Diagnostic value of gadolinium-enhanced MR imaging of active sacroiliitis in seronegative spondyloarthropathy

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Summary

Background:
Seronegative spondyloarthropathy (SpA) is a group of diseases including: ankylosing spondylitis, psoriatic spondyloarthritis, reactive arthritis, spondyloarthritides associated with inflammatory bowel disease, and undifferentiated spondyloarthritis. One of the diagnostic criteria of SpA is the presence of sacroiliitis. Periarticular bone marrow oedema (histologically corresponding to osteitis) is a primary symptom of the active stage of inflammation, which can be identified by MR using T2-weighted images. Its presence is essential for the therapeutic decision. The aims of this study were: 1. to compare the diagnostic value of T2-weighted images with T1 gadolinium-enhanced fat saturation (FS) images. 2. to establish if T1 gadolinium-enhanced images increase the diagnostic value of the MRI examination.

Material/Methods:
With the use of a 1.5T MRI scanner, 35 patients aged 19–67 years were examined. They were classified as having SpA or suspicious of SpA. The following findings were assessed: bone marrow oedema, synovitis, capsulitis/enthesitis. They were evaluated and compared on T2 and T1 gadolinium-enhanced FS images.

Results:
Active sacroiliitis was identified in 21 patients, chronic in 1 patient. Two patients had signs of synovitis without any features of bone marrow oedema. One patient had fracture of the sacral bone. Ten patients had no signs of sacroiliitis. There was no significant difference in the diagnostic value between FSE T2 images and T1 gadolinium-enhanced images with FS in the evaluation of bone marrow oedema and capsulitis/enthesitis. However, T1 gadolinium-enhanced images were more sensitive than FSE T2 images in visualising synovitis.

Conclusions:
MRI is a very sensitive method to identify active sacroiliitis in SpA. MRI without contrast administration is sufficient to identify bone marrow oedema as a crucial finding in active sacroiliitis. The gadolinium-enhanced images make the diagnosis easier, especially in patients with minimal bone marrow oedema because they reveal or better depict synovitis, while they do not improve visualisation of capsulitis/enthesitis.

Key words: seronegative spondyloarthropathies • sacroiliitis • magnetic resonance

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Background

Seronegative spondyloarthropathy (SpA) is a group of diseases including: ankylosing spondylitis, psoriatic spondyloarthritides, reactive arthritis (Reiter’s syndrome), spondyloarthritides associated with inflammatory bowel disease, and undifferentiated spondyloarthritides [1].

One of the diagnostic criteria of SpA is the presence of sacroiliitis. Until recently, this symptom was diagnosed in an advanced stage of the disease, on the basis of X-ray and CT images. Introduction of MR imaging enabled visualisation of sacroiliitis in its early active stage, i.e. a few years before the appearance of lesions in X-ray [2].
In 2008, the Assessment of Spondyloarthritis International Society (ASAS), together with a group of experts composed of radiologists and rheumatologists (OMERCAT working group) defined MRI features of an active sacroiliitis, and determined the role of sacroiliac joint imaging in SpA diagnostics [3]. Based on that, MRI was included into the group of diagnostic methods helpful in revealing early forms of SpA.

In the early stages of sacroiliitis, a basic symptom that may be found on MRI is the periarticular bone marrow oedema. Other features of an active inflammation process, found on MRI, are the synovitis, capsulitis and enthesitis.

The aim of the work was to compare the usefulness of FSE T2 images with fat saturation (fat sat) and the T1 gadolinium-enhanced images with fat saturation (T1+C fat sat), in the diagnostics of active sacroiliitis, and to establish whether the administration of the contrast medium significantly influences the diagnostic value of the examination.

Material and Methods

In the years 2008–2009, 35 patients with a clinically suspected or diagnosed SpA were examined (17 men and 18 women in the age group of 19–67 years, mean age of 32.35). The examination was performed with a MR 1.5 T SIGNA Hdx (GE Medical Systems) unit and a 16-canal coil of HD type (CTL 456/Fl: p), by applying the following study protocol:

- FSE T1 images (TR/TE 640/23)
- FSE T1 fat sat images (TR/TE 580/23)
- FSE T2 fat sat images (TR/TE 6580/87)
- FSE T1+C fat sat images after the administration of intravenous contrast Gadovist 0.1 mg/kg of body mass or Magnevist 0.2 mg/kg of body mass, in the oblique and transverse plane.

The applied matrix was: 512×224, slice width 3.0/5.0, FOV 28×28 cm or 24×24 cm.

We evaluated the features of the active inflammation: periarticular bone marrow oedema, synovitis and capsulitis/enthesitis as one.

Periarticular oedema, visible as a region of increased signal intensity of the bone marrow in FSE T2 images, and the sphere of enhancement after contrast medium administration, was evaluated with respect to size and the degree of enhancement in T1+C images.

In the evaluation of the extent of oedema, we based on the following scale:

- 0 – no oedema,
- 1 – scattered or linear foci of periarticular oedema,
- 2 – moderate oedema, not exceeding 1 cm in width,
- 3 – diffuse oedema, exceeding 1 cm in width.

In the assessment of signal intensity/degree of enhancement of the contrasted oedema, the following scale was applied:

- 0 – no enhancement/increased signal intensity,
- 1 – enhanced signal intensity,
- 2 – intensive signal enhancement.

The lower part of the lumbar spine was also subjected to evaluation. In patients showing an extensive inflammatory reaction of the articular capsule, including peristeum, the distribution of the features of the active inflammatory process for these two groups of patients was shown in Table 1.

From among the remaining 14 patients, 1 individual was diagnosed with chronic sacroiliitis, 2 with non-specific inflammatory lesions of the synovial membrane without concomitant periarticular oedema, and 1 with sacral fracture.

In 10 patients (3 men and 7 women), sacroiliitis was negative.

Table 1. The prevalence of lesions in active sacroiliitis.

| Sacroiliitis type | Osteitis (N) | Synovitis (N) | Capsulitis/enthesitis (N) |
|------------------|-------------|---------------|--------------------------|
| Active (N=10)    | 10          | 10            | 3                        |
| Active and chronic (N=11) | 11      | 7             | 5                        |

Synovitis and capsulitis/enthesitis were evaluated in the same way.

FSE T2 fat images and T1+C fat sat images were compared in the evaluation of these lesions.

The lower part of the lumbar spine was also subjected to evaluation, with respect to active features of inflammation, typical for SpA (capsulitis enthesitis, synovitis). The material was analysed retrospectively by 2 radiologists (HM and KK).

The statistical analysis was carried out with the use of the PASW Statistics 18.0.

Results

In the study group, the following results were obtained: in 21 patients out of 35 (10 men and 11 women), an active form of sacroiliitis was revealed - in 10 patients, these were only the active features of inflammation, in 11 – coexistence of active and chronic features, and in 2 – an extensive inflammatory reaction of the articular capsule, including peristeum. The distribution of the features of the active inflammatory process for these two groups of patients was shown in Table 1.

By evaluating specific features of active sacroiliitis with respect to the value of the highest incidence, it was found that in most cases, the area of periarticular oedema in FSE T2 and T1+C images was insignificant and the mode was equal to 1. For signal intensity, the mode in FSE T2 images amounted to 2, and for T1+C images =1. In case of synovitis, the mode was equal to 1 for FSE T2 images, and for
Lesions of capsulitis type were not revealed in most of the patients (Table 2).

**Statistical analysis**

In the evaluation of the periarticular site of oedema, no significant statistical difference was found between the FSE T2 FS and the T1+C images ($p=1.57$). Their diagnostic value turned out to be similar in the evaluation of the oedema extension (Table 3).

In the assessment of signal intensity within the oedema, a significant statistical difference was revealed ($p=0.008$) and the diagnostic value of FSE T2 with FS images was found to be higher than of T1+C images (Table 3).

In the evaluation of synovitis, significantly higher statistical differences ($p=0.001$) were found, as well as the advantage of T1+C FS images over FSE T2 FS images.

The diagnostic value of both images turned out to be similar (Table 3).

**Discussion**

In the presented work, the diagnosis of active and chronic sacroiliitis based on guidelines and definitions assumed by the ASAS/OMERCAT group [3].

**Periarticular bone marrow oedema** was defined as a periarticular area, hyperintense in T2 and STIR images, hypointense in T1 images, undergoing enhancement after contrast medium administration. The enhancement results from an increased perfusion and corresponds histopathologically to aseptic osteitis. Its presence in MRI images is sufficient to diagnose active sacroiliitis. If found alone, it indicates an early stage of the inflammatory lesions. In our material, the diagnosed oedema was mostly bilateral.
scattered or linear (Figure 1A,B) and it was totally impossible to detect on the basis of X-ray or CT images.

In the second group of patients, in which the oedema was accompanied by chronic sacroiliitis, it was demonstrating the activity and the progression rate of the inflammatory process. Apart from different rates of oedema, there were also erosions (sometimes filled with contrast-enhanced synovial membrane), periarticular fatty bone marrow changes and bone union.

The comparative analysis of the FSE T2 and T1+C images showed that the administration of the contrast medium did not have any significant influence on visualisation of the oedema extent in any of the selected groups (p<0.005).

On the other hand, signals from oedematous areas in FSE T2 FS images turned out to be strongly hyperintense and additionally enhanced by the applied fat saturation (Figure 2A,B). FSE T2 images revealed a higher diagnostic value than T1+C images (p=0.008).

Owing to the fact that the presence of the periarticular oedema is sufficient to diagnose active sacroiliitis according to ASAS/OMERCAT criteria from 2009 [3], and that the results obtained by us showed the advantage of FSE T2+FS over T1+C images in the evaluation of the oedema, we decided that contrast medium administration is not obligatory to diagnose sacroiliitis, and abstention from contrast medium injection is connected with additional advantages, such as lower costs and a shorter examination time.

Resignation from contrast medium administration in the evaluation of sacroiliitis was also mentioned by Z. Bozygenik et al. They applied DWI sequences and ADC coefficient measurements as an alternative method of

Figure 2. (A) T2 FS image, frontal-oblique plane. (B) T1 FS+C image, frontal-oblique plane. Generalised oedema of the bone marrow/osteitis in both sacroiliac joints.

Figure 3. (A) T2 FS image, transverse plane. (B) T1 FS+C image, transverse plane. Linear enhancement of the synovial membrane in the left sacroiliac joint.
diagnosis and monitoring of the periarticular oedema [4]. Many authors point to the usefulness of the STIR sequence [1,3]. However, the opinion on contrast medium application is not unanimous and some authors believe that contrast medium administration is important, especially in case of early sacroilitis [5,6], and the diagnostic value of such images is additionally increased by fat saturation [2,7], used in our protocol as well. Periarticular oedema and the degree of its enhancement after contrast medium administration was studied in correlation to the laboratory studies [2,8].

In our material, contrast administration turned out to be important only in case of inflammatory lesions of the synovial membrane (p=0.001), the second feature of the inflammatory process activity. Synovitis, according to the accepted definition, is presented by a hyperintense, linear signal in T2 images and in STIR sequence, which is hard to distinguish form fluid in the articular cavity. Only in T1+C images, the inflamed synovial membrane is distinctly shown as an enhanced linear structure in the synovial part of the joint [5], with signal intensity similar to the one of vessels (Figure 3A,B). In all cases, the inflammatory lesions of the synovial membrane were present in the synovial part of the joint where the inflammatory process occurred as first [5]. There were only a few cases with inflammation present in the ligamentous part of the joint as well. The lesions were much more distinct in T1+C images, which was also reported in other, previous studies [5,6], and were mostly accompanied by periarticular bone marrow oedema and by chronic lesions (Table 1) (Figure 4A–D).

Only in 2 patients (a 29-year-old man and a 53-year-old woman), synovitis was diagnosed in isolation – without any concomitant bone marrow oedema.
Due to the fact that according to the recent criteria, synovitis alone does not allow for diagnosis of early sacroiliitis, those cases were classified (after considering patients’ age) as suspicious of very early nonspecific inflammatory or degenerative lesions, and thus the follow-up MRI examination was recommended.

In case of capsulitis/enthesitis, i.e. one more feature of an active inflammatory process, contrast administration turned out to be insignificant in our material (p=0.157). The inflamed articular capsule was present in T2-weighted images with FS as a linear structure on the rim of the joint spaces and along periosteum, and, after contrast agent administration, it exhibited a distinct enhancement. In our material, lesions of capsulitis type were found in 8 cases only. They were mostly minor and always accompanied by synovitis and by periarticular oedema, as in the study by Muche et al. [5]. According to those authors, these lesions tend to point to the advanced stage of active sacroiliitis. This was also confirmed by our material, with a higher number of cases in the group of active and chronic sacroilitis (Table 1). The inflammatory process involves both the anterior and the posterior part of the joint capsule, extending from the anterior part the into periosteum of the sacral and the iliac bone (enthesitis). That is why these two lesions are treated as one [3]. In our material, there were only 2 cases in which there was a visible spreading of the inflammatory lesions within the iliac periostium. In one case, the inflammatory process involved paravertebral muscles and the adipose tissue [3] (Figure 5A–C).

In one case, we found only features of chronic sacroilitis. The image was dominated by bone union surrounded by the periarthritic area of fatty degeneration of the bone marrow. Fatty degeneration of bone marrow alone is not a specific symptom of SpA, but its periarthritic location points to the chronic character of the process [5,8]. As already mentioned above, it may also coexist with periarthritic oedema which is a marker of the inflammatory activity (Figure 6A,B).

Our material showed that apart from the evaluation of sacroiliac articles, it is also important to assess the adjacent anatomical structures, and especially the visualised lumbar spine, being a potential area of active inflammatory lesions typical for SpA, and for ankylosing spondylitis mainly [1,8]. Enthesitis revealed by us could be observed as a region of increased signal intensity around spinous processes in FSE T2 images with FS and T1+C images with fat sat (Figure 7A,B), indicating inflammation of the ligaments and tendons of the paravertebral muscles. In zygapophyseal joint inflammation, the predominant feature was the inflammation of the articular capsule, and in spondylitis – the Romanus lesion, demonstrated as a small region of signal intensity similar to the one of bone marrow oedema and characteristically located, in the anterosuperior and anteroinferior corners of the vertebral bodies, revealing enhancement after contrast medium administration [9].

The MRI image of sacroilitis in SpA, and especially the lesions of osteitis type, are not specific. When establishing
the differential diagnosis in correlation with the clinical data, the following conditions should be taken into consideration: septic arthritis, exceeding the anatomical barriers of a joint in most of the cases, degenerative lesions of sacroiliac joints in older people, and sacral fractures (in our material there was one case of the sacral fracture, in the lower part of the sacral bone) and, rarely, bone tumours, constituting metastatic foci, most of the time [3].

Conclusions

MRI examination is a sensitive method of sacroiliitis diagnosis and classification. Unenhanced MRI is sensitive enough to reveal periarticular oedema and to diagnose active sacroiliitis, according to the newly accepted criteria. FSE T1 images after contrast administration increase the sensitivity of the examination, by visualising or showing more distinctly all lesions of synovitis type. However, they do not influence visualisation of capsulitis/enthesitis in any significant way.

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