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Comparison of MRI and CT in the Diagnosis of Early Sacroiliitis

Erken Sakroiliit Tanısında BT ve MRG'nin Karşılaştırılması

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ABSTRACT: ***Objective***: A prospective study to compare the effectiveness and usefulness of CT and MR in diagnosis of sacroiliitis, and then to determine the most appropriate sequences to be used in MR.
Material and Methods: The sacroiliac joints (SIJs) of 40 patients with strong clinical suspicion of inflammatory sacroiliitis (median duration of inflammatory low back pain of 5 months) were evaluated by MR imaging using T1, T2 fat saturated (FS), STIR, two-dimensional (2D) T2* FLASH and after i.v Gd contrast medium T1 fat saturated (FS) sequences on a 1.5 T system. The findings were compared with those obtained by CT.
Results: Sacroiliitis was found in 25 patients by CT and 26 patients by MR. MR and CT had equal efficacy in the diagnosis of sacroiliitis. There was no significant difference between CT and MR in the determination of erosion and osseous sclerosis. Only MR allowed the determination of active inflammatory changes in the subchondral bone and joint space. Post contrast T1-weighted sequence did not contribute to the assessment of sacroiliitis.
Conclusion: MRI and CT can determine destructive bony changes related with sacroiliitis in close estimates. On the other hand, only MRI can visualize early inflammatory changes such as bone marrow edema and enhancement in the joint space that can not be shown by CT. Another advantage of MRI is that it has no ionizing radiation. When available, MRI has to be first modality to choose in diagnosis of early sacroiliitis. In addition, coronal T1 and STIR should be considered as the first sequences.
Key Words: Sacroiliitis; MRI; CT

ÖZET: ***Amaç***: Bu prospektif çalışmanın amacı, erken sakroiliit tanısında bilgisayarlı tomografi (BT) ve manyetik rezonans görüntülemenin (MRG) kullanılışlığını ve etkinliğini kıyaslamak ve sonrasında MRG' de kullanılabilecek en uygun sekansları belirlemektir.
Gereç ve Yöntem: Klinik olarak erken sakroiliit şüphesi olan (hastaların inflamatuar bel ağrılarının ortalama süresi 5 ay'dır) 40 hastanın sakroiliiak eklemleri koronal planda T1, yağ baskılı T2, STIR, 2D T2* FLASH ve intravenöz (I.V) kontrast madde uygulanımı sonrasında yağ baskılı T1 sekansları kullanılarak 1.5 T MRG ile değerlendirildi. Elde edilen bulgular BT bulguları kıyaslandı.
Bulgular: Kırk hastanın 26'sında MRG ile 25'inde ise BT ile sakroiliit saptandı. MRG ve BT sakroiliit tanısında benzer etkinliğe sahipti. Erozyon ve sklerozun tespitinde BT ve MRG arasında anlamlı bir farklılık saptanmadı. Bununla birlikte subkondral kemik ve eklem mesafesindeki aktif inflamatuar değişiklikler yalnızca MRG ile gösterilebildi. Kontrast madde kullanımı sakroiliitin değerlendirilmesinde ek bir fayda sağlamadı.
Sonuç: Sakroiliit ile ilişkili kemik değişikliklerinin saptanmasında MRG ve BT arasında belirgin bir farklılık yoktur. Bununla birlikte; MRG BT'den farklı olarak erken inflamatuar değişiklikleri görüntüleyebilme özelliğine sahiptir. MRG'nin diğer bir avantajı iyonizan radyasyon içermemesidir. Ulaşılabilir olduğunda MRG erken sakroiliit tanısında kullanılacak ilk yöntem olmalıdır. Böyle bir durumda öncelikle koronal T1 ve STIR sekanslarından oluşan bir çalışma planlanabilir.
Anahtar Kelimeler: Sakroiliit; MRG; BT

INTRODUCTION

Sacroiliitis is the most characteristic finding of patients with seronegative spondyloarthopathy. Radiographically, early diagnosis is difficult in the absence of osseous changes in the sacroiliac joints (SIJs) (1). Late- stage findings can be shown by conventional radiography, if diagnosis is based on radiography, and it may lead to a delay in diagnosis for years especially in the early stages of disease (2-4). As sacroiliitis occurs mainly in young patients, an early diagnosis would be valuable with regard to therapy, prognosis, and working capacity (5). Computerized tomography (CT) is superior to conventional radiography in establishing morphological changes in the SIJs with sacroiliitis. In spite of this, it is insufficient in the detection of early inflammatory changes of sacroiliitis or in the differentiation between active and inactive sacroiliitis (1, 2).

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Magnetic resonance (MR) imaging has been used effectively as a primary modality in the evaluation of cartilage of the peripheral joints. It seems to be superior to other imaging modalities in the diagnosis of sacroiliitis due to the evaluation of bone marrow and contrast enhancement in the joint space. MR is capable of visualization of early active inflammatory changes of the SIJs, so the early diagnosis of sacroiliitis is usually established by MRI (6, 7). Recently, studies related to this topic are reported more frequently. The main objectives of our study are to compare the effectiveness and usefulness of CT and MRI in the diagnosis of sacroiliitis and especially in the determination of early stage sacroiliitis by revealing early inflammatory changes, and then to determine the most appropriate sequences to be used in MRI.

MATERIALS AND METHODS

Eighty sacroiliac joints of 40 patients with strong clinical suspicion of inflammatory sacroiliitis were evaluated by CT and enhanced MRI. Complete clinical examinations were available for all patients before the application of CT and MRI. All patients fulfilled The European Spondylarthropathy Study Group (ESSG) criteria for spondylarthropathies (SpA) localized to the SIJs (8) having inflammatory low back pain (ILBP) with at least four of the following manifestations: 1) onset before the age of 45 years; 2) insidious onset; 3) improvement with exercise; 4) associated morning stiffness; and 5) at least 3 months duration. Patients were excluded if they showed evidence or had a clinical history of metabolic diseases or malignancies and/ or a positive rheumatoid factor.

The patients had a mean age of 23 years (17-56 years), with 23 women and 17 men. The median duration of ILBP was 5 months (3 -11 months). The patients gave written consent to participate in the prospective clinical and radiological investigations of sacroiliitis.

CT scans of the SI joints in all patients were performed in the supine position with a 19-20° cranial gantry tilt to obtain coronal images through both the cartilaginous and ligamentous portions of the SI joints using Toshiba X- Vision plus spiral CT scanner. Examination parameters were: contiguous 5-mm slices using 130 kV/ 320 mAs. MR images were obtained with a 1.5 T unit (Vision Plus, VB 330, Siemens). All patients were examined while in the supine position with their knees flexed for comfort. The examinations were performed with a body array coil and consisted of the following sequences: spin echo T1 (SE T1) (TR/TE 500/15 ms), fast spin-echo T2 with fat saturation (FSE T2 FS) (TR/TE 3000/45 ms), two-dimensional (2D) T2* FLASH (fast low angle shot) (TR/TE/FA 660/18 ms, 30°), short tau inversion recovery (STIR) (TR/TE/TI 5000/90/125 ms), and after the administration of i.v gadolinium (Gd) (Omniscan, 1mmol/kg, maximum 100 mmol) spin echo T1 with fat saturation (SE T1 FS) (TR/TE 500/15 ms). The slice thickness was 3-mm at all sequences with 1-mm spacing. The matrix was determined as 192x256 and FOV as 260-mm for all sequences. Sequences were acquired in a coronal plane tilted parallel to the long axis of the sacroiliac joint and 12 slices acquired.

ASSESSMENT OF IMAGES:

CT and MR images of each SI joint were evaluated separately by a radiologist who was blind to the information of other images. At CT the SIJs were assessed with regard to 1) erosions (destruction of the joint surface); 2) bone marrow sclerosis (increased density) (Fig. 1a, 2a); 3) joint width alteration. Spiral CT images of the SIJs (Fig. 1a, 2a, 3a) were graded according to modified New York criteria (9) for sacroiliitis using a 5-point scale: 1) normal; 2) suspicious changes; 3) minimal abnormality in the form of small areas of erosions or sclerosis without alteration in the joint width; 4) unequivocal abnormality- moderate or advanced sacroiliitis consisting of erosions, sclerosis, widening, and/or partial ankylosis; and 5) severe abnormality in the form of total ankylosis. After evaluation, all cases with a score of 2 or above were diagnosed as sacroiliitis.

In a preliminary overview of SI joint MR images from other patients with ankylosing spondylitis (AS), the cartilaginous portion was consistently evident in 5 consecutive coronal slices. Of the 12 acquisitions from posterior to anterior, this way typically slices 7 to 11. We also assessed all consecutive coronal slices from posterior to anterior to evaluate both of ligamentous and cartilaginous portions of the joint. Assessment of the MR examinations included following findings:1) osseous sclerosis (low signal intensity in all sequences, without enhancement after gadolinium administration); 2) erosion 3) fat accumulation in the bone marrow (high signal intensity at T1); 4) joint space width; 5) bone marrow edema (high signal intensity at STIR and T2); 6) Gd contrast enhancement in the bone marrow separated in regions with abnormally low and normal signal intensity at precontrast T1 and high signal intensity at STIR and T2; and 7) Gd contrast enhancement in the cartilaginous and ligamentous joint space.

For the evaluation of joint space, expansion of joint distance and properties of partial or total

ankylosis were determined. In MRI, erosion, subchondral bone edema and Gd contrast enhancement in the bone marrow and cartilaginous and ligamentous joint space were the findings giving the diagnose sacroiliitis. The MRI sequences used in this study were assessed with regard to their capability to visualize the articular and osseous abnormalities of sacroiliitis.

After the MRI and CT examinations of all patients, findings obtained for all joints were evaluated by using the Sign test (paired-dual) statistically. Values of $p<0.01$ were considered to be significant.

FINDINGS

The evaluation of sacroiliitis on the basis on the CT and MR imaging respectively in 40 patients with strong clinical suspicion of inflammatory sacroiliitis is shown in Table 1. Sacroiliitis is found in 25 patients with CT and 26 patients in MRI. Out of 80 sacroiliac joints examined, 40 with CT and 45 with MRI were detected as having sacroiliitis. MRI detected sacroiliitis in 7 joints where CT was negative (Fig. 3), whereas CT was positive in 2 joints where MRI was negative (Table 2) .There was no significant difference between CT and MR imaging in the detection of sacroiliitis ($p=0.38$).

Erosions were observed in 39 joints out of 40 with CT and 37 joints out of 45 with MR (Table 2). Observation of joint cartilage in high signal intensity in T2* FLASH 2D facilitated the evaluation of erosion since bone defects are related to the surface of the joint. CT established erosions in 6 joints where MRI was negative, whereas MRI was positive in 4 joints where CT was negative (Fig. 3b). There was no significant difference between CT and MRI in the determination of erosion ($p=0.37$). T1 and T2* FLASH 2D were most valuable sequences in the detection of erosion (Table 3). Except in 2 patients with erosions in the ligamentous portions of both joints, erosions were mostly found in the cartilaginous portion of the joints where they predominated on the iliac side, anteriorly and inferiorly.

Sclerosis was observed in 26 joints out of 40 with CT and 22 joints out of 45 with MRI (Table 2). T2* FLASH 2D and STIR were not effective in the diagnosis of sclerosis, as periarticular bone was observed as low signal intensity. Sclerosis was mostly found in the cartilaginous portion of the joints. There was no significant difference between CT and MRI in the determination of sclerosis ($p=0.1$).

Alterations in joint width: Changes in joint width, either narrowing or widening, were observed in 30% of joints by MR and in 33% by CT. MRI with all sequences other than STIR was used to evaluate joint width alteration. The changes were mainly seen in the cartilaginous portion of the joints.

Bone marrow edema was present in 64% of joints with sacroiliitis by MR. STIR was able to demonstrate all of the joints with bone marrow edema (Table 4) (Fig. 1b, 3b). Bone marrow edema predominantly occurred in the cartilaginous portion and at the iliac side of the joints.

Enhancement of bone was observed in 62% of joints. Enhancement was seen in both ligamentous and cartilaginous portions of the joints, but most often in the latter and on the iliac sides. Bone marrow edema and contrast enhancement occurred simultaneously in 28 (62%) and were absent in 16 (36%) of the joints with sacroiliitis. Bone marrow edema was observed in 1 (2%) of the joints with sacroiliitis without signs of enhancement.

Enhancement in the joint space was seen in 37% of the joints with sacroiliitis by MR (Fig. 1b, 2b). It occurred in both joint portions, but more frequently in the cartilaginous than in the ligamentous portion of the joints. All of the joints for which enhancement in the joint space was observed had abnormal high signal in the joint space on STIR.

Bone marrow edema and enhancement in the joint space were seen simultaneously in 11 joints (24%). In 18 (40%) of the joints, bone marrow edema was observed without enhancement in the joint space. In 6 (13%) of the joints, enhancement in the joint space was present without bone marrow edema. Considering the fact that enhancement in the joint space and bone marrow edema are findings compatible with active inflammation, inflammatory changes in 35 joints might be significant for active sacroiliitis.

Evaluation of the MR sequences used disclosed that the STIR sequence in all patients was most valuable for the detection of active inflammation. All the areas of enhancement of bone marrow or joint space produced high signal intensity on the STIR sequence. T2* FLASH 2D sequence was considered to facilitate evaluation of erosion. The FS T2 sequence did not give additional information about early inflammatory changes compared to the postcontrast T1 FS and STIR. Except in 2 joints, the T1 was considered to give information about fat accumulation in bone marrow that could not be achieved by other sequences.

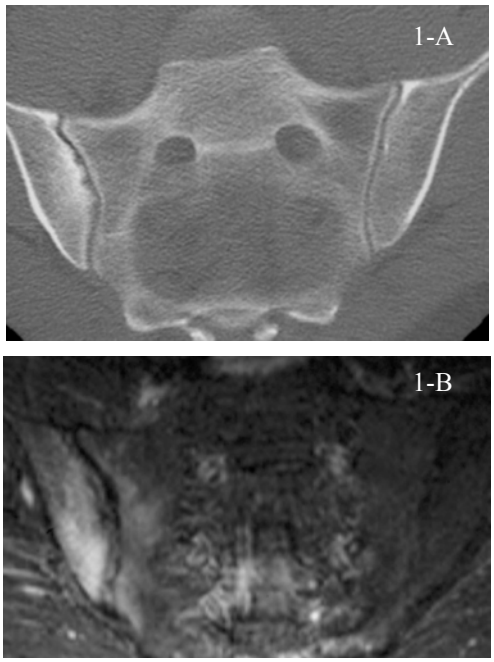

Figure 1. Images of bilateral sacroiliitis in a 31-year-old woman with suspected sacroiliitis. a) CT scan showing two erosions and sclerosis on the right iliac surface. b) STIR sequence obtained in the same section position as 'a' demonstrates abnormal high signal in the cartilaginous portion of the right sacroiliac joint and abnormal increase in signal in the adjacent iliac subchondral marrow, indicating active inflammation.

Table 1. *Comparison of MR with CT images for detecting sacroiliitis*

	No. of patients with sacroiliitis		
	Sacroiliitis	unilateral	bilateral
CT	25	10	15
MRI	26	7	19

Table 2. *Comparison of MR with CT in the detection of sacroiliitis, erosion and sclerosis*

	No. of joints			
CT and. MRI pos.	MRI pos.	MRI neg.		p- value
MRI pos	CT neg.	CT pos.		Sign test
Sacroiliitis	38	7	2	0.38 (p> 0.01)
Erosion	33	4	6	0.37 (p> 0.01)
Sclerosis	21	1	5	0.1 (p> 0.01)

Table 3. *Comparison of erosion detected at baseline by MR sequences in 26 patients with sacroilitis*

	MR, 52 joints			
	T2* FLASH 2d	T1 SE	FS T2 TSE	STIR
Erosion*	23(44.2%)	33 (63.4%)	16 (30.7%)	13 (25%)

Comparison by Sign test (paired dual)
p< 0.01 for T1 SE and T2 FLASH 2d vs FS T2 TSE as well as STIR
p> 0.01 for T1 SE vs T2* FLASH 2d

Table 4. *Comparison of findings of sacroiliitis detected by MR sequences in 26 patients with sacroiliitis*

	MR, 52 joints			
	STIR pos. FS PC T1 SE pos.	STIR pos. FS PC T1 SE neg.	STIR neg. FS PC T1 SE pos	p-value Sign test
Bone marrow edema	28	1	0	0.7 (p> 0.01)
Contrast enhancement in the joint space	0	0	17	0.06 (p>0.01)
High signal intensity in the joint space	17	0	0	0.06 (p>0.01)

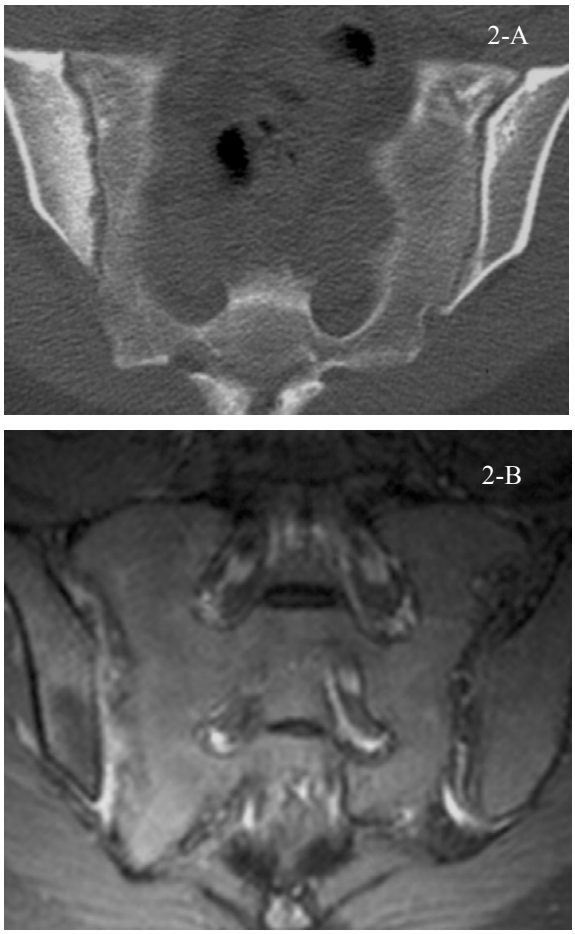

Figure 2. Images of a 26-year-old HLA B27 positive man with 6 months ILBP associated psoriatic skin. a) Coronal CT scan demonstrates sclerosis, cortical irregularity and erosions of right iliac surface. b) Corresponding SE PC T1 weighted shows obvious contrast enhancement in the ligamentous joint space. Assessment of the left sacroiliac joint by the CT and MR is normal.

DISCUSSION

Diagnosis of sacroiliitis is important in planning a treatment of the disease and in determining a follow-up protocol for patients with spondyloarthopathy (10, 11). CT can show chronic destructive bone changes in joints whereas it can not give information about active inflammation. For planning a suitable and effective treatment, active inflammation has to be exposed (1, 10, 11, 12). MRI is the primary visualization method in the evaluation of peripheral joints of the body. However, the use of MRI in the evaluation of sacroiliac joints has started in recent years (6, 10, 13, 14, 15, 16). MRI has excellent soft-tissue contrast resolution, enabling a clear distinction of the two portions of the SIJ based upon a well-delineated differentiation between fatty tissue in the ligamentous portion and cartilage in the cartilaginous portion (17, 18).

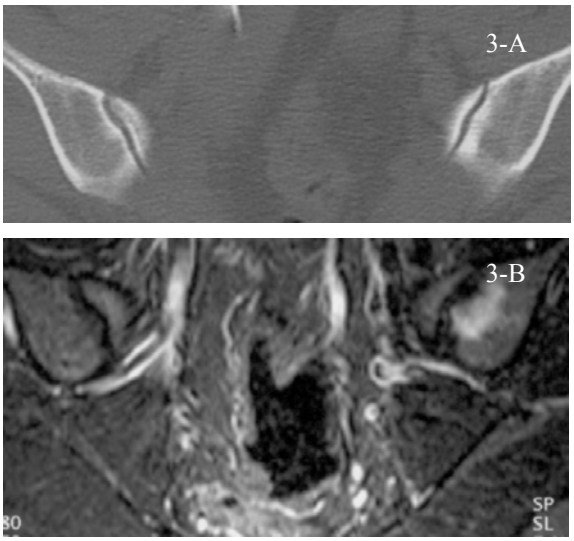

Figure 3. HLA B27 negative 28-year-old women with strong clinical suspicion of sacroiliitis. a) Coronal CT scan depicted no pathologic changes of the antero-superior part of the both joints. b) STIR image at approximately the same level demonstrates abnormal high signal of the iliac subchondral marrow adjacent to left sacroiliiac joint indicating a region of bone marrow edema

The advantages of MR compared with CT are that it visualizes early active inflammatory changes in the form of bone marrow edema and contrast enhancement, making it possible to diagnose sacroiliitis by MR before definite joint destruction is detectable by CT and radiography (11, 13, 14, 19, 20, 21). MRI is documented in the literature as a unique imaging method for the detection of early and active sacroiliitis (1, 10, 11, 12, 22). Advances in superficial coil technology, invention of new sequences and fast visualization methods are the factors increasing the sensitivity of MRI in the detection of early sacroiliitis (11, 15, 16).

To our knowledge, seven studies comparing MR and CT of the SIJs with regard to sacroiliitis have been published (1, 6, 14, 15, 22, 23, 24). The number of patients included in these studies varied from 17 to 50 (mean 40). The duration of symptoms was mentioned in only one of these studies, but as in most of the studies (except one), they included patients who had defined SpA. Therefore it seems likely that our patients were examined at an earlier stage of the disease because they were referred from

the primary ward and most had a relative short disease duration (24). In one of the seven studies, MR and CT were not evaluated independently (15). In the remaining studies different sequences and scan parameters were used, and post-contrast MR images were obtained in two studies (23, 24). When looking at the results of the five comparative studies, MR has been reported as equally good or even better than CT at detecting overall SIJ changes. There are two comparative studies in the literature claming that MR is equal to CT in the evaluation of sacroiliitis. In the same studies it is also emphasized that MRI is the only technique to show bone marrow edema (15, 23).

Taking all aspects of sacroiliitis into consideration, MR has been found significantly inferior to only CT for the diagnosis of sacroiliitis in one study (1). A possible explanation for the different results could be the fact that the study was based on a comparison of a high resolution CT technique (slice thickness of 2 mm and 480 mAs) and MR performed with a body coil and only T1- and T2- weighted sequences. On the other hand, it is claimed that MRI could be superior to CT in the diagnosis of sacroiliitis by visualizing early inflammatory changes (6, 16). In our study, we did not find any significant between CT and MR in the detection of sacroiliitis. However, MRI detected sacroiliitis by showing early inflammatory changes in the form of bone edema and enhancement in the joint space in seven joints where CT was negative. It is in line with similar studies.

In this study, there was no significant difference between MRI and CT in the detection of erosions, and this is in agreement with the literature (22, 23). Furthermore, T1 and T2* FLASH 2D were the most successful sequences in the detection of erosion. We have observed that the visualization of cartilage in high signal intensity at FLASH 2D facilitates the detection of erosion since bone defects are related to joint surface. Our finding is also in line with Wittram et al.'s results stating that the detection of erosion is facilitated better in FS T1 than T1 as cartilage is seen as a bright structure (22). It should be noted that the use of T2* FLASH 2D in detecting erosion has never been reported in the literature. In addition, erosions were found mostly in the iliac side of the joints anteroinferiorly, which is concordant with literature data.

CT has been found superior to MR in detecting sclerosis and bone production in one study (6). In the same study, it is also emphasized that CT identification of sclerosis may be misinterpreted as sacroiliitis because this change has been described in asymptomatic individuals and patients with osteoarthritis. Similarly, Remy et al. stated that sclerosis and paraarticular ankylosis can be observed mostly in the iliac side of the joint in normal individuals (1). Therefore, the finding of sclerosis without erosion may not be sufficient for the diagnosis of sacroiliitis. CT and MRI had equal efficacy in detecting osseous sclerosis in this study, which is also concordant with literature data (1, 22).

Ahlström has defined two types of pathologic signal changes in MRI related with periarticular bone marrow as type 1 and type 2. Different patterns of intensities in type 1 and 2 lesions are due to different water contents of those lesions, and MRI can differentiate water-rich lesions like edema (Type-1 lesions) from water-poor lesions like fibrosis and sclerosis (Type-2 lesions) (15). In the literature, some cases have been reported with negative CT and bone edema with MRI. Based on this finding, it is proposed that bone edema could be the earliest sign of sacroiliitis (12, 15, 22).

We have observed bone marrow edema concordant with type-I changes in 64% of the joints with sacroiliitis. In three joints where CT was negative, the only sign leading to the diagnosis of sacroiliitis was bone edema assessed by MRI. In the majority of the joints, edema was associated with erosion. This finding was different from literature and did not support the hypothesis that type-I changes could be the earliest sign of sacroiliitis. STIR was the best sequence to detect bone marrow edema.

Gd enhancement in the joint space was found in 37% of the joints, which is completely concordant with literature (16, 17, 25). Bone edema was also present in more than half of the joints in which enhancement in the joint space was seen. All the areas of enhancement of bone marrow or joint space produced high signal intensity on the STIR sequence. Therefore, the administration of Gd did not provide any additional information for the diagnosis of sacroiliitis and the evaluation of features of active inflammation.

The advantages of MRI compared to CT in evaluating sacroiliitis include: (a) detection of bone marrow edema (b) detection of Gd enhancement in the joint space (6). The capability of MR to distinguish between acute and chronic changes and estimate the degree of disease activity can be beneficial in monitoring the effect of pharmacological treatment (26). Moreover, the use of dynamic contrast-enhanced MRI to reflect

inflammatory activity could be of value (8, 25). This method is, however, difficult to apply in routine clinical practice because the assessment is time-consuming, and reproduction of the findings may be difficult.

Limitation of this study included the absence of the histopathologic confirmation. However, the bias with a lack of histological confirmation of sacroiliitis would apply to studies using all imaging modalities (13), and all of the 26 patients with sacroiliitis in this study fulfilled the ESSG criteria (8) for spondylarthropathies (SpA) localized to the SIJs.

It is reported in the literature that MRI and CT can show destructive bone changes in SIJs with sacroiliitis in close estimates. On the other hand, only MRI can visualize early inflammatory changes such as bone marrow edema and enhancement in the joint space that can not be shown by CT. MRI also allows differentiation between active and chronic sacroiliitis. Another advantage of MRI is that it has no ionizing radiation.

As a result, MRI and CT can determine destructive bony changes related with sacroiliitis in close estimates. On the other hand, only MRI can visualize early inflammatory changes such as bone marrow edema and enhancement in the joint space that can not be shown by CT. Another advantage of MRI is that it has no ionizing radiation. When available, MRI has to be first modality to choose in diagnosis of early sacroiliitis. In addition, coronal T1 and STIR should be considered as the first sequences.

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