Semiquantitative analysis of sacroiliac joint to sacrum ratio of bone scintigraphy to predict spinal progression in early axial spondyloarthritis: a pilot study

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Abstract

Objective

To investigate whether bone scintigraphy with semiquantitative analysis in patients with early axial spondyloarthritis (axSpA) has prognostic value for predicting spinal structural progression of these patients after 2 years.

Methods

The records of 53 patients with early axSpA who underwent baseline bone scintigraphy were reviewed retrospectively. The sacroiliac joint to sacrum (SIS) ratio of bone scintigraphy was measured for semiquantitative analysis, and modified Stoke Ankylosing Spondylitis Spinal Score (mSASSS) and syndesmophyte growth were calculated at baseline and after 2 years. Receiver operating characteristic (ROC) curve analysis was used to determine the cut-off for the SIS ratio of bone scintigraphy. To identify factors associated with significant spinal structural progression, univariate and multivariate logistic regression analyses were performed. Significant progression of spinal structural damage over 2 years was defined as an increase of mSASSS of at least 2 units for 2 years or new syndesmophyte growth/bridging of pre-existing syndesmophytes.

Results

Multivariate regression analysis revealed current smoking status (p=0.010), and high SIS ratio of bone scintigraphy (p=0.016) as independent predictors for worsening mSASSS by at least 2 units over 2 years. For new syndesmophyte growth/bridging of pre-existing syndesmophytes over 2 years, current smoking (p=0.013), high SIS ratio of bone scintigraphy (p=0.025), and pre-existing syndesmophyte (p=0.036) were independent predictors.

Conclusion

Semiquantitative analysis of bone scintigraphy (high SIS ratio) in patients with early axSpA may be useful for identifying patients at high risk for spinal structural progression after 2 years.

Key words

axial spondyloarthritis, bone scintigraphy, semiquantitative analysis, mSASSS, syndesmophyte

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Introduction

Axial spondyloarthritis (axSpA) is a chronic inflammatory disease that typically affects the axial joint and enthesis (1-3). AxSpA includes both non-radiographic axSpA and radiographic axSpA, which is also called ankylosing spondylitis (AS) (1). "Bamboo spine", which is caused by syndesmophyte formation, is one step further, causing tremendous discomfort and limitation in motions.

Abnormal hyperplasia of osteoblasts in the vertebral corner is the underlying pathogenesis of syndesmophyte formation (4), and bone-derived cells from AS showed increased ability of osteoblast differentiation and osteogenesis (5). Therefore, detecting abnormal osteoblast hyperactivity in the axial joints of patients with axSpA might be an attractive imaging modality to detect potential of spinal structural progression.

The main treatment goals for axSpA include managing arthritis and extra-articular symptoms, preventing comorbidities, and attenuating spinal structural progression and ankylosis (6). Nonsteroidal anti-inflammatory drugs (NSAIDs) are the first-line therapy option, but in patients who do not respond to or cannot tolerate NSAIDs, many biologics have shown dramatic improvement in symptoms (6). We know that controlling inflammation by tumor necrosis factor (TNF)-α inhibitors has a suppressive effect on spinal structural damage (7-9) and smoking is a well-known aggravating factor of spinal progression in axSpA (10). Pre-existing syndesmophyte, elevated C-reactive protein (CRP) level, male gender, and severity of sacroiliitis have also been associated with spinal progression in AS patients (11). Fat metaplasia found in magnetic resonance imaging (MRI) of the spine and sacroiliac joint (SIJ) might also predict spinal structural damage (12-14). However, despite our knowledge of managing symptoms and identifying some precipitating factors, we have not been able to identify patients with axSpA at high risk for spinal structural progression.

Bone scintigraphy may be the answer. This well-known nuclear medicine bone-imaging modality is used to evaluate the activity of bone formation related to physiological and pathological conditions (15). Radiotracer, composed of phosphate analogues labeled with technetium-99m (^{99m}Tc), binds to the skeleton and the unbound radiotracer is eliminated from the soft tissues rapidly when intravenously injected. The amount of radiotracer uptake is determined by local blood flow and osteoblast/osteoclast activity (15). Although a pilot study showed bone scintigraphy to be a potential imaging tool to detect subclinical peripheral arthritis in axSpA (16), the usefulness of bone scintigraphy to predict spinal structural progression of axSpA has not been evaluated.

The Assessment of SpondyloArthritis international Society (ASAS) classification criteria (17) and updated definitions for MRI lesions (18), included noting the presence or absence of deep bone marrow oedema of the SIJ on MRI as one of the diagnostic components of axSpA. Fat metaplasia of the spine and SIJ increased odds for spinal structural damage in axSpA (12-14). Although research on the spine and SIJ MRI of axSpA is ongoing, the direct evidence of fat metaplasia and osteoblast hyperplasia is weak.

In the nuclear medicine imaging modalities, semiquantitative analysis such as the standardised uptake value of ^{18}F-fluorodeoxyglucose (FDG) positron emission tomography/computed tomography (PET/CT) or uptake ratio of tumor to contralateral normal breast on breast-specific gamma imaging has demonstrated usefulness in the evaluation of questionable lesions (19, 20). Recently, PET imaging showed potential for detecting osteoblastic activity in the axial joints of axSpA patients (3). Ouichka *et al*. showed that the quantitative activity score of PET/CT using ^{18}F-sodium fluoride on SIJ correlated with the inflammatory score of SIJ MRI in axSpA patients (21). These studies support the potential roles of nuclear medicine imaging in axSpA patients. In this study, we investigated whether bone scintigraphy with semiquantitative analysis in patients with early axSpA provides a prognostic value for predicting the spinal structural progression of these patients after 2 years.

Methods

Patients

The records of consecutive patients who underwent bone scintigraphy for the baseline evaluation of axSpA from August 2005 to July 2017 were reviewed retrospectively. Bone scintigraphy was performed in patients who needed to be evaluated for the extent of involved joints to differentiate axSpA from other forms of arthritis. Patients fulfilled modified New York criteria for AS or ASAS classification criteria for axSpA (17, 22) with less than 3 years of symptom duration (early axSpA) (23), at least 2 years of follow-up study conducted, and older than age 18. Finally, 53 patients with early axSpA were included for this study, which was conducted in accordance with the Declaration of Helsinki and Good Clinical Practice guidelines. This study was approved by the Institutional Review Board (IRB) of our hospital (IRB number: 2019-08-045). The need for written informed consent was waived by the IRB because the data were collected retrospectively.

Demographic characteristics, laboratory data, medical history, and clinical parameters were collected when bone scintigraphy was performed. Body mass index (BMI) was assessed as normal (18.5–22.9), pre-obese (23–24.9), or obese (≥25) according to the Korean Society for the Study of Obesity (24). Cut-off values for the pre-obese and obese categories for Koreans were different from that of Western populations because the Korean population has a higher mortality rate with relatively lower BMIs than the non-Asian population (25); therefore, the World Health Organisation (WHO) recommends defining obesity criteria differently (26). Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) was evaluated, and the cut-off value for BASDAI elevation was >4 units (27). High-sensitivity CRP (hsCRP) level was checked every 3 months, and time-averaged hsCRP was calculated by averaging hsCRP levels over the 2-year follow-up period.

Radiographic assessment

Baseline and 2-year follow-up radiography of the cervical (C-) and lumbar (L-) spine was conducted to calculate the modified Stoke Ankylosing Spondylitis Spinal Score (mSASSS) and syndesmophyte count (28). The C-/L-spine radiographies were assessed separately by two experienced physicians (Min and Kim) who were unaware of the clinical results and the date of examination. The mean mSASSS scored by both readers was used for analysis. Significant progression of spinal structural damage over 2 years was defined as either an increase of mSASSS of at least 2 units for 2 years or new syndesmophyte growth/bridging of pre-existing syndesmophytes (29, 30). If mSASSS evaluations differed by more than 5 units between the two assessors, the same readers recalculated the radiographies. If the discordance persisted, the third independent assessor (Lee) made the final decision.

Baseline and 2-year follow-up sacroiliitis grade was measured according to modified New York criteria by using plain radiography of the pelvis (22). Total change of sacroiliitis grade was determined by subtracting the sum of baseline right and left sacroiliitis grade from the 2-year follow-up right and left sacroiliitis grade, and a change of more than two grades was defined as a significant change.

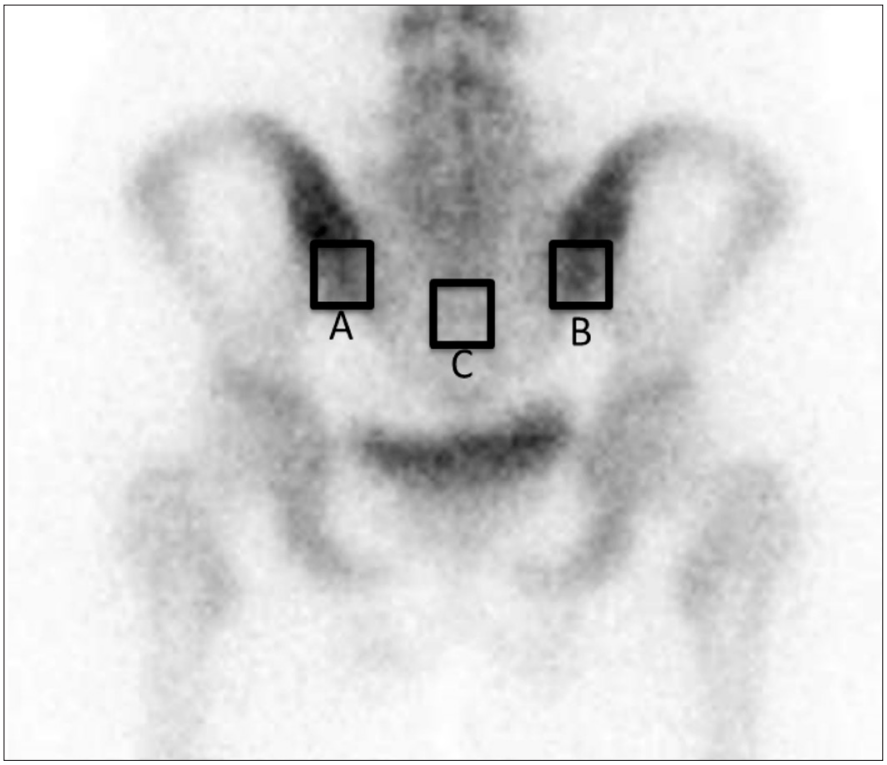

Fig. 1. The sacroiliac joint/sacrum ratio (SIS ratio) was measured by dividing the summation of the total uptake count of ROI (**A**) and (**B**) by the total uptake count of ROI (**C**).

Bone scintigraphy

Bone scintigraphy was performed 3 hours after intravenous administration of 555-740 MBq ^{99m}Tc-hydroxydiphosphonate (HDP) using a dual-headed gamma camera with a low-energy, high-resolution, parallel-hole collimator (E.CAM, Siemens Medical Solutions, USA). Anterior and posterior whole-body images and planar static images were acquired.

For semiquantitative analysis, the Syngo workstation software (v. 2008, Siemens) was used to draw rectangular regions of interest (ROI) on the bilateral SIJ and the central part of the sacrum. Using posterior whole-body imagery, ROI was drawn on the SIJ with relatively prominent uptake first. Then, copied ROIs were drawn on the contralateral SIJ and sacrum (Fig. 1). The SIJ to sacrum (SIS) ratio was calculated by dividing the summed total uptake count of the bilateral SIJ ROIs by the total uptake count of the sacrum ROI. Images were evaluated by two experi-

enced nuclear medicine physicians (So and Chung) who were unaware of the clinical results. Any discrepancies were resolved by consensus.

Statistical analysis

Continuous variables and binary variables were presented as the mean ± standard deviation (SD) and percentage, respectively. Spearman's correlation coefficient was used to seek correlation between bone scintigraphy finding (SIS ratio) and baseline spinal structural damage (mSASSS and syndesmophyte count). To evaluate the reliability of radiographic scoring, we calculated the inter-reader reliability of the baseline and change of mSASSS and syndesmophyte count by intraclass correlation coefficients (ICC). The receiver operating characteristic (ROC) curve analysis was used to determine the cut-off value of the baseline SIS ratio of bone scintigraphy to predict significant spinal structural progression. Univariate logistic regression analysis was performed to find predictors of significant spinal structural progression over 2 years (worsening mSASSS by ≥2 units or new syndesmophyte growth/bridging of pre-existing syndesmophytes). Variables were selected from previous studies demonstrating predictors of radiographic progression in AS (10, 11, 31). Variables with *p*-values <0.1 in univariate analysis were included in multivariate logistic regression analysis. *p*-values <0.05 were considered statistically significant. All statistical tests were performed using IBM SPSS Statistics v. 20.

Table I. Baseline characteristics of total axSpA patients.

	Total axSpA (n=53)
Age (years)	35.7 ± 9.4
Symptom duration (years)	0.9 ± 1.2
Male gender, n (%)	36 (67.9 %)
BMI (kg/m^2)	23.6 ± 3.5
Current smoker, n (%)	27 (50.9 %)
Peripheral arthritis, n (%)	23 (43.4 %)
BASDAI (0-10)	3.6 ± 2.1
Positive HLA-B27, n (%)	44 (83.0 %)
Baseline mSASSS (0-72)	3.2 ± 4.5
Baseline syndemophyte, n (%)	26 (49.1 %)
Sacroiliitis grade, Right (0-4)	1.7 ± 0.9
Sacroiliitis grade, Left (0-4)	1.8 ± 1.0
CRP elevation (hsCRP > 0.3mg/dL), n (%)	30 (56.6 %)
SIS ratio of bone scintigraphy	4.0 ± 1.0
Current medication	
TNF-α inhibitor, n (%)	27 (50.9 %)
NSAID, n (%)	46 (86.8 %)
Sulfasalazine, n (%)	27 (50.9%)

Continuous variables were presented as mean ± standard deviation.
axSpA: axial spondyloarthritis; BASDAI: Bath Ankylosing Spondylitis Disease Activity Index; BMI: body mass index; HLA: human leukocyte antigen; hsCRP: high-sensitivity C-reactive protein; mSASSS: modified Stoke Ankylosing Spondylitis Spinal Score; NSAID: non-steroidal anti-inflammatory drug; SIS: sacroiliac joint to sacrum; TNF: tumour necrosis factor; ^{99m}Tc-MDP: technetium-99m-methylene diphosphonate

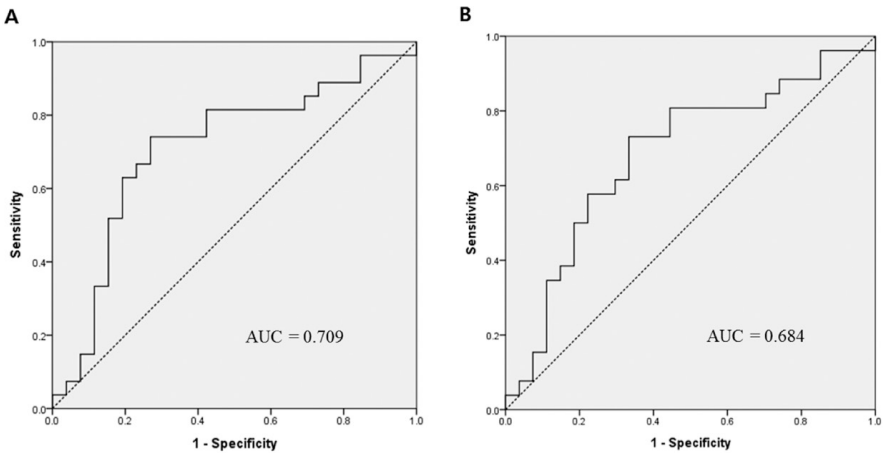

Fig. 2. ROC curves identifying area under curve and optimal SIS ratio of bone scintigraphy cut-off value for predicting significant spinal structural progression, (**A**) mSASSS increase more than 2 units over 2 years, and (**B**) new syndesmophyte/bridging of pre-existing syndesmophyte over 2 years.

Results

Patient characteristics and image analysis

The baseline characteristics are summarised in Table I. The baseline SIS ratio of bone scintigraphy did not show significant correlation with baseline mSASSS and syndesmophyte counts (Rho = -0.136, *p*=0.333, Rho = -0.221, *p*=0.112, respectively).

ICCs with a 95% confidence interval (CI) for baseline mSASSS, change of mSASSS over 2 years, baseline syndesmophyte count, and change of syndesmophyte count over 2 years were 0.972 (0.951–0.984), 0.878 (0.786–0.930), 0.951 (0.914–0.972), and 0.898 (0.821–0.942), respectively. Mean changes over 2 years were 2.1±2.6 for mSASSS and 1.0±1.4 for syndesmophyte count. Significant spinal structural progression over 2 years was observed in 27 of 53 (50.9%) patients demonstrating mSASSS worsening by at least 2 units and in 26 of 53 (49.1%) patients experiencing new syndesmophyte growth/bridging of pre-existing syndesmophyte. Almost half (26 of 53, or 49.1%) of the patients demonstrated both mSASSS worsening by at least 2 units and new syndesmophyte growth/bridging of pre-existing syndesmophyte over 2 years.

ROC curve analysis of SIS ratio of bone scintigraphy

Cut-off values of the SIS ratio of bone scintigraphy for predicting mSASSS worsening by at least 2 units and for predicting new syndesmophyte growth/bridging of pre-existing syndesmo-

Table II. Univariate and multivariate regression analysis for predicting worsening mSASSS at least 2 units over 2 years

	Univariate			Multivariate*		
	OR	95% CI	*p*	OR	95% CI	*p*
Age	1.039	0.978, 1.104	0.215			
Male gender	1.429	0.195, 2.011	0.469			
BMI						
18.5-22.9	1.000 (reference)			1.000 (reference)		
23.0 – 24.9	2.267	0.419, 12.265	0.342	2.205	0.214, 22.729	0.506
≥25.0	3.683	1.062, 12.771	**0.040**	4.154	0.566, 30.506	0.162
Current smoker	7.755	2.286, 26.305	**0.001**	8.228	1.667, 40.618	**0.010**
Baseline elevated BASDAI (≥4)	2.089	0.679, 6.429	0.199			
Time-averaged hsCRP (mg/dL)	1.097	0.653, 1.843	0.727			
Positive HLA-B27	2.588	0.564, 11.876	0.221			
TNF-α inhibitor user	0.368	0.121, 1.117	0.078	0.162	0.025, 1.046	0.056
NSAID user	0.750	0.151, 3.732	0.725			
High SIS ratio of bone scintigraphy	1.967	1.035, 3.736	**0.039**	3.340	1.249, 8.928	**0.016**
Pre-existing syndesmophyte	3.825	1.221, 11.981	**0.021**	5.521	0.925, 32.938	0.061

BASDAI: Bath Ankylosing Spondylitis Disease Activity Index; BMI: body mass index; CI: confidence interval; hsCRP: high-sensitivity C-reactive protein; OR: odds ratio; SIS: sacroiliac joint to sacrum

*All variables yielding *p*-value under 0.1 in univariate logistic regression analysis were included in multivariate analysis, except variables showing multicolinearity with other variables.

Table III. Univariate and multivariate regression analysis for predicting new syndesmophyte or pre-existing syndesmophytes progression over 2 years.

	Univariate			Multivariate*		
	OR	95% CI	*p*	OR	95% CI	*p*
Age	1.060	0.994, 1.130	0.075	1.039	0.942, 1.147	0.443
Male gender	1.125	0.250, 2.526	0.808			
BMI						
18.5-22.9	1.000 (reference)			1.000 (reference)		
23.0 – 24.9	2.267	0.419, 12.265	0.342	1.419	0.136, 14.810	0.770
≥25.0	2.914	0.864, 9.833	0.085	5.633	0.825, 38.459	0.078
Current smoker	9.524	2.717, 33.383	**<0.001**	6.976	1.514, 32.145	**0.013**
Baseline elevated BASDAI (≥4)	1.247	0.414, 3.754	0.695			
Time-averaged hsCRP (mg/dL)	0.969	0.581, 1.614	0.903			
Positive HLA-B27	2.333	0.509, 10.692	0.275			
TNF-α inhibitor user	0.587	0.198, 1.740	0.336			
NSAID user	1.333	0.268, 6.635	0.725			
High SIS ratio of bone scintigraphy	1.823	0.983, 3.384	0.057	3.115	1.156, 8.391	**0.025**
Pre-existing syndesmophyte	6.429	1.941, 21.294	**0.002**	6.347	1.129, 35.664	**0.036**

BASDAI: Bath Ankylosing Spondylitis Disease Activity Index; BMI: body mass index; CI: confidence interval; hsCRP: high-sensitivity C-reactive protein; OR: odds ratio; SIS: sacroiliac joint to sacrum.

*All variables yielding *p*-value under 0.1 in univariate logistic regression analysis were included in multivariate analysis, except variables showing multicolinearity with other variables.

phyte over 2 years were determined by ROC curve analysis (Fig. 2). For predicting mSASSS worsening by at least 2 units over 2 years, area under the curve (AUC) was 0.709 (95% CI 0.563–0.855, p=0.009). The cut-off value of the SIS ratio was 3.96 with 74.1% sensitivity and 73.1% specificity. For predicting new syndesmophyte growth/bridging of pre-existing syndesmophyte over 2 years, AUC was 0.684 (95% CI 0.536–0.831, p=0.022) with a cut-off value of 3.87, sensitivity 73.1%, and specificity 66.7%.

Predictors for significant spinal structural progression and sacroiliitis progression

In univariate logistic regression analysis, obesity (BMI ≥25.0, odds ratio (OR) 3.683), current smoking status (OR 2.089), high SIS ratio of bone scintigraphy (OR 1.967), and pre-existing syndesmophyte (OR 3.825) were significant predictors for worsening of mSASSS by at least 2 units over 2 years (Table II). For new syndesmophyte growth/bridging of pre-existing syndesmophyte over 2 years, current smoking status (OR 9.524) and pre-existing syndesmophyte (OR 6.429) were significant predictors (Table III). After multivariate regression analysis, obesity (OR 8.750), current smoking status (OR 6.359), and high SIS ratio of bone scintigraphy (OR 3.175) were independent predictors for worsening mSASSS by at least 2 units over 2 years (see Table II). For new syndesmophyte growth/bridging of pre-existing syndesmophyte over 2 years, current smoking status (OR 6.976), high SIS ratio of bone scintigraphy (OR 3.115),

Table IV. Univariate regression analysis for predicting radiographic sacroiliitis grade progression (change of total sacroiliitis grade ≥2) over 2 years.

	Univariate		
	OR	95% CI	*p*
Age	0.984	0.901, 1.076	0.727
Male gender	0.580	0.115, 3.281	0.515
BMI			
18.5-22.9	1.000 (reference)		
23.0-24.9	2.083	0.161, 26.963	0.574
≥25.0	3.333	0.543, 20.451	0.193
Current smoker	1.333	0.268, 6.635	0.725
Baseline elevated BASDAI (≥4)	0.568	0.100, 3.244	0.525
Time-averaged hsCRP (mg/dL)	1.290	0.713, 2.333	0.400
Positive HLA-B27	0.745	0.153, 13.849	0.745
TNF-α inhibitor user	0.336	0.059, 1.913	0.219
NSAID user	0.900	0.092, 8.837	0.928
High SIS ratio of bone scintigraphy	2.735	1.168, 6.406	**0.020**
Pre-existing syndesmophyte	3.250	0.570, 18.523	0.184

BASDAI: Bath Ankylosing Spondylitis Disease Activity Index; BMI: body mass index; CI: confidence interval; hsCRP: high-sensitivity C-reactive protein; OR: odds ratio; SIS: sacroiliac joint to sacrum.

and pre-existing syndesmophyte (OR 6.347) were independent predictors (see Table III). High SIS ratio of bone scintigraphy showed significant association with a change in total sacroiliitis grade of more than two grades (OR= 2.735, 95% CI 1.168–6.406, Table IV).

Discussion

To our knowledge, this is the first report to evaluate the prognostic value of bone scintigraphy with semiquantitative analysis for predicting spinal structural progression in patients with early axSpA. Research on evaluating the utility of nuclear medicine imaging technique in inflammatory arthritis is ongoing (32), but the usefulness of semiquantitative measurement of bone scintigraphy in predicting bony structural damage of axSpA has not yet been evaluated. The progression of spinal structural damage eventually can result in ankylosis of the spine, limiting spinal motility and decreasing quality of life. Therefore, identifying patients with axSpA at higher risk for spinal structural progression at an early stage is important.

Among predictors of spinal structural progression in axSpA, fat metaplasia observed in the spine or SIJ on MRI and pre-existing syndesmophyte on plain radiography are the most well-known predictors provided by imaging modalities (1, 7, 12-14, 29, 31, 33, 34). Inflammatory change in SIJ MRI is included as one of the classification criteria of axSpA recommended by ASAS (17). However, MRI evaluates only a limited area at a time and is expensive. Although plain radiography is easily available and has the advantages of being low cost and causing low radiation exposure, it is not able to detect early spinal changes in patients with axSpA.

Bone scintigraphy is used to evaluate the sites of active bone formation by detecting osteoblast activities and visualising the whole skeleton at once (15). Most pathological bone conditions are associated with increased vascularity and bone remodelling, and abnormal osteoblast hyperactivity on the vertebral corner and SIJ is the cornerstone pathological mechanism of ankylosis in patients with axSpA (4). Inflammatory arthritis on axial joints is the predominant manifestation of axSpA; however, peripheral arthritis also is frequently observed in patients with axSpA (17). Bone scintigraphy identified overall involvement of arthritis in the early phase of AS (35) and even subclinical peripheral arthritis of axSpA, which is not detectable in plain radiography (16). Bone scintigraphy is cost-effective and useful in assessing inflammatory arthritis as a whole in systemic inflammatory diseases such as axSpA and RA (16,36) because it can evaluate the extent of involved joints in the early phase, unlike plain radiography.

PET/CT with ^{18}F-fluoride is another promising bone-imaging modality. Compared with radiotracers in bone scintigraphy, ^{18}F-fluoride also binds to the area of new bone formation and acts as a marker of bone blood flow and osteoblastic activity (37). In patients with AS, ^{18}F-fluoride PET/CT detected bone formation (38) and TNF-α inhibitor responder showed decreased ^{18}F-fluoride uptake in the costovertebral joint and SIJ (39). Furthermore, increased ^{18}F-fluoride uptake in the vertebral corner was associated with new syndesmophyte formation (40), and the maximum standardised uptake value of SIJ correlates with the inflammatory score of SIJ MRI (21). However, because of the limited availability and high cost of ^{18}F-fluoride, ^{18}F-fluoride PET/CT is less ideal than widely available, low-cost bone scintigraphy.

Spinal structural damage can be evaluated by measuring mSASSS and syndesmophyte formation in patients with axSpA. Several clinical factors were proved to be associated with spinal structural damage progression. Recently, obesity showed an independently significant association with the progression of spinal damage over 5-year follow-up in patients with AS (31). Furthermore, obesity predicted poor therapeutic response to TNF-α inhibitor in patients with SpA, including AS, non-radiographic axSpA, and psoriatic arthritis (41-43). In this study, obesity showed a positive association with significant mSASSS worsening (Table 2, univariate regression analysis), suggesting that obese axSpA patients might have more spinal structural damage. Although predictive values of obesity on poor disease outcomes with regard to spinal radiologic progression are weak, further research including a larger sample size and basic research revealing the role of adipocytes on axSpA may reinforce the pathologic role of obesity on axSpA. Baseline pre-existing syndesmophyte presence observed in radiography consistently demonstrated significant association with spinal structural damage in AS (7, 8, 29, 33, 34). In this study, similar to previous studies, smoking status and pre-existing syndesmophyte were significantly associated with spinal structural progres-

sion. The representative clinical factor for modification is the smoking status (10, 29).

Several limitations exist in the present study. First, and most important, the results were obtained from a small study population by retrospective review at a single institution. However, this study included a relatively large number of patients with early axSpA who underwent bone scintigraphy when considering the nature of the pilot study. Second, this study did not compare findings of bone scintigraphy and MRI. MRI is recommended as a standard imaging method in ASAS classification criteria (17, 18), and fat metaplasia found by MRI is one of the well-known predictors of spinal radiographic progression in axSpA (12-14); therefore, comparing MRI findings with bone scintigraphy results could help determine the complementary value of each imaging modality for predicting spinal radiography progression. Third, we only enrolled patients with early-stage axSpA whose symptoms' duration was less than 3 years; therefore, the usefulness of bone scintigraphy on long-standing axSpA patients is uncertain.

In conclusion, this study demonstrated that a high SIS ratio of bone scintigraphy is an independent prognostic predictor for spinal structural progression after 2 years in patients with early axSpA. Therefore, semiquantitative analysis of bone scintigraphy in patients with early axSpA may be a useful method to identify patients at high risk for spinal structural progression and allow for early intervention treatments to improve patient outcomes.

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