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Spine abnormalities associated with bone edema on sacroiliac joints MRI in patients with definite non-ax-SpA mechanical chronic back pain

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Abstract

Objective

To investigate whether bone marrow edema (BME) fulfilling the ASAS definition of magnetic resonance imaging (MRI) sacroiliitis is associated with non-inflammatory spine abnormalities in patients with definite mechanical chronic back pain (CBP).

Methods

Patients with definite mechanical CBP, according to the physician, started before the age of 45 and be lasting for more than 3 months but less than 3 years underwent a protocolized MRI and radiographs of sacroiliac joint (SIJ) and spine. BME and structural changes were scored, by three readers, for SIJ as well as non-inflammatory abnormalities for spine, including degenerative lesions and static disorders. Univariate analysis by Chi Square test was performed to search a statistical association between BME fulfilling the ASAS definition of MRI sacroiliitis and the presence of at least one non-inflammatory spine abnormality.

Results

A total of 94 patients were analyzed, 27 (27%) patients had BME and 16 (17%) patients had BME fulfilling the ASAS definition of MRI sacroiliitis; 86 (91.5%) patients had at least one non-inflammatory spine abnormality which are associated into 3 distinct clusters. BME was slightly more frequent at the lower and posterior part of the SIJ. MRI sacroiliitis was associated with interspinous bursitis, facet joint effusion and lateral spinal deviation and was more likely in patients with at least one non-inflammatory spine abnormality (OR 4.96, 95% CI [1.47; 16.72]).

Conclusions

BME fulfilling the ASAS definition of MRI sacroiliitis is significantly associated with non-inflammatory spine abnormalities in patients with mechanical CBP.

Keywords : mechanical chronic back pain, mechanical sacro-iliitis, MRI

1-Introduction

Axial SpA (ax-SpA) is a chronic inflammatory rheumatic disease involving spine and sacroiliac joints (SIJ). Historical criteria for classifying ax-SpA (New York criteria [1]) were primarily based on structural changes on SIJ radiographs (*i.e.* radiographic sacroiliitis). Radiographs only detect structural changes, consequences of chronic inflammation, which appear lately after the start of symptoms, leading to a diagnosis delay of several years. Therefore, these criteria were poorly adapted to early non-radiographic forms. Subsequently, the spread of use of magnetic resonance imaging (MRI) allowed demonstrating the existence of active inflammation in SIJ well before the observation of radiographic structural changes [2]. Then, Assessment of Spondyloarthritis International Society (ASAS) developed new classification criteria for ax-SpA, which are appropriate for both early and late disease stages[3]. Imaging data now include, in addition to radiographic sacroiliitis, active inflammation on MRI suggestive of sacroiliitis. MRI sacroiliitis definition was developed and recently revised by ASAS expert's consensus. It corresponds to the presence of bone marrow edema (BME) in subchondral region of SIJ, on two consecutive slices in case of a single location or on one slice in case of multiple locations [4].

Recent data has risen the question of the lack of specificity of the ASAS definition of MRI sacroiliitis. Indeed, MRI sacroiliitis might be found in patients with non-inflammatory chronic back pain (CBP) [5-10], during pregnancy or in postpartum [9, 11], in athletes [9, 10, 12], and even in healthy subjects [6, 9, 13] in respectively 7-23%, 21-63%, 4-41% and 7-23%.

Thus, degenerative aetiologies of SIJ BME should be considered, given the high prevalence in patients with CBP [14, 15]. SIJ lesions related to degenerative disease are commonly located at the upper and anterior part of the joint, where biomechanical loads are important [16]. Simultaneous involvement of the spine and SIJ is also frequent in degenerative conditions [7].

While MRI spine lesions related to ax-SpA did not provide incremental value compared to MRI of SIJ [17], identification of non-inflammatory spine abnormalities may help to rule out ax-SpA diagnosis. We hypothesized that SIJ BME is associated with non-inflammatory spine abnormalities (*i.e.* degenerative lesions and static disorders) in patient with definite mechanical chronic back pain.

The main objective of our study was to investigate whether SIJ BME fulfilling the ASAS definition of MRI sacroiliitis was associated with at least one non-inflammatory spine abnormality in patients with mechanical CBP. We also aimed at describing the topographic distribution and extent of BME in SIJ.
To our knowledge this is the first paper assessing this question in the literature.

2-Methods

2.1-Population

Consecutive inpatients and outpatients consulting for definite mechanical CBP were prospectively included in the study, in four tertiary French care centres from 2014 to 2015 [18]. Exclusion of the diagnosis of ax-SpA was made as published elsewhere [18]. Briefly, the diagnosis of SpA was excluded before inclusion of the patient in the ILOS cohort by a senior rheumatologist based on clinical and para-clinical data. To be included, back pain had to be mechanical and the diagnosis of ax-SpA had to be excluded by the physician . Back pain had to have started before the age of 45 and be lasting for more than 3 months but less than 3 years. Clinical data regarding age, weight, height were collected. All patients provided their written informed consent. We have obtained the agreement of the ethic committee of Ile de France III (N°2014-A00400-47).

2.2-Imaging procedures

Patients underwent a standardized imaging of SIJ and entire spine on 1.5 or 3 Tesla MRI. Semi coronal slices for SIJ and sagittal slices for spine on short tau inversion recovery (STIR) and T1 fat spin echo (T1 FSE) sequences were performed. Slice thickness was 3-4mm. Each SIJ MRI slice was divided into 4 quadrants according to the Spondyloarthritis research Consortium of Canada (SPARCC) method: upper iliac, lower iliac, upper sacral and lower sacral quadrants [19]. Each SIJ was also divided into 3 parts from anterior to posterior: anterior, central and posterior parts (**supplementary figure 1**). Spine was divided into disco-vertebral units from T9-10 to L5-S1. Patients for whom SIJ or spine MRI were not available were excluded from the study. Radiographs of the pelvis (frontal incidence) and of lumbar spine (frontal and lateral incidences) were also performed.

2.3-Sacroiliac joint lesions

The presence of BME and structural changes (erosion, sclerosis and fat metaplasia) was reported in each quadrant, according to pre-established standardized definitions [4]. In brief, erosion is a defect in subchondral bone associated with full-thickness loss of the dark appearance of the subchondral

cortex at its expected location, with loss of signal on a T1W non-fat-suppressed sequence compared with the normal bright appearance of adjacent bone marrow, sclerosis is a very low signal on all sequences located in a typical anatomical area, fat metaplasia is a bright signal seen on a T1W non-fat-suppressed sequence that is brighter than normal bone marrow, which meets the following requirements: homogeneously bright, located in a typical anatomical area (subchondral bone) and sharply defined along its non-articular border with normal bone marrow. The extension (mm) of the BME was measured in height (axis parallel to the joint) and in depth (axis perpendicular to the joint). Finally, it was specified whether the BME fulfilled the ASAS definition of MRI sacroiliitis (edema affecting the subchondral and periarticular areas of the bone marrow visible on 2 consecutive slices in case of one location, a single slice may be sufficient if there is more than one inflammatory lesion present) and whether it was extensive (depth ≥ 10mm [20]).

2.4-Non-inflammatory spine abnormalities

Non-inflammatory spine abnormalities included both static disorders and degenerative lesions. Static disorders included lumbosacral transitional anomalies, hypolordosis or hyperlordosis, lateral spinal deviation and leg length inequality. Degenerative lesions included degenerated disk, endplates vertebral signal changes, interspinous bursitis, facet joint effusion.

2.4.1-Degenerative lesions

The presence of disk degeneration, endplates vertebral signal changes, interspinous bursitis, facet joint effusion was reported in each disco-vertebral unit. Disk degeneration was graded according to the Pfirmann's classification that comprises 5 stages, ranging from 1 (healthy disk) to 5 (collapsed disk). Degenerated disk corresponds to a threshold ≥ 3 [21]. Endplates vertebral signal changes were graded according to the MODIC's classification [22].

2.4.2-Static disorders

The presence of leg length inequality was determined by searching a coronal pelvic tilt and a difference in height ≥ 10 mm between the tops of femoral heads

(threshold above which back pain may occur [23]) on frontal pelvis radiographs. The presence of lateral spinal deviation on frontal spine radiographs was reported. We also reported the presence of lumbosacral transitional anomalies (lumbarization or sacralization). Lumbarization was defined as the presence of 6 lumbar vertebras because of S1 was separated from the sacrum; sacralization was defined as the presence of 4 lumbar vertebrae because of L5 was fused to the sacrum [24]. Finally, lumbar lordosis was measured by the L1-L5 lordosis angle. Hypolordosis was defined as a L1-L5 lordosis angle ≤ 25° and hyperlordosis as a L1-L5 lordosis angle ≥ 55° [25].

2.5-Reading

All images were read and scored independently by 3 readers (2 rheumatologists (GM, CB) and 1 radiologist (AC)) who were blinded to demographic and clinical data. A calibration session was executed by the 3 readers and was supervised by an experimented radiologist in ax-SpA (PC). Definitions of abnormalities, examples and pitfalls were discussed, followed by a supervised reading of a set of 10 training cases. Only data recorded by ≥ 2/3 readers were considered for this analysis.

2.6-Statistics

A descriptive analysis of demographic and clinical characteristics as well as spine and SIJ abnormalities was performed. Results were expressed as mean with standard deviation (SD) for continuous variables or as number (percentages) for dichotomous variables. Demographic data were compared between patients with BME fulfilling the ASAS definition of MRI sacroiliitis and the remaining patients. Student T test was used for continuous variables and Chi Square test or Fisher test were used for dichotomous variables.

Univariate analysis by Chi Square test was performed to search a statistical association between BME fulfilling the ASAS definition of MRI sacroiliitis and the presence of at least one non-inflammatory spine abnormality. Results were expressed as odds ratio (OR) with their 95% confidence interval (95% CI). P-value < 0.05 were considered statistically significant.

Focused principal component analysis is a statistical model representing accurately the correlations of a given variable with the other variables [26]. Results are expressed as a two-dimensional diagram focused on the variable of interest corresponding in our study to BME fulfilling the ASAS definition of MRI sacroiliitis.

Finally, interobserver reproducibility was calculated by the kappa (k) test and was judged as low ($k<0.2$), fair ($0.2<k<0.4$), moderate ($0.4<k<0.6$), good ($0.6<k<0.8$) and excellent ($0.8<k<1$).

3-Results

3.1-Population

A total of 101 patients were screened for eligibility; 7 patients were excluded because SIJ or spine MRI were not available. A total of 94 patients were finally analyzed. The main demographic and clinical characteristics are shown in **Table 1.** The mean (SD) age was 35.3 (7.4) years, the mean body mass index (BMI) was 24.7 (4.8) kg/m^2 and the proportion of men was 41.5%. Excluded patients displayed a significantly higher BMI (mean 29.0 (3.5) kg/m^2) than included patients (mean 24.7 (4.8) kg/m^2). Other demographic parameters were similar in both populations (**Supplementary table 1**).

3.2-Descriptive analysis of sacroiliac joint and spine abnormalities

A total of 48 SIJ BME and 35 SIJ BME fulfilling ASAS criteria were found in respectively 27 (27%) and 16 (17%) patients. 11 (11.7%) patients had at least one structural change in SIJ. Most of the patients (86 (91.5%)) had at least one non-inflammatory spine abnormality. Degenerative lesions have been more frequently reported than static disorders: 83 patients (88.3%) had at least one degenerative lesion while 27 patients (28.7%) had at least one static disorder. The most frequent degenerative lesions reported were degenerated disk and facet joint effusion, found in 78 patients (83%) and in 21 patients (22.3%) respectively. The most frequent static disorders reported were hypolordosis or hyperlordosis and lumbosacral transitional anomalies, found in 11 patients (11.7%) and 6 patients (6.4%) respectively (**Table 2**). **Figure 1** showed the frequency and the topographic distribution of the degenerative lesions according to the presence or not of a static disorder. Degenerative lesions were more frequent in the lowest disco-vertebral units, especially in L4-L5 and L5-S1. Degenerated disk and facet joint effusion were more frequent in case of a static disorder.

3.3-Descriptive analysis of sacroiliac joint bone marrow edema

The topographic distribution of BME in SIJ is shown in **Table 3.** Similar results were observed for BME fulfilling or not the ASAS definition of MRI sacroiliitis. BME was more frequent on the inferior and posterior part of the joint (SIJ foot). BME mean height was 11.7± 5.6 mm and the mean depth 7.4 ± 2.5mm, almost all BME

(96%) were not extensive (*i.e.* <10mm in depth). BME fulfilling the ASAS definition of MRI sacroiliitis was almost exclusively identified in women (91.7% were females, p<0,05) and patients with higher BMI (mean 27.7 (6.7) *vs.* 24.2 (4.2) kg/m^2, p<0,05).

3.4-Association between non-inflammatory spine abnormalities and BME on SIJ

The univariate analysis found a statistically significant association between SIJ BME fulfilling the ASAS definition of MRI sacroiliitis and the presence of at least one non-inflammatory spine abnormality (OR 4.96, 95% CI [1.47; 16.72], p<0,01). The principal component analysis, represented on **Figure 2**, showed that SIJ BME fulfilling the ASAS definition of MRI sacroiliitis was associated with the following non-inflammatory spine abnormalities: interspinous bursitis, facet joint effusion, lateral spinal deviation; as well as the following SIJ structural lesion: fat metaplasia. Moreover, 3 clusters of spine or SIJ abnormalities were observed: i) facet joint effusion, lateral spinal deviation and hypolordosis or hyperlordosis, ii) interspinous bursitis, degenerated disk and lumbosacral transitional anomalies and iii) SIJ structural changes (*i.e.* fat metaplasia, sclerosis and erosion).

3.5-Interobserver reproducibility

Interobserver reproducibility was excellent for the detection of BME, good for the detection of endplates vertebral signal changes, hypolordosis or hyperlordosis, leg length inequality and moderate for the detection of facet joint effusion, lumbosacral transitional anomalies, lateral spinal deviation and sclerosis. Interobserver reproducibility was fair for the other SIJ and spine abnormalities (**Table 4**).

4-Discussion

Our study suggests that non-inflammatory spine abnormalities are 5 times more frequent in presence of BME fulfilling the ASAS definition of MRI sacroiliitis in patients with mechanical CBP. We also confirmed the existence of MRI sacroiliitis, as defined by ASAS, in conditions unrelated to ax-SpA and more precisely in patients under 45 years of age with mechanical CBP. The prevalence was about 17%, in agreement with previous reports whose prevalence ranged between 21 and 23% [5, 7].

In this paper we show that the perturbation of the spinal balance is related to degenerative spinal disorders that we link to the presence of degenerative sacroiliac edema. From our point of view, this is the first study to show such a link between mechanical spinal stress and degenerative sacroiliac damage. We also demonstrate that bone marrow edema of the sacroiliac lower and posterior part is not specific of an inflammatory condition.

Spine static disorders are associated with non-inflammatory spine abnormalities, especially in the two lowest disco-vertebral units, because they cause changes in loads distribution on spine. The critical role of static disorders on loads distribution is suggested by the principal component analysis which showed distinct association between specific non-inflammatory spine abnormalities and spine misalignments Hence, lateral spinal deviation and spine curvature (hypolordosis or hyperlordosis) are associated with facet joint effusion. Association between facet joint disease and spine misalignment have been previously described [27, 28]. Moreover, lumbosacral transitional anomalies are associated with degenerated disk and interspinous bursitis. It can be explained by the hypermobility of the spinal segment overlying the transitional level exposing it to a risk of earlier disc degeneration[29]. Hence, our data suggest that static disorders also induce SIJ BME. We could not determine whether static disorders directly generate SIJ degeneration leading to BME or indirectly through spine degeneration.

SIJ have been considered as immobile joints almost until 1980's [30]. However, similarly to other synovial joints, SIJ may degenerate and display subchondral BME according to biomechanical loads applied to the joint. Gender-related

divergence of the pelvic dimension and SIJ articular surface area [31], higher rate of SIJ misalignment and higher SIJ mobility [32], especially in multiparous women, may explained why most of the BME were observed in female patients. SIJ BME seems more frequent in women indicating pregnancy-related CBP [7].

Topographic distribution of SIJ BME has been poorly studied in patients with ax-SpA and no preferential localization has been identified. Recently, two studies have provided new information: BME was found throughout the joint, without predominance for the iliac or sacral bone, the upper or lower part and the anterior or posterior part [9, 33]. BME associated with ax-SpA is usually bilateral unlike BME unrelated to ax-SpA which is almost exclusively unilateral [33, 34]. BME at the lower and posterior part of SIJ is often considered specific to inflammatory diseases and particularly ax-SpA whereas BME can also be observed at these locations in non-inflammatory conditions[16].
We confirmed in this paper that BME at the lower and posterior part was not specific of ax-SpA. Indeed, in patients with mechanical CBP, BME was slightly more frequent at the lower and posterior part of the joint whereas we could have assumed a predominance in the upper and anterior part often considered as exposed to the greatest biomechanical loads. Similar results were reported in other non-inflammatory conditions like in athletes [9], healthy subjects [12] or in postpartum women [11]. We found that BME was always not extensive in patients with mechanical CBP as previously reported in non-inflammatory conditions such as healthy subjects or athletes whereas BME associated with ax-SpA is generally extensive [9]. However extensive BME was also described in post-partum but have regressed within a year of delivery [11].

In addition, we described very low frequency of SIJ erosions (5%) similarly to other studies in patients with CBP (7-8%) [5]whereas such structural changes are more frequent in patients with inflammatory back pain evocative of ax-SpA (60-67%) [35]. Several authors have suggested the diagnostic value of structural changes. De Hooge *et. al* concluded that the presence of ≥ 3 erosions, ≥ 3 fat metaplasia, ≥ 5 erosions and/or fat metaplasia provided a better specificity than the ASAS definition of MRI sacroiliitis [36]. Likewise, the combination of

inflammatory lesions and structural changes provided a better specificity than the ASAS definition of MRI sacroiliitis, with an optimal threshold for ≥ 3 BME and ≥ 1 erosion [35].

The main strength of our study was the systematic analysis of non-inflammatory spine abnormalities and SIJ lesions in young patients with mechanical CBP for whom the diagnosis of ax-SpA should be discarded in daily practice because one out of five patients present with BME of SIJ fulfilling the ASAS definition of MRI sacroiliitis. Non-inflammatory spine abnormalities of the studied population were similar to CBP population: degenerated disk (83% vs 88%) [5], endplate signal changes (12% vs 21%) [5], facet joint effusion (22 % vs 34%) [37], interspinous bursitis (6 %vs 8%) [38], lumbosacral transitional anomalies (6 vs 15%) [39], lateral spinal deviation, (14% vs 8%) [40], leg length inequality (2% vs 7%) [41].

Moreover, our study provide data on interobserver reproducibility of non-inflammatory spine abnormalities, which has been poorly reported. We report greater reproducibility of BME compared to other SIJ lesions. All non-inflammatory spine abnormalities displayed moderate to good reproducibility, except degenerated disk and interspinous bursitis which display only fair reproducibility. Our study reports similar or greater interobserver reproducibilities than other studies [42], which could be explained by the prior readers calibration.

A few limitations should be emphasized. We excluded 7 patients because spine and/or SIJ MRI were not available. These patients had significantly higher BMI. Considering the association between BMI and degenerative spine abnormalities as well as between BMI and BME in SIJ, excluding patients with higher BMI may have underestimated these lesions[43]. Due to the limited number of patients, the size of each variable of interest could be small and lead to a low statistical power. We consequently chose to use a composite criterion for our principal analysis which also reflects clinical practice. Indeed, in a patient suffering from CBP, the

diagnostic approach is often based on multiples arguments including the global analysis of the spine on imaging.

SIJ BME was 5 time more frequent in case of non-inflammatory spine lesions. Due to the high prevalence of non inflammatory spine lesions in this cohort groups were not balanced in size. Our study being only descriptive it had no impact on our results.

Patients included in this trial displayed non inflammatory low back pain, as a consequence ASAS criteria for Ax-SpA should not be applied to this population. Exclusion of Ax-SpA diagnosis was made by a senior rheumatologist based on clinical and para-clinical data avaiblale. Since the performances of the ax-SpA criteria and Rheumatologist's axSpA diagnosis are highly correlated inclusion of ax-SpA patients in our study is unlikely but this constitute a possible bias [44].

Finally, clinical data such as pregnancy status, levels of physical activity were not available. These data could be of importance to interpret the presence of bone marrow edema in our population.

Our results imply that SIJ BME fulfilling the ASAS definition of MRI sacroiliitis is associated with non-inflammatory spine abnormalities, such as degenerative lesions and static disorders, in patients with mechanical CBP. This could help clinicians managing patients for whom diagnosis of ax-SpA is doubtful. Moreover, we reported topographic distribution and quantitative data on extent of SIJ BME in this population.

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6-Figures and Tables

Table 1. Demographic and clinical characteristics of included patients

	Whole population (n = 94)	Patients with BME fulfilling the ASAS definition of MRI sacroiliitis (n = 16)	Patients without BME fulfilling the ASAS definition of MRI sacroiliitis (n = 78)
Age, years	35.3 (7.44)	33.7 (6.10)	35.6 (7.7)
Gender, male	34/82 (41.5)	1/12 (8.3)*	11/12 (91.7) *
BMI	24.7 (4.8)	27.7 (6.7)*	24.2 (4.2)*
Arthritis	2/83 (2.4)	1/13 (7.7)	1/70 (1.4)
Heel pain	4/82 (4.9)	2/13 (15.3)	2 /69 (2.9)
Uveitis	1/83 (1.2)	0/13 (0)	1/70 (1.4)
IBD	2/83 (2.4)	1/13 (7.7)	1/70 (1.4)
Psoriasis	4/83 (4.8)	0/13 (0)	4 /70 (5.7)
Familial history of SpA	10/79 (12.6)	0/12 (0)	10/67 (14.9)
Good response to NSAIDs	23/74 (31.1)	3/11 (27.3)	20/63 (31.7)

Data are represented as mean (SD) for continuous variables or numbers (percentage) for dichotomous variables. BME: bone marrow edema. ASAS: assessment of spondyloarthritis international society. SIJ: sacroiliac joints. MRI: magnetic resonance imaging. BMI: body mass index. IBD: inflammatory bowel disease. SpA: spondyloarthritis. NSAIDs: non-steroidal anti-inflammatory drugs. Fisher Test was performed except for age (Student T test). * $P<0.05$, ** $P<0.01$, ** $P<0.001$.

Table 2. Frequencies of sacroiliac joints and spine abnormalities

	Whole population (n = 94)	Patients with BME fulfilling the ASAS definition of MRI sacroiliitis (n = 16)	Patients without BME fulfilling the ASAS definition of MRI sacroiliitis (n = 78)
Sacroiliac joints			
BME	27/94 (28.7)	16/16 (100)	11/78 (14.1)
BME fulfilling the ASAS definition of MRI sacroiliitis	16/94 (17)	16/16 (100)	0/16 (0)
Erosion	5/94 (5.3)	2/16 (12.5)	3/78 (3.8)
Fat metaplasia	4/94 (4.3)	3/16 (18.8)	1/78 (1.3)
Sclerosis	7/94 (7.4)	3/16 (18.8)	4/78 (5.1)
At least one structural change	11/94 (11.7)	6/16 (37.5)	5/78 (6.4)
Spine			
Degenerative lesion			
Degenerated disk (Pfirrmann ≥ 3)	78/94 (83)	14/16 (87.5)	64/78 (82.1)
Endplate signal change (MODIC all types)	11/94 (11.7)	2/16 (12.5)	9/78 (11.6)
Facet joint effusion	21/94 (22.3)	5/16 (31.3)	16/78 (20.5)
Interspinous bursitis	6/94 (6.4)	2/16 (12.5)	4/78 (5.2)
At least one degenerative lesion	83/94 (88.3)	15/16 (93.8)	66/76 (86.8)
Static disorder			
Lumbosacral transitional anomalies	6/94 (6.4)	1/16 (6.3)	5/78 (6.4)
Hypolordosis or hyperlordosis	11/94 (11.7)	4/16 (25)	7/78 (9)
Lateral spinal deviation	13/94 (13.8)	5/16 (31.3)	8/78 (10.3)
Leg length inequality	2/94 (2.1)	0/16 (0)	2/78 (2.6)
At least one static disorder	27/94 (28.7)	7/16 (43.8)	20/78 (25.6)
At least one non-inflammatory spine abnormality	86/94 (91.5)	16/16 (100)	70/78 (89.7)

Data are represented as mean (SD) for continuous variables or numbers (percentage) for dichotomous variables. BME: bone marrow edema. ASAS: assessment of spondyloarthritis international society. SIJ: sacroiliac joints. MRI: magnetic resonance imaging.

Table 3. Topographic distribution of bone marrow edema in sacroiliac joints

	BME n=48		BME fulfilling the ASAS definition of MRI sacroiliitis n=35	
	Sacral bone	Iliac bone	Sacral bone	Iliac bone
Upper part	10 / 48 (20.8)	11 / 48 (22.9)	9 / 35(25.7)	8/ 35 (22.8)
Lower part	8 / 48 (16.7)	19 / 48 (39.6)	6/ 35 (17.2)	12/ 35 (34.3)
Anterior part	16 / 48 (33.3)		13 / 35 (37.2)	
Central part	7 / 48 (14.6)		4 / 35 (11.4)	
Posterior part	25 / 48 (52.1)		18 / 35 (51.4)	

Data are presented as ratio (percentage) of BME on either the upper, lower, anterior, central or posterior part of SIJ / total number of SIJ BME.

BME: bone marrow edema. ASAS: assessment of spondyloarthritis international society. SIJ: sacroiliac joints. MRI: magnetic resonance imaging.

Table 4. Interobserver reproducibility for sacroiliac joints and spine abnormalities

	Kappa	95% Confidence Interval
Sacroiliac joints		
BME	0.83	0.72, 0.93
BME fulfilling the ASAS definition of MRI sacroiliitis	0.87	0.77, 0.98
Erosion	0.28	0.02, 0.44
Fat metaplasia	0.29	0.07, 0.50
Sclerosis	0.41	0.22, 0.61
Spine		
Degenerated disk (Pfirrmann ≥ 3)	0.30	0.07, 0.51
Endplate signal changes (MODIC all types)	0.68	0.53, 0.84
Facet joint effusion	0.46	0.30, 0.62

Interspinous bursitis	0.36	0.15, 0.59
Lumbosacral transitional anomalies	0.51	0.33, 0.72
Hypolordosis or hyperlordosis	0.68	0.51, 0.85
Lateral spinal deviation	0.52	0.37, 0.68
Leg length inequality	0.60	0.35, 0.89

BME: bone marrow edema. ASAS: assessment of spondyloarthritis international society. SIJ: sacroiliac joints. MRI: magnetic resonance imaging.

Figure 1. Heatmap of degenerative lesions per disco-vertebral unit according to the presence or not of a static disorder

Each spot is a representation of the frequency (in %) of the degenerative lesion according to the presence or absence of static disorder for each disco-vertebral unit. A darker spot is representative of a higher frequency according to gray scales provided. Static disorder is defined as leg inequality >10mm, lateral spine deviation or abnormal lumbar lordosis. Degenerative lesions were more frequent in the lowest disco-vertebral units, especially in L4-L5 and L5-S1. Degenerated disk and facet joint effusion were more frequent in case of a static disorder.

Figure 2 Focused principal component analysis focused on bone marrow oedema in sacroiliac joints fulfilling the assessment of spondyloarthritis international society definition of MRI sacroiliitis and non-inflammatory spine abnormalities

Each dot represents a non-inflammatory spine abnormalities. The interpretation is as follows: i) The closer the dot is to the center, the closer is the correlation between SIJ BME and the variable of interest, ii) 2 points close to one another indicate a strong positive correlation between both lesions, iii) Two diametrically opposed dots indicate a strong negative correlation between both lesions; iv) Two dots placed at a similar distance from the origin, parallel to one of the axes, indicate absence of correlation between both lesions The dashed circle delimits statistical significance at the 5% level.

BME: Bone Marrow Edema. SIJ: Sacro-Iliac Joint. MRI: magnetic resonance imaging.

Supplementary table 1. Demographic and clinical characteristics of excluded patients

	Excluded patients (n = 7)	Whole population (n = 94)
Age, years	35.3(5.0)	35.3 (7.4)
Gender, male	4/7 (57.1)	34/82 (41.5)
BMI	29.0 (3.5)*	24.7 (4.8)*
Arthritis	0/7 (0)	2/83 (2.4)
Heel pain	0/7 (0)	4/82 (4.9)
Uveitis	0/7 (0)	1/83 (1.2)
IBD	0/7 (0)	2/83 (2.4)
Psoriasis	0/7 (0)	4/83 (4.8)
Familial history of SpA	0/7 (0)	10/79 (12.6)
Good response to NSAIDs	0/7 (0)	23/74 (31.1)

Data are represented as mean (SD) for continuous variables or numbers (percentage) for dichotomous variables. BME: bone marrow edema. ASAS: assessment of spondyloarthritis international society. SIJ: sacroiliac joints. MRI: magnetic resonance imaging. BMI: body mass index. IBD: inflammatory bowel disease. SpA: spondyloarthritis. NSAIDs: non-steroidal anti-inflammatory drugs.
Fisher Test was performed except for age (Stutent T test).
* P<0.05, ** P<0.01, ** P<0.001.

Supplementary Figure 1.

Schematic representation of the correspondance between anatomical parts of the sacro-iliac joints and MRI.
1: anterior part. 2: central part. 3: posterior part