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Original article

Topographic MRI evaluation of the sacroiliac joints in patients with axial spondyloarthritis☆

Laís Uyeda Aivazoglou[a], *Orlando Rondan Zotti*[b], *Marcelo de Medeiros Pinheiro*[c], *Moacir Ribeiro de Castro Junior*[c], *Andrea Puchnick*[a,*], *Artur da Rocha Corrêa Fernandes*[a], *Eloy de Ávila Fernandes*[a]

[a] *Universidade Federal de São Paulo (UNIFESP), Escola Paulista de Medicina (EPM), Departamento de Diagnóstico por Imagem (DDI), São Paulo, SP, Brazil*

[b] *Universidade Federal de São Paulo (UNIFESP), Escola Paulista de Medicina (EPM), Departamento de Cirurgia, São Paulo, SP, Brazil*

[c] *Universidade Federal de São Paulo (UNIFESP), Departamento de Medicina, Disciplina de Reumatologia, São Paulo, SP, Brazil*

ARTICLE INFO

Article history:
Received 29 September 2015
Accepted 18 May 2016
Available online 2 December 2016

Keywords:
Magnetic resonance imaging
Sacroiliac joints
Spondyloarthritis
Sacroiliitis
Topographic evaluation

ABSTRACT

Objective: To evaluate the imaging features of spondyloarthritis in magnetic resonance imaging (MRI) of the sacroiliac (SI) joint and topography (in thirds) and affected margin, considering that this issue is rarely addressed in the literature.

Methods: A cross-sectional study evaluating MRI (1.5 T) of SI in 16 patients with axial spondyloarthritis, for the presence of acute (subchondral bone edema, enthesitis, synovitis and capsulitis) and chronic (erosions, subchondral bone sclerosis, bony bridges, and fatty infiltration) changes, performed by two blinded radiologists. MRI findings were correlated with clinical data, including age, duration of disease, medications, HLA-B27, BASDAI, ASDAS-ESR and ASDAS-CRP, BASMI, BASFI, and mSASSS.

Results: Bone edema pattern and erosions were predominant in the upper third of SI ($p = 0.050$ and $p = 0.0014$, respectively). There was a correlation between disease duration and structural changes by affected third ($p = 0.028$–0.037), as well as between the presence of bone bridges with BASMI ($p = 0.028$) and mSASSS ($p = 0.014$). Patients with osteitis in the lower third showed higher values for ASDAS (ESR: $p = 0.011$ and PCR: $p = 0.017$).

Conclusion: Chronic inflammatory changes and the pattern of bone edema predominated in the upper third of SI, but a simultaneous involvement of middle or lower thirds of the joint was also noted. The location of involvement in the upper third of SI is insufficient to differentiate between degeneration and inflammation.

☆ Study conducted at the Universidade Federal de São Paulo (UNIFESP), Escola Paulista de Medicina (EPM), Departamento de Diagnóstico por Imagem (DDI), São Paulo, SP, Brazil.

* *Corresponding author.*
E-mail: andrea.ddi@epm.br (A. Puchnick).

http://dx.doi.org/10.1016/j.rbre.2016.09.002

Avaliação topográfica das articulações sacroilíacas por ressonância magnética em pacientes com espondiloartrite axial

Palavras-chave:
Ressonância magnética
Articulações sacroilíacas
Espondiloartrite
Sacroiliíte
Avaliação topográfica

RESUMO

Objetivo: Avaliar as características de imagem das espondiloartrites na ressonância magnética (RM) das articulações sacroilíacas (SI) quanto à topografia (em terços) e margem acometida, uma vez que esse aspecto é pouco abordado na literatura.
Métodos: Estudo transversal com avaliação por RM (1,5 T) das SI em 16 pacientes com diagnóstico de espondiloartrite axial quanto à presença de alterações agudas (edema ósseo subcondral, entesite, sinovite e capsulite) e crônicas (erosões, esclerose óssea subcondral, ponte óssea e substituição gordurosa), feita por dois radiologistas, com leitura cega. Os achados da RM foram correlacionados com dados clínicos, incluindo idade, tempo de doença, medicações, HLA-B27, Basdai, Asdas-VHS e Asdas-PCR, Basmi, Basfi e mSASSS.
Resultados: Padrão de edema ósseo e erosões apresentaram predomínio no terço superior das SI (p = 0,050 e p = 0,0014, respectivamente). Houve correlação entre o tempo de doença e alterações estruturais por terço acometido (p = 0,028-0,037), bem como a presença de pontes ósseas com o Basmi (p = 0,028) e o mSASSS (p = 0,014). Pacientes com osteíte no terço inferior apresentaram maiores valores de Asdas (VHS: p = 0,011 e PCR: p = 0,017).
Conclusão: As alterações inflamatórias crônicas e o padrão de edema ósseo predominaram no terço superior das SI, mas também havia acometimento concomitante dos terços médio ou inferior da articulação. A localização do acometimento no terço superior das SI se mostra insuficiente para a diferenciação entre degeneração e inflamação.

Introduction

The spondyloarthritides (SpA) are a group of disorders with a prevalence from 0.5 to 1.9%, encompassing ankylosing spondylitis, psoriatic arthritis, arthritis associated with inflammatory bowel disease, reactive arthritis, and undifferentiated forms. In addition, SpA exhibit a genetic association with human leukocyte antigen (HLA) B27, and an overlapping in clinical forms may occur in the same patient, or in first-degree relatives.[1,2]

The conventional radiography (Rx) is inadequate for the diagnosis of the disease at an early stage, especially before the onset of structural damage, since this modality does not detect acute inflammatory lesions, resulting in a mean delay of 8–11 years for obtaining a diagnosis.[1,3]

Due to diagnostic difficulties and also to the overlapping of clinical cases of mechanical and inflammatory sacroiliitis, a topographic study of SpA by magnetic resonance imaging (MRI) can help to fulfill this gap in the literature.

This study was intended to describe the topographical features of the involvement of sacroiliac (SI) joints with the use of MRI, in order to aiding in the differentiation between mechanical *versus* inflammatory involvement, since these subjects are infrequently addressed in the literature. In addition, the study aims to correlate clinical and laboratory data with the imaging findings.

Materials and methods

This is a cross-sectional observational study involving 16 patients from the Spondyloarthritis Outpatient Clinic of the Universidade Federal de São Paulo (UNIFESP). Patients with axial SpA according to the criteria proposed by the Assessment of Spondyloarthritis International Society (ASAS) and who were referred to perform MRI of their SI joints (24 patients) were included. Patients who showed no change in MRI of the sacroiliac joints and patients with incomplete laboratory data were excluded; thus, 16 patients remained. Of these patients, 12 were diagnosed with ankylosing spondylitis and 4 were diagnosed with non-radiographic axial spondyloarthritis. The tests were analyzed separately by two blinded radiologists from the Department of Diagnostic Imaging (DDI) of UNIFESP with a specialization in the musculoskeletal system and with 5 and 15 years of experience (MRC and EAF). The cases in which there was disagreement were resolved by consensus.

MRI examinations were performed in DDI-UNIFESP in Siemens (Siemens Medical Solutions, Erlangen, Germany) and Philips (Gyroscan; Philips, Eindhoven, The Netherlands) 1.5-T devices with a matrix ranging from 320 × 70 to 320 × 90. All acquisitions were of 4-mm thickness. The evaluation of images was performed on a standard video monitor with a 32-bit, 1024 × 768 pixels resolution.

The routine protocol used in the sacroiliac region was: 3-plane finder, Coronal Short-Tau Inversion Recovery (STIR), coronal fat saturation T1-weighted MR image, axial T1-weighted MR image; after an intravenous injection of paramagnetic contrast, axial and coronal fat saturation T1-weighted MRI images were obtained.

With the use of MRI, acute and chronic inflammatory changes of SI joints were studied; SI joints were divided into three thirds: an upper third above the first sacral foramen, a middle third between the first two sacral foramens, and a lower third below the second sacral foramen.

With regard to acute changes, the presence of osteitis, characterized by subchondral bone edema (high-signal sequences sensitive to liquid and enhanced by contrast medium), was checked and topographed. Furthermore, signals of capsulitis, enthesitis and synovitis were checked; these signals, in the absence of an associated osteitis, are not sufficient to ensure a diagnosis of active sacroiliiitis, as defined according to the resolution of the Outcome Measures in Rheumatology Clinical Trials (OMERACT) 10[4]:

- Capsulitis: high signal on STIR and/or T1 fat-sat after intravenous (IV) contrast in anterior or posterior capsule, with a potential for medial and/or lateral extension to the adjacent periosteum.
- Enthesitis: high signal on STIR and/or T1 fat-sat after IV contrast in places where ligaments and tendons are inserted into bones, including the retroarticular space (interosseous ligaments). The signal change may extend to the bone marrow and to adjacent soft tissues.
- Synovitis: high signal on T1 fat-sat after IV contrast in the synovial portion of the SI joints (signal intensity similar to that of blood vessels).

Chronic injuries in the sacroiliac joints were characterized by the presence of erosion, subchondral bone sclerosis, bony bridges and fatty infiltration, as established by ASAS.[5]

Through an analysis of the medical records, the following clinical data were recorded: age, gender, skin color, disease duration, continuous use of non-steroidal anti-inflammatory drugs (NSAIDs) and other disease-modifying antirheumatic drugs (DMARDs) such as sulphasalazine and methotrexate, as well as tumor necrosis factor inhibitors (anti-TNF), HLA-B27 survey, and specific tools for the evaluation of disease activity (BASDAI – Bath Ankylosing Spondylitis Disease Activity Index and ASDAS – Ankylosing Spondylitis Disease Activity Score with CRP – C-reactive protein, and with ESR – erythrocyte sedimentation rate), mobility (BASMI – Bath Ankylosing Spondylitis Metrology Index), and function (BASFI – Bath Ankylosing Spondylitis Functional Index), as well as for structural damage (mSASSS – modified Stoke Ankylosing Spondylitis Spine Score).

MRI findings were compared with each other and also with the clinical data obtained from medical records, and a correlation was established between the data on disease activity (BASDAI, BASFI, ASDAS-ESR, and ASDAS-CRP) with acute findings by MRI and disease duration and clinical tests associated with chronicity (BASMI and mSASSS) with chronic findings by MRI.

For categorical variables, chi-squared and Fisher exact tests were used; for numeric variables, the Student's *t*-test for independent samples was used. In order to simultaneously evaluate the association between categorical (use of medications and changes observed in SI by MRI) and numeric (disease duration, BASDAI, ASDAS-CRP, ASDAS-ESR, BASMI, BASFI, mSASSS) variables, a cluster analysis was carried out with the application of the Student's *t*-test. The significance level (*p*-value) considered was 0.05.

Table 1 – Demographic, clinical and laboratory characteristics.

Parameters assessed	Values
Age (years)	46.4 ± 13.2
Gender, n (%)	
Male	11 (68.8)
Female	5 (31.2)
Race, n (%)	
White	11 (68.8)
Nonwhite	5 (31.2)
Disease duration (years)	8.6 ± 7.2
Presence of PJM and EAM, n (%)	
Uveitis	6 (37.5)
Psoriasis	2 (12.5)
Colitis	0 (0.0)
Urethritis	2 (12.5)
Enthesitis	14 (87.5)
Arthritis	7 (43.8)
Indices for evaluation of disease activity, mean ± SD	
BASDAI	3.9 ± 3.0
BASMI	3.3 ± 2.2
BASFI	4.3 ± 2.3
ASDAS-ESR	3.4 ± 1.6
ASDAS-CRP	3.1 ± 1.8
mSASSS	7.9 ± 6.2
Concomitant medications, n (%)	
Nonsteroidal anti-inflammatory agents	11 (68.8)
TNF blockers	2 (12.5)
Sulfasalazine	4 (25.0)
Not used	4 (25.0)

PJM, peripheral joint manifestations; EAM, extra-articular manifestations.

Results

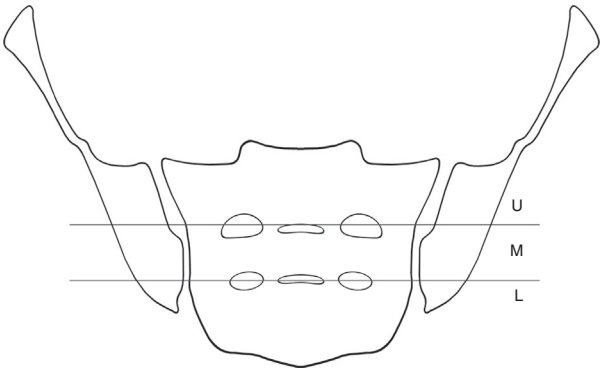
The group of patients studied was composed of 11 male and 5 female subjects, with a mean age of 46.4 years and a mean disease duration of 8.6 years.

The HLA-B27 was positive in 9 (56.3%) patients, negative in 6 (37.5%) and unavailable in 1 (6.3%) patient. Table 1 shows demographic, clinical and laboratory data.

In relation to the topography of the findings by MRI, the upper third was the most affected, both by bone edema ($p = 0.049$) and by chronic changes ($p = 0.0014$). In the case of acute changes, the second most affected third was the lower third, and in the case of chronic changes, the middle third.

A statistically significant correlation was noted between changes in upper, middle and lower thirds compared to the presence of edema in the iliac face ($p = 0.050$), that is, when the change was present in the upper third of the iliac border, it was also present in the middle- or lower third. This did not occur in relation to the presence of edema in the sacral margin, in which 2 patients showed isolated edema in the upper third, or when the iliac and sacral faces were considered together.

Acute changes were observed in nearly 60% of patients. The most frequent finding was bone edema ($n = 6$, 37.5%; 5 in the sacral face and 4 in the iliac face; Figs. 1 and 2), followed by



U, upper third; M, middle third; L, lower third.

Fig. 1 – Schematic drawing of the division into thirds performed to evaluate imaging findings.

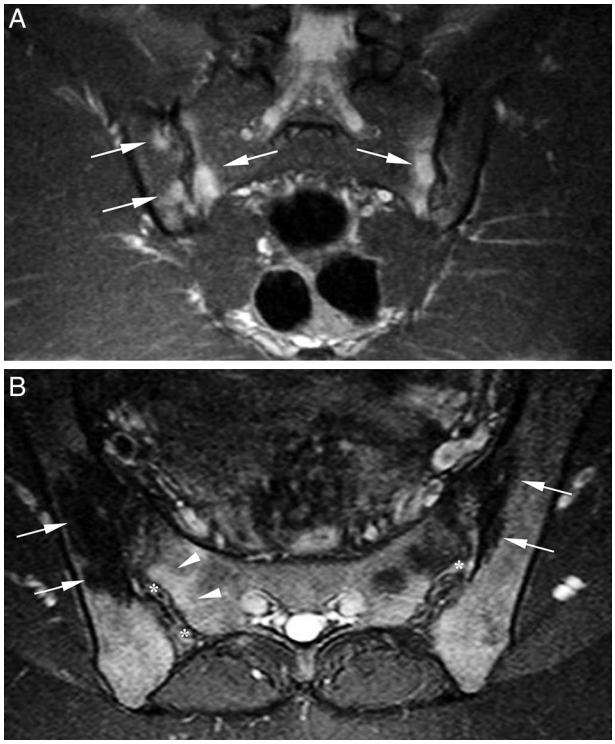


Fig. 2 – A, T2-weighted coronal MRI image with fat signal saturation, showing bone marrow edema in the upper and middle thirds of sacroiliac joints (arrows); B, T2-weighted axial MRI image with fat signal saturation, showing bone sclerosis in the upper third of sacroiliac joints (arrows). Subchondral edema in the right sacral aspect (arrowheads) and enthesitis in iliac and sacral aspects (asterisks) are found.

synovitis ($n = 5$, 31.2%) and enthesitis ($n = 4$; 25%; Fig. 2). Capsulitis was not observed.

Chronic changes were observed in the majority of patients ($n = 14$; 87.5%). The findings (in order of decreasing frequency) were erosions ($n = 13$; 81.2%), subchondral sclerosis ($n = 6$, 37.5%; Fig. 2), fatty infiltration ($n = 5$, 31.2%) and bony bridges ($n = 2$; 12.5%).

Patients with osteitis signals in the lower third showed higher ASDAS-ESR and ASDAS-CRP values ($p = 0.011$ and $p = 0.017$ respectively, Table 2). An association was observed between longer disease duration and the presence of chronic changes, both globally as well as by involved third (upper: $p = 0.031$; middle: $p = 0.037$; lower: $p = 0.028$; Table 3). Furthermore, an association between the presence of bony bridges, independent of the topography, with longer disease duration ($p = 0.015$) and higher values of BASMI ($p = 0.028$) and mSASSS ($p = 0.014$) was also observed.

Table 2 – Correlation of acute changes and bone edema areas by thirds with clinical and laboratory data related to disease activity.

Acute changes	Clinical laboratory data			
	BASDAI	BASFI	ASDAS-ESR	ASDAS-CRP
Bone edema				
Presence (n = 7)	3.4 ± 3.4	3.5 ± 2.3	3.8 ± 2.0	3.4 ± 2.4
Absence (n = 9)	4.3 ± 2.8	5.0 ± 2.2	3.0 ± 1.2	2.9 ± 1.2
t-Test (p)	0.576	0.193	0.299	0.592
Enthesitis				
Presence (n = 4)	5.4 ± 4.6	3.4 ± 2.4	4.4 ± 2.4	3.8 ± 3.1
Absence (n = 12)	3.4 ± 2.3	4.7 ± 2.3	3.0 ± 1.1	2.8 ± 1.2
t-Test (p)	0.256	0.346	0.144	0.357
Synovitis				
Presence (n = 5)	5.6 ± 4.0	3.1 ± 2.2	4.0 ± 2.2	3.6 ± 2.7
Absence (n = 11)	3.1 ± 2.2	4.9 ± 2.3	3.1 ± 1.2	2.9 ± 1.3
t-Test (p)	0.133	0.167	0.261	0.457
Bone edema				
Upper third				
Presence (n = 6)	4.0 ± 3.3	3.7 ± 2.4	3.6 ± 2.0	3.0 ± 2.4
Absence (n = 10)	3.9 ± 3.0	4.7 ± 2.3	3.2 ± 1.3	3.2 ± 1.4
t-Test (p)	0.946	0.416	0.680	0.863
Medium third				
Presence (n = 2)	6.7 ± 4.7	2.8 ± 2.5	5.3 ± 2.7	5.0 ± 3.7
Absence (n = 14)	3.5 ± 2.7	4.6 ± 2.3	3.1 ± 1.3	2.8 ± 1.4
t-Test (p)	0.177	0.320	0.060	0.117
Lower third				
Presence (n = 3)	4.4 ± 5.1	2.5 ± 1.8	5.3 ± 1.9	5.2 ± 2.7
Absence (n = 13)	3.8 ± 2.6	4.8 ± 2.3	2.9 ± 1.1	2.6 ± 1.2
t-Test (p)	0.752	0.135	0.011	0.017

Discussion

Magnetic resonance imaging is a breakthrough technology, not only for diagnosis but possibly in the clinical management of spondyloarthritides, including their differential diagnosis and therapeutic monitoring,[6,7] due to its sensitivity and reliability for the evaluation of signs of active inflammation.[8]

To the best of our knowledge, the highest frequency of acute and chronic findings observed in this study in the upper third of sacroiliac joints is a new finding in the literature. The fact that bone edema and chronic changes present this behavior suggests that this has been one of the activity sites of the disease, which has raised questions about the justification from the point of view of the joint anatomy and also of the pathophysiology of the disease.

Table 3 – Correlation of structural (chronic) damage *versus* disease duration, BASMI and mSASSS.

Structural damage	Disease duration	BASMI	mSASSS
Fatty infiltration			
Presence (n = 5)	12.4 ± 10.9	4.4 ± 2.3	11.8 ± 7.4
Absence (n = 11)	6.8 ± 4.3	2.8 ± 2.0	6.2 ± 5.1
t-Test (p)	0.155	0.192	0.096
Bony bridges			
Presence (n = 2)	19.5 ± 16.3	6.4 ± 0.6	17.5 ± 3.5
Absence (n = 14)	7.0 ± 4.2	2.9 ± 1.9	6.6 ± 5.3
t-Test (p)	0.015	0.028	0.014
Subchondral sclerosis			
Presence (n = 6)	9.8 ± 2.6	3.2 ± 2.4	7.2 ± 6.0
Absence (n = 10)	7.8 ± 9.0	3.4 ± 2.1	8.4 ± 6.7
t-Test (p)	0.601	0.878	0.716
Erosion			
Presence (n = 13)	9.5 ± 7.5	3.2 ± 2.3	7.2 ± 6.3
Absence (n = 3)	4.3 ± 3.5	3.8 ± 2.0	11.0 ± 6.1
t-Test (p)	0.272	0.701	0.364
Total of structural injuries by third			
Upper third			
Presence (n = 14)	9.4 ± 7.3	3.4 ± 2.3	7.8 ± 6.4
Absence (n = 2)	2.5 ± 2.1	2.7 ± 1.0	9.0 ± 7.0
t-Test (p)	0.031	0.683	0.807
Middle third			
Presence (n = 9)	11.8 ± 8.0	3.9 ± 2.0	8.9 ± 6.7
Absence (n = 7)	4.4 ± 2.9	2.5 ± 2.3	6.7 ± 5.9
t-Test (p)	0.037	0.220	0.509
Lower third			
Presence (n = 5)	14.2 ± 10.0	4.2 ± 2.1	11.8 ± 5.2
Absence (n = 11)	6.0 ± 3.7	2.9 ± 2.2	6.2 ± 6.1
t-Test (p)	0.028	0.306	0.096

Anatomy of the sacroiliac joints

The sacroiliac joint is considered a "amphiarthrosis",[9] with a cartilaginous diarthrodial (synovial) portion (composed of sacral and iliac auricular faces), and with other fibrous portion (through interosseous ligaments). Its cartilaginous portion (in the shape of C with the convexity toward the anterior aspect) is considered as a synovial joint since 1920, but this is not a usual synovial joint, in view of the unique characteristics of the sacroiliac joint. First, the articular surfaces are provided, on the sacral side, with a thick hyaline cartilage; and in the iliac face, the joint is fibrocartilaginous. Additionally, the joint capsule is fibrous and shows areas of discontinuity.

In the upper third of the sacroiliac joint, the presence of thick bands of fibrous tissue stands out, with a wide transitional area composed of fibrocartilage, beginning in the ventral sacroiliac ligament with its insertion on the sacral and iliac articular cartilage. Dorsally, in the ligamental portion of the joint, ligament-resistant fibers insert both in the bone and in sacral and iliac cartilages.[10]

Puhakka et al.,[11] when correlating the histology of the sacroiliac joint with MRI findings, showed an absence of synovial tissue in the upper third of the joint in normal individuals within the cartilaginous region and the joint capsule. Bowen and Cassidy[10] reported that the joint capsule, from the third and fourth decades of life, becomes more collagenous and less cellular, which could explain the absence of synovial tissue in the pathology study by Puhakka et al.,[11] in which the cadavers were aged between 20 and 45 years.

Pathophysiology of spondyloarthritides

In ankylosing spondylitis, the finding of an enthesitis is so striking as to be considered the primary lesion of this disease. In other spondyloarthritides, Benjamin and McGonagle[12] proposed that the synovitis is secondary to the release of inflammatory mediators from the involvement of adjacent entheses.

Correlating these data to the fact that the iliac face is covered by fibrocartilage, and since the inflammatory activity usually has its onset and predominates on this face, these ligamental and cartilaginous fibrous components may be the key to the antigen target involved.[13,14] There may be a possibility that the fibrous component of fibrocartilage is the preferred target of an inflammatory attack, instead of the purely hyaline cartilage present on the sacral side of the joint.

There are two types of entheses[12]: fibrous and fibrocartilaginous, and the involvement of spondyloarthritides is generally located in the former type, sparing the latter type. The fibrocartilaginous entheses are not mere tendon or ligament junctions to the bone, and can be considered as complex organs. This complexity is not only observed in "true" entheses but also in attrition sites with bone surfaces or fibrous structures, when they are then called functional entheses. One should still comment on the similarity of this type of enthesis with the fibrocartilaginous lining of some articular surfaces in synovial joints, whose the most striking example is the iliac side of the sacroiliac joint.

Only the constitution of entheses does not determine their involvement, and it has been noted that osteitis seems to follow mechanical stress lines, and also that the functional entheses are affected – although there is no direct contact with the bony component. Thus, it appears that biomechanical influences can initiate and/or perpetuate bone inflammatory changes.[13]

It is likely that the presence of acute and chronic inflammatory changes prevalent in the upper third of the joints, found in this study, relates to the anatomical and pathophysiological characteristics commented above, corresponding to the inflammatory activity in entheses, and also involving the upper third of the sacroiliac joints. Bone erosions were found predominantly in the upper thirds of the iliac faces. Assuming that those erosions are the most specific finding[15] of spondyloarthritides, our findings suggest that inflammatory activity has also occurred in the upper third. However, it is important to emphasize that in no patient an involvement solely on the upper third of the SI occurred.

There is no consensus in the literature regarding the topographic criterion of sclerosis in the sacroiliac joints for the definition of degenerative change. Resnick et al.[16] evaluated the degenerative arthropathy of the sacroiliac joints using conventional radiography, having found that the focal sclerosis finding was more common in upper and lower margins of

the sacroiliac joint cavity. Shibata et al.[17] performed a tomographic evaluation; the finding of (degenerative) sclerosis was more common in the upper and middle portions of the anterior iliac joint face. In their histological evaluation, Brunner et al.[18] found a higher frequency of degenerative changes in the middle third. In our study, the greatest frequency of findings of sclerosis in the upper third of the sacroiliac joint could raise the question as to its degenerative origin, considering that more than half of our patients were aged over 50 years and, in addition, findings of degenerative arthropathy are described increasingly from the age of 20.[10] However, given the concomitance with other more specific findings for inflammatory arthropathy (erosions, fatty infiltration) in the upper third of the sacroiliac joints, we believe that sclerosis should be related to chronic structural lesions of spondyloarthritis.

In this study, the observation of a higher frequency of chronic *versus* acute changes can be justified by the long mean disease duration in our patients, considered from diagnosis (8.2 years). Considering that the diagnosis may have been delayed primarily due to the sole evaluation by conventional radiography,[19] it can be inferred that the actual disease duration should be even greater than that found.

The long duration of the disease favors the viewpoint that the chronic changes should change the load axis of its axial skeleton, by the change in sagittal balance in the face of the rectification of lumbar lordosis, and by variable changes of thoracic kyphosis. Knowing that the movement of the SI joints occurs by nutation and counter-nutation, and that the pivot of the joint is the iliac tubercle at S2 level, posteriorly to the auricular face of the joint,[9,18] more studies are needed to evaluate how the structural changes influence the sagittal balance, and if this relates to the topography of the lesions.

Correlation of MRI findings with clinical and laboratory data

The higher ASDAS-ESR and ASDAS-CRP values in patients with signs of osteitis in the lower third suggest that these areas of bone edema were related to the inflammatory activity.

The statistical correlation between the chronic findings and disease duration is supported by the long mean disease duration of the patients, as well as by the possible diagnostic delay inherent to the conventional radiologic method. The significant correlation between the presence of bony bridges, regardless of the topography, with BASMI and mSASSS strengthen the relationship between the structural damage of the SI joints with the joints of the spine and impaired mobility.

The limitations of this study included the limited sample and the variable time interval between the onset of symptoms, diagnosis, and MRI.

Conclusions

Chronic inflammatory changes and a pattern of bone marrow edema predominated in the upper third of the sacroiliac joints, but these findings were also observed in the lower 2/3 of these joints, suggesting that the whole joint can be affected by the inflammatory process of the synovio-entheseal complex in patients with axial SpA. On the other hand, only the location does not seem to be sufficient to differentiate between inflammatory *versus* degenerative changes.

In addition, there was a significant correlation between ASDAS-ESR and ASDAS-CRP with the presence of osteitis in the lower third of SI joints and between the long duration of the disease with the presence of chronic structural changes, as well as between clinical assessment tools BASMI and mSASSS with the presence of bony bridges in SI joints.

Conflicts of interest

The authors declare no conflicts of interest.

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