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Frequency and anatomic distribution of magnetic resonance imaging lesions in the sacroiliac joints of spondyloarthritis and non-spondyloarthritis patients

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Abstract

Background: Lesions detected by magnetic resonance imaging (MRI) of the sacroiliac joints are critical to the diagnosis of non-radiographic axial spondyloarthritis. However, inflammatory and structural lesions may be encountered in other conditions.

Objectives: The objective of this study was to evaluate and compare the frequency and localization of inflammatory and structural lesions on MRIs of the sacroiliac joint of spondyloarthritis (SpA) and non-spondyloarthritis (non-SpA) patients.

Design: This is a retrospective study including 200 patients, each having undergone an MRI of the sacroiliac joints.

Methods: Two experienced readers evaluated the whole set of images to detect erosions, subchondral sclerosis, fatty lesions, bone marrow edema (BME) and ankylosis according to the definitions established by the ASAS MRI working group. We divided sacroiliac joints into five segments: upper, antero-middle, intermediate-middle, postero-middle and lower.

Results: A total of 96 subjects with SpA (mean age 37.4 ± 11.8 years) and 104 without SpA (mean age 39.9 ± 11.6 years) were included. Of the 96 SpA patients, 65% had inflammatory buttock pain compared with 25% in the non-SpA group. BME was seen in 65% of SpA patients, mainly in the intermediate-middle segment, and in 20% of non-SpA patients, predominantly in the antero-middle segment. Subchondral sclerosis occurred in 44% of non-SpA patients, mostly in the antero-middle segment, and in 36% of SpA patients. Fatty lesions were present in 34% of SpA and in 21% of non-SpA patients. Erosions were seen in 25% of non-SpA and in 60% of SpA patients. BME and structural lesions were minimally observed in the postero-middle segment in non-SpA patients.

Conclusion: Inflammatory and structural lesions were observed in all segments of the joint in SpA, mainly in the middle segments, while lesions predominantly affected the antero-middle segment in non-SpA, and were uncommon in the postero-middle segment.

Keywords: MRI, sacroiliac, sacroiliitis, spondyloarthritis

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Introduction

Spondyloarthritis (SpA) is a chronic musculoskeletal disease affecting young adults and resulting in pain and disability.[1] Prior to the emergence of magnetic resonance imaging (MRI), the diagnosis of ankylosing spondylitis (AS) or radiographic axial spondyloarthritis (r-axSpA) was established based on the presence of radiographic sacroiliitis according to the modified New York criteria. The development of MRI has led to the early identification of patients with axial spondyloarthritis (axSpA), that is, the subchondral bone marrow

edema (BME) visualized at the sacroiliac (SI) joint preceding radiographic structural damage.[2] The clear presence of BME on two consecutive slices of an MRI of the SI joint or multiple BME lesions on a single slice, highly suggestive of SpA, defines sacroiliitis, according to the Assessment of SpondyloArthritis international Society (ASAS). Sacroiliitis patients are further classified as non-radiographic axial spondyloarthritis (nr-axSpA) in the absence of radiographic sacroiliitis and as radiographic (r)-axSpA in presence of radiographic sacroiliitis, according to the imaging arm of the ASAS classification criteria.[3–5] However, a growing body of evidence suggests the presence of BME in patients without SpA, particularly in postpartum women and in athletes, but also in the general population.[6–11] Furthermore, structural lesions observed on the MRI of the SI joints of patients with SpA can also be seen in non-SpA patients.[12] Thus, it is essential to have a good command of the interpretation of SI joint MRIs, in order to establish the most likely diagnosis. The anatomic distribution of inflammatory and structural lesions in a large cohort of patients with and without SpA has previously been investigated in a single study.[13] Division of the SI joint to enable easy analysis seems indispensable in current practice, as it has been suggested that some segments are preferentially associated with the inflammatory or mechanical origin of the lesions.[13] In this retrospective study, we aimed to analyse and compare the anatomic distribution of structural and inflammatory lesions present on the MRI of SI joint in patients with and without SpA, including, as in current practice, patients with non-specific low back pain, women with obstetric history, and athletes, with no age restrictions.

Subjects and methods

This study did not require ethics committee approval because of its retrospective nature and its lack of impact on the diagnostic and therapeutic management of patients. In this single-centre, retrospective study, patients provided consent before proceeding with any examinations, according to the guidelines for Good Clinical Practice. The study was performed in compliance with the requirements of the Declaration of Helsinki and French national legislation for the protection of personal data. This study is reported in compliance with the RECORD statement.[14] We included patients with suspected SpA who had undergone MRI of the SI joint between January 2013 and February 2020. A total of 200 patients were collected, 96 axSpA patients fulfilling the ASAS classification criteria and whose diagnosis had been retained by an expert committee, as well as 104 non-SpA patients.[3,4,15]

The MRIs used in this study were diagnostic MRIs. Thus, the clinical and imaging data were obtained from biologic disease-modifying anti-rheumatic drugs (bDMARDs)-naive patients with active disease and a Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) $>$ 40/100. MRI lesions were evaluated taking account of age, physical activity, obstetric history, HLA-B27 positivity, and BMI $>$ 30 kg/m^2.

We excluded patients with an anatomical variant of the SI joints that could influence the lesions observed on MRI.[16,17] Accessory SI joints, iliosacral complex, bipartite bony plate, semicircular defect, iliac bony plate, and ossification centres were considered as anatomical variants.

The following data were recorded for all patients: (1) high-intensity sport or work activity (running, basketball, soccer, horseback riding, law enforcement officers, construction workers, service workers) on a regular basis (more than once a week), defining active subjects; (2) obstetrical history, defined as a delivery within the previous 3 years; (3) medical history of psoriasis, inflammatory bowel disease or uveitis. All data were rendered anonymous before analysis.

MRI Protocol

MRI of the SI joint was performed on one of two MRI machines (1.5 T Aera, Siemens, Erlangen, Germany, and 3 T Skyra, Siemens, Erlangen, Germany). The sequences included a semicoronal T1-weighted sequence, with time to recovery (TR) of 468 ms, time to echo (TE) of 12 ms and slice thickness of 4 mm; a short tau inversion recovery (STIR) sequence, with TR of 3000 ms, TE of 31 ms and slice thickness of 4 mm for the 1.5 T MRI; a semicoronal T1 sequence, with TR of 418 ms, TE of 22 ms and slice thickness of 4 mm; and a STIR sequence, with TR of 3660 ms, TE of 45 ms and slice thickness of 4 mm for the 3 T MRI.

Anatomic distribution

Based on the SPARCC score, each sacroiliac MRI was divided into eight successive slices, the first two slices corresponded to the antero-middle segment of the joint; slices 3 and 4 were divided

into two, the upper half corresponding to the intermediate-middle segment and the lower half to the lower segment; slices 5 and 6 were also divided into two, with the upper half corresponding to the postero-middle segment and the lower half to the lower segment; and finally, slices 7 and 8 were also divided into two, with the upper half corresponding to the upper segment and the lower half to the lower segment (Figure 1).

MRI interpretation

Two experienced readers blindly analysed the MRI scans of all 200 patients included. They noted the presence or absence of the following lesions: inflammatory changes such as BME, and structural changes such as subchondral sclerosis, fatty lesions, erosions and ankylosis. The lesions were classified according to their anatomical localization. The complete cartilaginous compartment was scored. In case of discordance, the MRIs were reread and discussed until consensus was reached.

Lesion definitions

Structural and inflammatory lesions had to meet the definitions outlined by the ASAS to be included.[3,4] The lesion definitions used applied in each segment studied.

Statistical analyses

The analyses included anatomical localization of lesion per segment (upper, antero-middle, intermediate-middle, postero-middle and lower). Patient characteristics, clinical, biochemical and MRI data are described with descriptive statistics. The Mann–Whitney *U* test was used to compare SpA patients with non-SPA patients. A p value 0.05 was considered statistically significant. The diagnostic utility of inflammatory and structural lesions for the diagnosis of SpA was determined according to their distribution by calculating the sensitivity, specificity, and positive and negative predictive values (PPV and NPV, respectively). Reliability for the presence/absence of each lesion was assessed using the kappa statistic.

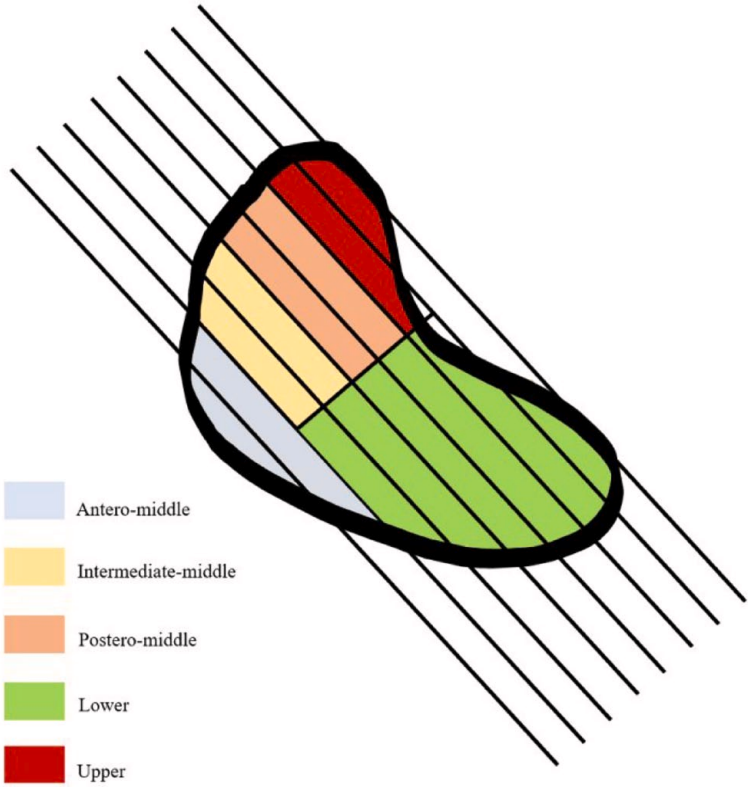

Figure 1. Division of one side of a sacroiliac joint

Results

Demographic characteristics of study subjects

Table 1 presents the clinical characteristics of the subjects included in the study. We included 96 SpA and 104 non-SpA patients. The mean age of the participants was comparable in the SpA and non-SpA groups (mean age 37.4 ± 11.8 years *versus* 39.9 ± 11.6 years, respectively, $p = 0.48$). We excluded two patients in the non-SpA group due to the presence of anatomical variations of the SI joints. We observed a higher proportion of women and patients with an obstetrical history in the non-SpA group ($p < 1.10^{-4}$). We noted no significant difference between groups with regard to the proportion of subjects engaging in physical activity; active subjects represented 15% of those in the SpA group and 18% in the non-SpA group ($p = 1.3$). Among the SpA patients, 11% had swollen joints and 39% had tender joints. Regarding the lesions visualized on MRI of the SI joint, a significantly higher number of BME and fatty lesions were observed in patients with SpA ($p < 0.05$; $p < 1.10^{-9}$, respectively).

Distribution of Inflammatory and Structural Lesions in SpA and non-SpA Patients

Tables 2–5 report the proportion of inflammatory and structural lesions observed in SpA and non-SpA patients. BME was visualized in all segments of the SI joints in SpA patients, with a predominance

Table 1. Demographic and clinical characteristics and MRI lesions.

	Non-SpA $n=104$	Spondyloarthritis $n=96$	p value
Age, mean ± SD (years)	39.9 ± 11.6	37.4 ± 11.8	0.48
Men/women ratio	28/76	44/52	0.008
Body mass index (kg/m²)	26.6 ± 5.9	25.3 ± 4.9	0.26
Disease duration, mean ± SD (month)	-	48 ± 69	-
Buttock pain (%)	25	65	$<1.10^{-8}$
Low back pain (%)	55	80	$<1.10^{-5}$
Tender joints (%)	0	39	$<1.10^{-14}$
Swollen joints (%)	0	11	0.0002
Dactylitis (%)	0	4	0.05
Uveitis (%)	0	3	0.1
IBD(%)	3	9	0.07
Psoriasis (%)	10	17	0.1
HLA-B27 (%)	11	47	$<1.10^{-8}$
Physical activity (%)	18	15	0.85
Obstetric history (%)	37	12	$<1.10^{-4}$
Bone marrow edema (%)	20	65	$<1.10^{-11}$
Sclerosis (%)	44	36	0.3
Fatty lesions (%)	21	34	$<1.10^{-3}$
Erosions (%)	25	60	$<1.10^{-7}$

IBD, inflammatory bowel diseases; MRI, magnetic resonance imaging; SD, standard deviation.

of the iliac side of the intermediate-middle and antero-middle segments (25% and 24%, respectively) (Table 2). In non-SpA subjects, BME was also observed in the antero-middle segment, but in a smaller proportion of patients (9%, $p=0.002$) (Table 2). However, no BME was observed in the postero-middle segment in non-SpA patients. Similarly, fatty lesions were observed on the iliac side of the posterior and lower SI segments in SpA patients (7% and 11%, respectively), whereas these two segments were rarely affected by this type of lesion in non-SpA subjects (1% and 2%, $p=0.03$ and $p=0.008$, respectively) (Table 4). Erosions were visualized in all segments of the SI joint in SpA patients and were also present in non-SpA patients, mainly in the antero-middle segment (Table 5). In both groups, inflammatory and structural lesions were predominant on the iliac side, except for fatty lesions. The distribution of BME in the different segments is largely similar on the iliac and sacral sides in both groups. Sclerosis and erosions predominate on the iliac side of the joint, while fatty lesions are more frequently observed on the sacral side.

Distribution of inflammatory and structural lesions in patients with sustained physical activity, with an obstetrical history or with a BMI > 30 kg/m²

BME was present in the lower segment of the SI joints in SpA patients but also in non-SpA patients with an obstetrical history or who were physically active ($p=2.5$ and $p=1$, respectively) (Table 2). In SpA patients with physical activity, the proportion of BME was more frequent in the antero-middle and intermediate-middle segments than in physically inactive SpA patients (32% *versus* 24% and 35% *versus* 25% on the iliac side respectively, $p=0.2$ and $p=0.2$). Erosions and fatty lesions were also seen in the lower joint segment in non-SpA subjects who were physically active (7% and 8%, respectively on the iliac side) (Tables 4 and 5).

In patients with an obstetrical history, we observed more BME, subchondral sclerosis and erosions, mainly in the antero-middle segment, regardless of the group (Tables 3 and 5). Erosions were also seen in the lower segment of the joint in patients who had had a delivery within the previous 3 years (Table 5). Women with three or more children had a higher proportion of BME, fatty lesions and erosion than women with one or two children (Tables 2, 4 and 5).

We observed 10% of BME and 15% of erosions in the antero-middle iliac segment in non-SpA patients with BMI > 30 kg/m² (Table 2 and 5). This same subgroup of patients had sclerosis in all segments of the iliac side of the SI joints, mainly in the antero-middle segment, where the rate reached 60% on the iliac side (Table 3).

Distribution of inflammatory and structural lesions according to clinical or biological characteristics of SpA patients

More BME was observed in subjects with a disease duration of less than 3 years, and more fatty

Table 2. Anatomic distribution of BME in the SI joint segments on MRI.

	Upper		Antero-middle		Intermediate middle		Postero-middle		Lower	
	Iliac	sacrum	Iliac	sacrum	Iliac	sacrum	Iliac	sacrum	Iliac	sacrum
Non-SpA ($n=104$), %	**0**	**0**	**9**	**8**	**1**	**1**	**0**	**0**	**2**	**0**
<45 years ($n=73$), %	0	0	5	3	1	1	0	0	1	0
>45 years ($n=31$), %	0	0	18	18	0	0	0	0	1	0
Physical activity ($n=19$), %	0	0	8	8	3	0	0	0	8	0
Obstetric history ($n=39$), %	0	0	12	13	1	1	0	0	3	0
1 child ($n=9$), %	0	0	11	0	0	0	0	0	0	0
< 3 children ($n=17$), %	0	0	9	9	2	2	0	0	0	0
⩾3 children ($n=17$), %	0	0	18	15	0	0	0	0	6	0
BMI > 30 kg/m² ($n=10$), %	0	0	10	0	0	0	0	0	0	0
HLA-B27 ($n=12$), %	0	0	12	12	0	0	0	0	0	0
Spondyloarthritis ($n=96$), %	**7****	**5***	**24****	**24****	**25****	**25****	**14****	**13****	**14****	**13****
<45 years ($n=72$), %	9	6	26	27	29	28	17	17	18	17
>45 years ($n=24$), %	2	0	19	15	8	15	4	2	2	4
Physical activity ($n=14$), %	4	4	32	25	35	18	14	11	21	21
Obstetric history ($n=12$), %	4	8	25	32	20	20	12	8	12	8
Psoriasis ($n=16$), %	32	32	22	19	25	19	12	12	9	9
HLA-B27 ($n=45$), %	11	9	21	28	27	29	18	18	19	16
Duration <3 years ($n=45$), %	10	7	33	31	33	29	18	18	20	13
Duration >3 years ($n=26$), %	2	0	12	15	12	17	8	6	8	8

BME, bone marrow edema; BMI, body mass index; IBD, inflammatory bowel disease; MRI, magnetic resonance imaging; SI, sacroiliac.
*$p \leqslant 0.05$ compared with the non-SpA group; **$p \leqslant 0.005$ compared with the non-SpA group.

lesions in subjects with a disease duration exceeding 3 years (Tables 2 and 4).

In the non-SpA group, the presence of HLA B-27 did not appear to influence the distribution of lesions, except for sclerosis, with a lower proportion of sclerosis observed in these subjects (Tables 2–5). In patients with psoriasis, BME lesions were more frequent at the upper level of the joint in comparison to the overall SpA group ($p=0.009$) (Table 2). Patients who had inflammatory bowel disease associated with SpA appeared to have fewer structural and inflammatory lesions than the overall population of SpA patients. Three of the SpA patients included had a history of uveitis, and a slightly lower proportion of BME was observed in these patients compared with patients with SpA without uveitis.

Diagnostic value of inflammatory and structural lesions according to their distribution

The sensitivity, specificity, positive and negative predictive values are presented in Table 6. The lesion and sites with the highest PPV for SpA were BME in the upper and postero-middle iliac

Table 3. Anatomic distribution of sclerosis in the SI joint segments on MRI.

	Upper		Antero-middle		Intermediate middle		Postero-middle		Lower	
	Iliac	sacrum	Iliac	sacrum	Iliac	sacrum	Iliac	sacrum	Iliac	sacrum
Non-SpA ($n=104$), %	**2**	**0**	**38**	**7**	**14**	**1**	**2**	**0**	**1**	**1**
<45 years ($n=73$), %	2	0	38	5	14	1	1	0	1	0
>45 years ($n=31$), %	2	0	35	11	14	0	3	0	3	2
Physical activity ($n=19$), %	5	0	34	5	5	0	0	0	0	0
Obstetric history ($n=39$), %	0	0	50	6	19	0	2	0	2	1
1 child ($n=9$), %	0	0	39	11	11	0	0	0	0	0
<3 children ($n=17$), %	0	0	59	9	19	0	2	0	2	0
⩾3 children ($n=17$), %	0	0	44	3	9	0	0	0	3	0
BMI > 30 kg/m² ($n=10$), %	0	0	60	10	15	0	15	0	15	0
HLA-B27 ($n=12$), %	4	0	2	1	1	0	0	0	1	0
Spondyloarthritis ($n=96$), %	**1**	**0**	**27**	**3**	**14**	**2**	**5**	**0**	**7***	**1**
<45 years ($n=72$), %	1	0	26	3	16	2	6	0	10	1
>45 years ($n=24$), %	0	0	15	1	4	1	1	0	0	0
Physical activity ($n=14$), %	0	0	25	0	14	11	11	0	7	0
Obstetric history ($n=12$), %	4	0	54	8	12	0	0	0	4	0
Psoriasis ($n=16$), %	0	0	9	3	12	3	3	0	3	0
HLA-B27 ($n=45$), %	0	0	23	0	15	0	4	0	10	0
Duration <3 years ($n=45$), %	1	0	18	1	17	2	6	0	9	0
Duration >3 years ($n=26$), %	2	0	25	4	10	0	4	0	6	0

BME, bone marrow edema; BMI, body mass index; IBD, inflammatory bowel disease; MRI, magnetic resonance imaging; SI, sacroiliac.
*$p \leqslant 0.05$ compared with the non-SpA group.

segment. For the majority of lesions, the highest specificity was observed in the upper and postero-middle segments.

Reliability of detection of inflammatory and structural lesions

Reliability [mean kappa (95%CI)] for the detection of erosion [0.75 (0.67–0.86)], sclerosis [0.87 (0.79–0.95)] and fatty lesions [0.85 (0.76–0.89)] was almost at the same level as for bone marrow edema [0.92 (0.86–0.95)]. The kappa coefficients (with 95%IC) for the upper, antero-middle, intermediate-middle, postero-middle and lower segments were, respectively, 0.93 (0.91–0.94), 0.85 (0.72–0.96), 0.95 (0.93–0.98), 0.92 (0.88–0.95), 0.89 (0.83–0.95) and 0.92 (0.87–0.96).

Discussion

This retrospective study reflects the patient population encountered in a rheumatologist's daily practice and provides a precise mapping of the inflammatory and structural changes observed on SI joint MRIs. This distribution of the lesions was performed using a reproducible model that any

Table 4. Anatomic distribution of fatty lesions in the SI joint segments on MRI.

	Upper		Antero-middle		Intermediate middle		Postero-middle		Lower	
	Iliac	sacrum	Iliac	sacrum	Iliac	sacrum	Iliac	sacrum	Iliac	sacrum
Non-SpA ($n=104$), %	1	**0**	**4**	**13**	**2**	**8**	**1**	**3**	**2**	**7**
<45 years ($n=73$), %	1	0	4	12	3	8	3	5	1	4
>45 years ($n=31$), %	0	0	5	13	0	6	0	0	3	13
Physical activity ($n=19$), %	5	0	8	8	2	10	0	0	8	10
Obstetric history ($n=39$), %	2	0	5	12	1	4	0	0	0	5
1 child ($n=9$), %	0	0	0	6	0	11	0	0	0	0
<3 children ($n=17$), %	0	0	6	12	0	6	0	0	0	3
⩾3 children ($n=17$), %	5	5	23	0	3	0	0	0	6	
BMI > 30 kg/m² ($n=10$), %	0	0	0	5	0	0	0	0	0	0
HLA-B27 ($n=12$), %	0	0	8	12	0	8	2	12	0	4
Spondyloarthritis ($n=96$), %	**4***	**4***	**11**	**17**	**9***	**16**	**7***	**9**	**11***	**11**
<45 years ($n=72$), %	3	3	11	19	10	16	8	8	12	12
>45 years ($n=24$), %	6	6	12	10	6	12	6	10	10	10
Physical activity ($n=14$), %	7	7	7	21	16	14	7	14	7	7
Obstetric history ($n=12$), %	0	4	12	17	0	17	0	4	12	4
Psoriasis ($n=16$), %	0	0	6	12	0	6	0	6	0	6
HLA-B27 ($n=45$), %	8	7	15	15	12	19	9	10	17	18
Duration <3 years ($n=45$), %	2	3	8	16	7	12	3	4	11	11
Duration >3 years ($n=26$), %	4	4	20	15	10	17	11	15	13	20

BME, bone marrow edema; BMI, body mass index; IBD, inflammatory bowel disease; MRI, magnetic resonance imaging; SI, sacroiliac.
*$p \leqslant 0.05$ compared with the non-SpA group.

clinician could use in daily practice to more easily distinguish MRI scans that are in favour of SpA from MRI scans of non-SpA subjects.

In recent years, an increasing body of data has demonstrated the existence of inflammatory and structural lesions on MRIs from non-SpA patients. These lesions may have led to over-diagnosis of SpA with the advent of SI joint MRI in this indication.[18]

Initial studies identified the presence of BME in postpartum women, which persisted in 12% of patients at 1 year after delivery.[19] The presence of BME was also found in athletes, 30–40% of whom met the ASAS criteria for sacroiliitis,[10] and in non-SpA patients.[6,7] Structural changes such as fatty lesions, sclerosis and erosions were also reported in postpartum women[9,12,20] and non-SpA patients.[6,7,21,22] Few studies have provided information on the localization of these different lesions in a simple way that can be used in routine practice.[23]

In our study, SpA subjects presented with inflammatory and structural changes in all segments of the SI joint. However, the lesions were predominant in the intermediate-middle and antero-middle

Table 5. Anatomic distribution of erosions in the SI joint segments on MRI.

	Upper		Antero-middle		Intermediate middle		Postero-middle		Lower	
	Iliac	sacrum	Iliac	sacrum	Iliac	sacrum	Iliac	sacrum	Iliac	sacrum
Non-SpA ($n=104$), %	**1**	**1**	**19**	**2**	**11**	**2**	**3**	**1**	**7**	**2**
<45 years ($n=73$), %	0	0	16	1	7	1	4	1	4	1
>45 years ($n=31$), %	5	3	18	5	12	3	3	1	14	5
Physical activity ($n=19$), %	5	5	7	5	7	7	7	3	7	5
Obstetric history ($n=39$), %	0	0	20	0	6	1	0	0	6	1
1 child ($n=9$), %	0	0	22	0	17	0	0	0	0	0
<3 children ($n=17$), %	0	0	18	0	5	0	0	0	0	0
⩾3 children ($n=17$), %	0	0	26	0	9	0	0	0	14	0
BMI > 30 kg/m² ($n=10$), %	0	0	15	0	0	0	0	0	0	0
HLA-B27 ($n=12$), %		0	0	16	4	20	0	0	0	8
Spondyloarthritis ($n=96$), %	**3**	**1**	**40****	**13****	**35****	**15****	**16****	**12****	**22****	**10***
<45 years ($n=72$), %	2	1	42	14	39	17	18	11	22	11
>45 years ($n=24$), %	6	0	31	8	25	10	10	6	19	10
Physical activity ($n=14$), %	7	0	46	25	39	25	28	14	28	14
Obstetric history ($n=12$), %	0	0	50	16	33	8	0	16	4	8
Psoriasis ($n=16$), %	6	0	25	9	16	6	12	0	15	0
HLA-B27 ($n=45$), %	2	0	40	11	38	11	15	8	23	11
Duration <3 years ($n=45$), %	4	1	35	13	34	11	14	8	21	11
Duration >3 years ($n=26$), %	0	0	40	10	31	17	21	12	20	12

BME, bone marrow edema; BMI, body mass index; IBD, inflammatory bowel disease; MRI, magnetic resonance imaging; SI, sacroiliac.
*$p \leqslant 0.05$ compared with the non-SpA group; **$p \leqslant 0.005$ compared with the non-SpA group.

segments. The proportion of BME in SpA subjects was comparable to that observed in the studies by Seven *et al.* and Weber *et al.*, and with similar localization, namely the intermediate middle and antero-middle segments of the SI joints.[10,23] The distribution of BME in the different segments was approximately the same on the iliac and sacral sides. Sclerosis and erosions predominated on the iliac side of the joint in SpA subjects, while fatty lesions were more frequently observed on the sacral side.

Our study is the first to study the impact of physical activity, obstetrical history, weight and associated clinical conditions such as psoriasis or uveitis on SI joint MRI findings in SpA patients. Accordingly, BME was present in comparable proportions in each subgroup, while subchondral sclerosis largely predominated in women with an obstetrical history in the antero-middle segment on the iliac side. Similarly, erosions are more frequently present in SpA patients with an obstetric history and in SpA patients with sustained physical activity.

In non-SpA patients, in contrast to SpA, it is interesting to note that no BME was observed in the postero-middle segment, especially in non-SpA subjects who were physically active. These data contradict the results presented by Weber *et*

Table 6. Diagnostic values for the different segments of the sacroiliac joint according to lesions.

	Sensitivity (%)	Specificity (%)	PPV (%)	PPN (%)
BME				
Upper	6.25	100	100	53.6
Antero-middle	24	91.3	71.9	56.5
Intermediate-middle	24.7	99	96	58.5
Postero-middle	13.5	100	100	55.6
Lower	13.5	98	86.7	55.1
Sclerosis				
Upper	1	98	33.3	51.8
Antero-middle	27	63	40.6	48.5
Intermediate-middle	14.6	86.5	50	52.3
Postero-middle	4.1	98	66.7	52.6
Lower	6.2	99	85.7	53.4
Fatty lesions				
Upper	3.1	99	75	52.5
Antero-middle	10.4	96.1	71.4	53.8
Intermediate-middle	8.3	98	80	53.9
Postero-middle	6.2	98.1	75	53.1
Lower	10.4	98.1	83.3	53.2
Erosions				
Upper	2	99	66.7	52
Antero-middle	40.6	81.7	67.2	59.9
Intermediate-middle	35.4	89.4	75.6	60
Postero-middle	16.7	97.1	84.2	55.8
Lower	21.9	93.3	75	56.4

BME, bone marrow edema; PPN, negative predictive value; PPV, positive predictive value.

al.[10] but are consistent with those of the study by Seven *et al.*[23] We observed less BME in non-SpA women with an obstetrical history in our study than in the other studies, especially in the posterior joint.[23,24] These differences can be explained by differences in SI joint division. Indeed, in the previous studies, the posterior segment was included in what we considered as the inferior segment in our SI joint division. Thus, when we take into account this difference in SI joint division, our results are consistent with previous data.

We observed a higher proportion of subchondral sclerosis in the antero-middle iliac side in women

without SpA and with an obstetrical history, than in previously published studies.[23,24] Interestingly, in this same subgroup of patients, we observed a significant proportion of erosions in the antero-middle and lower segments of the SI joints, in a higher proportion than previously described. Consistent proportions of BME, sclerosis and erosions were observed in the antero-middle, intermediate-middle and lower segments in subgroups of non-SpA patients practicing a physical activity or whose BMI was $>30\,kg/m^2$. As with BME, structural lesions are infrequently observed in the postero-middle segment in non-SpA patients, with the exception of sclerosis, which was observed in this segment in obese subjects, and erosions in physically active subjects. It is interesting to highlight that for the majority of lesions, the highest specificity was observed in the upper and postero-middle segments.

To improve the diagnostic performance of individual lesions, new definitions of inflammatory and structural lesions have recently been proposed. Thus, active sacroiliitis typical of axSpA would be defined by the presence of BME in $\geqslant 4$ SI joint quadrants at any location or at the same location in $\geqslant 3$ consecutive slices. Structural SpA changes are defined as the presence of erosion in $\geqslant 3$ SI joint quadrants, fat lesion in $\geqslant 5$ SI quadrants, erosion at the same location for $\geqslant 2$ consecutive slices, fat lesions at the same location for $\geqslant 3$ consecutive slices, or presence of a deep (i.e. >1 cm depth) fat lesion.[25] It would be interesting to study more precisely the distribution of inflammatory and structural lesions in light of these new definitions.

Our study suffers from limitations related to its observational and retrospective nature. Accordingly, some data were not available, in particular we had no data about disease activity score, concomitant NSAID use or HLA-B27 status. The proportion of B27 patients is low because typing was only performed in atypical clinical situations. We were also missing clinical data to explain the performance of sacroiliac MRI in non-SpA patients and the symptomatic nature of non-SpA patients. Moreover, the single-centre recruitment in a university rheumatology department may not be perfectly representative of SpA in the general population. Other limitations include the reader-dependent interpretation of lesions and the lack of availability of CT scans of the SI joints to detect erosions. One of the pitfalls of our work is the isolated use of coronal sections to localize lesions. Indeed, Weber *et al.* showed that the use of axial sections made it possible to localize lesions more accurately.[26] Our study excluded patients with anatomical variations in the sacroiliac joints. However, only a small proportion of these patients were observed in our work, in comparison with the recent work by Kiil *et al.*[27] One explanation for this small proportion is the diagnostic difficulty of these anatomical variants in the absence of axial sections, which is one of the previously described limitations of our study.[27] Finally, we chose not to use the SPARCC MRI score because it does not correspond to the clinical practice of MRI reading, and we sought to propose simplified and generalizable criteria for interpretation. It is important to emphasize that this study was performed in patients with a confirmed diagnosis of SpA, so the diagnostic performance of our results remains to be validated in a dedicated study. However, the division of patients into subgroups of interest and the SI joint division enables us to draw applicable conclusions for current practice.

Conclusion

In conclusion, our study reinforces existing data suggesting that, on SI joint MRIs, BME is primarily visualized in the middle segments in SpA patients, in the antero-middle segment in non-SpA patients, and is very rarely observed in the postero-middle segment in non-SpA subjects. Our study also suggests that erosions may be visualized in non-SpA patients with sustained physical activity and in women who have had a baby within the previous 3 years, to a lesser extent than in SpA subjects. Thus, precise analysis of the distribution of all lesions, both inflammatory and structural, and the integration of the clinical context are necessary to determine the origin of the abnormalities visualized on MRI of the SI joints.

Declarations

Ethics approval and consent to participate

This study did not require ethics committee approval because of its retrospective nature and its lack of impact on the diagnostic and therapeutic management of patients.

Consent for publication

Not applicable.

Author contributions

Sophie Hecquet: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Writing – original draft; Writing – review & editing.

Jean-Philippe Lustig: Data curation; Validation; Visualization; Writing – review & editing.

Frank Verhoeven: Validation; Visualization; Writing – review & editing.

Mickaël Chouk: Validation; Visualization; Writing – review & editing.

Sébastien Aubry: Supervision; Validation; Visualization; Writing – review & editing.

Daniel Wendling: Supervision; Validation; Visualization; Writing – review & editing.

Clément Prati: Conceptualization; Formal analysis; Methodology; Project administration; Supervision; Validation; Visualization; Writing – original draft; Writing – review & editing.

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