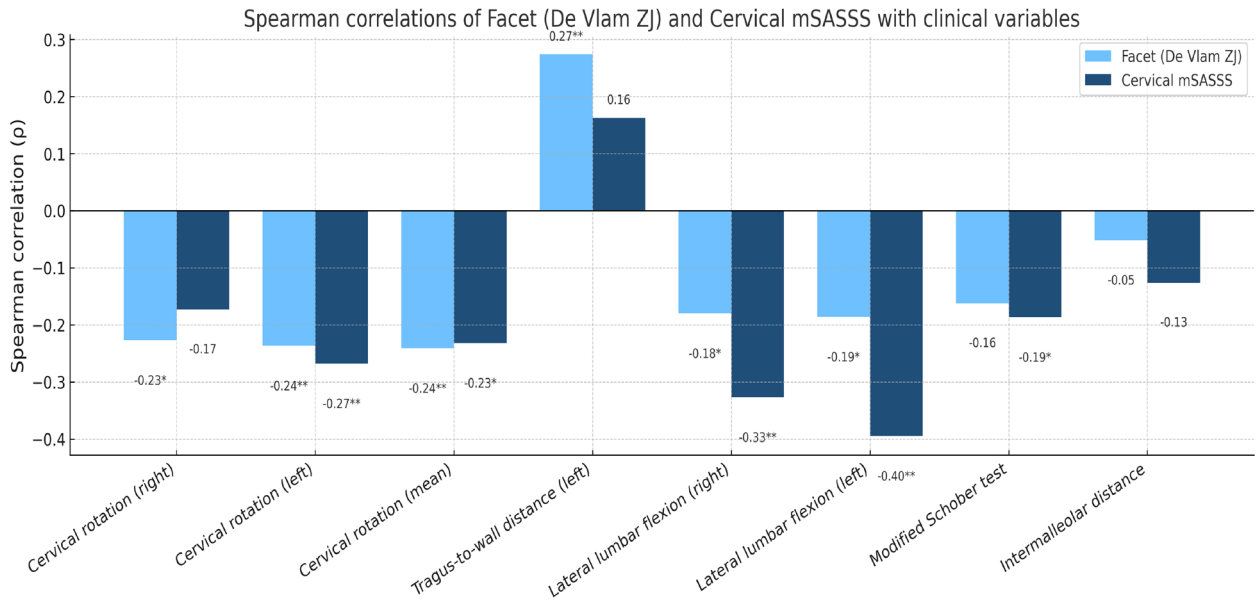

Figure 1. Spearman correlations (ρ) of posterior (cervical facet; De Vlam ZJ) and anterior (cervical mSASSS) structural scores with clinical/functional measures in axial spondyloarthritis (axSpA). Bars display ρ for cervical rotation (right/left/mean), tragus-to-wall distance (left only), lateral lumbar flexion (right/left), modified Schober test, and intermalleolar distance. Numeric labels on bars are r values.
*: p<0.05, **: p<0.01, ZJ: Zygapophyseal joint, axSpA: Axial spondyloarthritis, mSASSS: Modified Stoke Ankylosing Spondylitis Spinal Score

Table 5. Multivariate linear regression for determinants of cervical mobility in patients with axial spondyloarthritis

Variable	B	SE	Beta	p-value	95% CI (Lower)	95% CI (Upper)	Tolerance	VIF
De Vlam score	-2.397	0.668	-0.377	**<0.001**	-3.725	-1.068	0.762	1.312
Cervical mSASSS score	-1.007	0.390	-0.277	**0.012**	-1.782	-0.231	0.729	1.372
Male sex	0.305	0.161	0.179	0.062	-0.016	0.626	0.934	1.071
Age	1.637	3.357	0.048	0.627	-5.037	8.312	0.872	1.147
***HLA-B27* positivity**	5.240	3.368	0.153	0.123	-1.456	11.936	0.867	1.154

mSASSS: Modified Stoke Ankylosing Spondylitis Spinal Score, B: Unstandardised regression coefficient, CI: confidence interval, VIF: Variance inflation factor, SE: Standard error

Recent efforts to improve radiographic assessment have led to the development of the Combined Ankylosing Spondylitis Spine Score (CASSS), which incorporates both cervical mSASSS and ZJ scoring. CASSS has demonstrated greater sensitivity and consistency in tracking disease progression compared to mSASSS alone. In the study by Maas et al. (14), CASSS provided a more balanced representation of axial structural damage, supporting our observation that cervical ZJ ankylosis is independently associated with impaired spinal mobility.

Our findings support incorporating posterior cervical assessment into routine practice when anterior-focused scores are normal or low despite impaired mobility (e.g., high BASMI or reduced cervical rotation), when neck symptoms are disproportionate to anterior radiographic damage, and at baseline before longitudinal follow-up in established axSpA. Posterior scoring is also reasonable when syndesmophytes are present elsewhere or clinical-radiographic discordance is suspected, as it can uncover clinically relevant ZJ pathology that may be missed by anterior-only indices (6,7,13,14).

While the CASSS (cervical mSASSS + ZJ scoring) increases sensitivity to structural burden (14), its practical limitations include additional scoring time, need for reader training in facet-joint grading, and interobserver variability reported in some settings (7). Thus, a pragmatic approach is to apply CASSS at baseline and when clinical–radiographic discordance exists, reserving simpler indices for routine visits. Looking ahead, validated artificial

intelligence and machine-learning-based image analysis could streamline ZJ scoring and improve standardization, potentially enhancing the clinical feasibility of CASSS.

Study Limitations

Our study has several limitations. First, its retrospective and cross-sectional design precludes causal inference and limits our ability to evaluate disease progression over time. Second, the assessment of structural damage was based solely on conventional lateral spinal radiographs, which may lack sensitivity for detecting early or subtle lesions and does not allow evaluation of active inflammation, such as bone marrow oedema. Advanced imaging modalities, such as magnetic resonance imaging or CT, can provide a more comprehensive assessment of both inflammatory and structural changes, particularly in the posterior elements of the spine. Third, the relatively small number of patients with ZJ ankylosis (n=11) may limit the statistical power and generalizability of subgroup analyses. Despite these limitations, the inclusion of detailed functional measures, including BASFI and BASMI, strengthens the clinical validity of our findings. It supports the observed associations between posterior structural damage and spinal mobility impairment.

CONCLUSION

Cervical ZJ involvement and ankylosis are independently associated with reduced cervical mobility and increased structural damage in axSpA. Posterior lesions, which may be radiographically silent on anterior-focused scoring systems, provide additional prognostic information. These findings support the integration of posterior cervical assessments into routine imaging protocols to enhance the evaluation of functional limitation and radiographic severity in clinical practice.

Key Messages

- Cervical zygapophyseal joint involvement is associated with greater radiographic burden and impaired spinal mobility in axial spondyloarthritis.

- ZJ ankylosis is associated with significantly higher Bath Ankylosing Spondylitis Metrology Index scores, indicating more severe functional limitations.

- De Vlam scoring allows detection of posterior structural lesions not captured by modified Stoke Ankylosing Spondylitis Spinal Score.

Ethics

Ethics Committee Approval: This retrospective study was approved by the Uşak University Non-Interventional Clinical Research Ethics Committee (approval number: 600-600-13, date: 20.03.2025).

Informed Consent: Retrospective study.

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Footnotes

Authorship Contributions

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

Conflict of Interest: The authors have no conflicts of interest to declare.

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