Gadolinium-DTPA enhanced magnetic resonance imaging of bone cysts in patients with rheumatoid arthritis

F M Gubler, P R Algra, M Maas, P F Dijkstra, Th H M Falke

Abstract

Objectives—To examine the contents of intraosseous cysts in patients with rheumatoid arthritis (RA) through the signal intensity characteristics on gadolinium-DTPA (Gd-DTPA) enhanced magnetic resonance imaging.

Methods—The hand or foot joints of nine patients with the cystic form of RA (where the initial radiological abnormality consisted of intraosseous cysts without erosions) were imaged before and after intravenous administration of Gd-DTPA. A 0-6 unit, T1 weighted spin echo and T2* weighted gradient echo were used to obtain images in at least two perpendicular planes.

Results—Most cysts showed a low signal intensity on the non-enhanced T1 weighted (spin echo) images and a high signal intensity on the T2* weighted (gradient echo) images, consistent with a fluid content. No cyst showed an enhancement of signal intensity on the T1 weighted images after intravenous administration of Gd-DTPA, whereas synovium hyperplasia at the site of bony erosions did show an increased signal intensity after Gd-DTPA. Magnetic resonance imaging detected more cysts (as small as 2 mm) than plain films, and the cysts were located truly intraosseously. In six patients no other joint abnormalities were identified by magnetic resonance imaging; the three other patients also showed, after Gd-DTPA administration, an enhanced synovium at the site of bony erosions.

Conclusions—It is suggested that intraosseous bone cysts in patients with RA do not contain hyperaemic synovial proliferation. The bone cysts in patients with the cystic form of RA may be the only joint abnormality.

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Magnetic resonance imaging of patients with rheumatoid arthritis (RA) has been the subject of many studies, but little has been reported about the magnetic resonance imaging characteristics of the intraosseous periarticular cysts (synonyms: cysts, bone cysts, subchondral pseudocysts, geodes) found in patients with RA.1–4

The pathogenesis and contents of these cysts in patients with RA were discussed long before magnetic resonance imaging was available. Some workers saw an anatomical connection between the cysts and joint space, and hypervascular proliferative synovial tissue in the cysts. They postulated that the cysts arise from invaginations of the rheumatoid pannus.1–8 Others, who did not find a connection between the cysts and joint space, postulated that nutritional and metabolic injury to the bone might be the cause of the cysts in RA.2,9 Some workers found typical rheumatoid nodules in the cysts.5–10–12 We have previously described the magnetic resonance imaging findings in three patients with the cystic form of RA. Their cysts showed a low signal intensity on non-enhanced T1 weighted images, and a high signal intensity on T2 weighted images. Differentiation between fluid and hyperaemic pannus in the cysts was impossible.1 Hypervascular synovial proliferation (synovitis) shows signal intensity enhancement on T1 weighted magnetic resonance images after intravenous administration of gadolinium-DTPA (Gd-DTPA).5–9,11–16 In contrast, several studies report little or no enhancement of the signal intensity of joint fluid after Gd-DTPA, whereas Weissman and coworkers found late enhancement of joint fluid 15 minutes after intravenous administration of Gd-DTPA.17–19

The purpose of this study was to examine the contents of intraosseous cysts in patients with RA by describing the signal intensity characteristics of their cysts on Gd-DTPA enhanced magnetic resonance imaging, and to discover if the signal intensity in these cysts agrees with the presence of hypervascular synovial proliferation.

Patients and methods

The patients studied were recruited from a series of 70 patients with known cystic RA (five or more American Rheumatism Association criteria) whose radiological findings were published previously.1,20 Nine patients underwent Gd-DTPA enhanced magnetic resonance imaging after informed consent had been obtained. The group consisted of seven women and two men (age range 39–71 years, mean 53 years; disease duration 15–34 years, mean 21 years). The initial radiological abnormality seen on plain films in these patients consisted
Magnetic resonance imaging of bone cysts in RA

Table 1 Joints studied by magnetic resonance imaging

<table>
<thead>
<tr>
<th>Patient No</th>
<th>Both feet</th>
<th>Tarsal bones</th>
<th>MTP</th>
<th>IP-1</th>
<th>PIP</th>
<th>Wrist bones</th>
<th>MCP</th>
<th>MCP-1, CMC-1</th>
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</tbody>
</table>

Abbreviations: MTP=Metatarsophalangeal joints; IP-1=first interphalangeal joint; PIP=proximal interphalangeal joints; MCP=metacarpophalangeal joints; and CMC-1=first carpometacarpal joint.

Table 2 Location of the abnormalities

<table>
<thead>
<tr>
<th>Patient No</th>
<th>Cysts</th>
<th>Other abnormalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Both MCP-1 joints</td>
<td>Enhancing pannus: normal CMC-1 joint; Joint effusion: normal</td>
</tr>
<tr>
<td>2</td>
<td>MCP-2, MCP-3, radius capitale bone</td>
<td>At erosions of MCP-2 and MCP-3; Around normal ulna</td>
</tr>
<tr>
<td>6</td>
<td>IP-1 joints, MTP-1, joints, PIP joints</td>
<td>At erosions of both MCP-1 joints; Enhancing J surface: IP-1 R, ankle R</td>
</tr>
</tbody>
</table>

Abbreviations: MTP=Metatarsophalangeal joints; IP-1=first interphalangeal joint; PIP=proximal interphalangeal joints; MCP=metacarpophalangeal joints; CMC-1=first carpometacarpal joint; J=joint; and R=right.

Abnormalities found in patient 2. (A) T1 weighted magnetic resonance image of the wrist showing a large, intraosseous cyst in the distal radius, with a low signal intensity. (B) No enhancement of the signal intensity in the cyst is seen after Gd-DTPA administration (arrow). (C) T2* weighted image of the same section shows a high signal intensity in the cyst (arrow) and in the collection of fluid near the distal ulna (arrowhead), which did not enhance after Gd-DTPA administration. (D) On a T1 weighted image the head of the second metacarpal joint shows a small bone cyst with a low signal intensity (arrow) and an erosion with a soft tissue mass with an intermediate signal intensity (arrow head). (E) After Gd-DTPA administration only the soft tissue mass enhances (arrowhead), no enhancement is seen in the cyst (arrow).

MAGNETIC RESONANCE IMAGING TECHNIQUE

The examinations were performed with a 0.6 T Technicare unit (GE Medical Systems, Milwaukee, MI, USA) using a standard head coil. All joints were examined in the coronal plane; sagittal or transverse planes, or both, were also obtained.

Spin echo pulse sequences, repetition times of 485–660 ms and echo times of 28 ms were used to obtain T1 weighted images. Gradient echo pulse sequences, repetition time/echo time=280/32 with a flip angle of 32°, were used to obtain T2* weighted images. The section thickness was 3 mm, with a 20% gap; four to six acquisitions were obtained for the spin echo and eight acquisitions for the gradient echo images.

Before administration of the contrast material T1 weighted images in two orthogonal planes, and single plane T2* weighted images were obtained. The coronal T1 weighted

of periarticular intraosseous cysts without erosions; the intraosseous location of these cysts was established by multidirectional radiographs or computed tomography, or both.

Both feet of four patients and a hand of five patients were examined; the joints radiographed are summarised in table 1.

The examinations were performed with a 0.6 T Technicare unit (GE Medical Systems, Milwaukee, MI, USA) using a standard head coil. All joints were examined in the coronal plane; sagittal or transverse planes, or both, were also obtained.

Spin echo pulse sequences, repetition times of 485–660 ms and echo times of 28 ms were used to obtain T1 weighted images. Gradient echo pulse sequences, repetition time/echo time=280/32 with a flip angle of 32°, were used to obtain T2* weighted images. The section thickness was 3 mm, with a 20% gap; four to six acquisitions were obtained for the spin echo and eight acquisitions for the gradient echo images.

Before administration of the contrast material T1 weighted images in two orthogonal planes, and single plane T2* weighted images were obtained. The coronal T1 weighted
sequences were repeated at the same section locations immediately after the intravenous administration of Gd-DTPA (0.1 mmol/kg body weight). In seven patients it was possible to obtain subtraction images by subtracting the coronal T1 weighted images made before contrast administration from the corresponding T1 weighted images obtained after contrast administration.

The images were analysed for the bone marrow signal of the subchondral area (where the cysts are located), bone erosions (defined as marginal cortical defects), intra-articular and subchondral soft tissue masses (rheumatoid pannus/synovial hyperplasia), effusions, ligamentous disorders, and enhancing structures after Gd-DTPA administration by three radiologists (FMG, PRA, and MM) who reached a consensus.

Results

All cysts identified with plain films were also seen on magnetic resonance imaging. Most cysts were seen as circumscribed areas in the bone marrow with a low signal intensity on T1 weighted spin echo images, and a high signal intensity on T2* weighted gradient echo images. The cysts were seen around the metatarsophalangeal, first interphalangeal, and proximal interphalangeal joints of the foot or in the tarsal bones, or both, and around the metacarpophalangeal and first carpometacarpal joints of the hand or in the wrist bones (including the metacarpal bases and the distal radius), or both. In three patients some cysts showed a high signal intensity on T1 weighted images. Even small cysts, about 2 mm in size, could be recognised. In five patients additional cysts, which were not seen on the conventional radiographs, were recognised on the magnetic resonance images. All intraosseous cysts (defined on previous radiographs) were also located in intraosseous locations on the magnetic resonance images; they were defined by an outline of cortical bone and no connection with the adjacent joint space could be shown.

After intravenous administration of Gd-DTPA no enhancement of signal intensity was seen in any of the cysts on the T1 weighted nor subtraction images.

In six patients the intraosseous cysts were the only abnormality. The magnetic resonance images of these six patients showed no bony erosions, intra-articular or subchondral soft tissue masses, joint effusions, ligamentous disorders, nor enhancing structures. In three patients we found, in addition to the cysts, other joint abnormalities (summarised in table 2). Patient 1 showed a soft tissue mass at the otherwise normal left first carpometacarpal joint (intermediate signal intensity on T1 weighted and high signal intensity on T2* weighted images) that enhanced after Gd-DTPA administration. Patients 2 and 6 showed non-enhancing cysts and enhancing soft tissue masses (intermediate signal intensity on T1 weighted and high signal intensity on T2* weighted images) at the sites of bone erosions, around the same joints.

Furthermore we found a non-enhancing joint effusion around the distal ulna in patient 2 (figure), and linear enhancement at the right first carpometacarpal and ankle joint spaces of patient 6.

Discussion

Our magnetic resonance technique, using a 0.6 T main magnetic field, enabled us to see small cysts (2 mm), and more cysts were detected than by conventional radiographs. This finding has also been described by others using magnetic resonance imaging equipment of 1.0 and 1.5 T.21 23

The enhancement of signal intensity found in a joint space after Gd-DTPA administration is consistent with synovitis, and the enhancing soft tissue masses at the sites of bony erosions are consistent with rheumatoid pannus at those locations.3 4 13-16 The lack of enhancement of signal intensity after Gd-DTPA administration in intraosseous cysts using the same technique does not support the theory that the cysts in RA contain hyperaemic synovial tissue.5 9 It is more probable that the fluid content must be the cause of the low signal intensity on the T1 weighted images, and the high signal intensity on the T2* weighted images, which was usually found.24 25 Other workers have also found a low signal intensity on T1 weighted and a high signal intensity on T2* weighted images of the bone cysts in patients with RA.7-4 26 The occurrence of occasional rheumatoid cysts with a high signal intensity on the T1 weighted images has been described previously1 27; the fluid of these cysts probably has a higher protein content.25

The lack of enhancement of signal intensity in the intraosseous cysts after Gd-DTPA administration in our study disagrees with earlier reports where the signal intensity was enhanced in rheumatoid cysts.

Adams et al26 described the knees of 23 patients with RA: in 19 joints he found subcortical lesions with a low signal intensity on T1 weighted images; on T2* weighted images 13 showed a low signal intensity and six lesions showed a high signal intensity and were therefore classified as cysts. Two of these six subchondral cysts showed an enhancement of signal intensity at their outer margins after Gd-DTPA. No illustrations of these enhancing cysts were shown, however, and these workers did not report their definition of a subchondral cyst.

Bjorkengren et al3 reported magnetic resonance imaging of nine knees of patients with RA after Gd-DOTA administration. Eight patients showed an increase in the signal intensity of the synovium after Gd-DOTA administration. In two patients cysts not seen on the radiographs were identified. Imaging without Gd-DOTA suggested that the cysts contained fluid, but enhancement of the signal intensity of the lesions after Gd-DOTA administration indicated the presence of synovial tissue. The ‘cyst’ illustrated in this report seems to have a broad connection with the joint space, however, and thus is not in agreement with our definition of an intra-
Magnetic resonance imaging of bone cysts in RA

Bone cysts in RA may be present in a variety of locations, including the pelvis, and may be either articular or extraskeletal. Though usually asymptomatic, bone cysts may lead to pain and functional impairment in patients with RA.

Bone cysts are defined as a fluid-filled space within bone, which may contain a solid lining. They can be classified as intraosseous, which means they are within bone, or extraosseous, which means they are outside bone but within the soft tissues.

Bone cysts in RA are often seen in the femoral head, pelvis, and other weight-bearing bones. They may be solitary or multiple, and can vary in size. Some bone cysts in RA may be associated with radiographic evidence of erosion or subchondral cysts.

Bone cysts in RA can be visualized using magnetic resonance imaging (MRI), which is the imaging modality of choice for evaluating bone cysts. MRI allows for the assessment of bone cysts in terms of size, location, and wall characteristics. MRI can also be used to evaluate the surrounding bone and soft tissues, and to rule out other causes of bone lesions.

Bone cysts in RA can be treated with surgical excision or percutaneous aspiration and injection of bone cement. The treatment option depends on the size, location, and signs and symptoms of the bone cyst.

In conclusion, bone cysts in RA are a common finding that can be evaluated using MRI. MRI is the imaging modality of choice for evaluating bone cysts in RA, as it provides detailed information about the bone cyst's size, location, and wall characteristics.

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