

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

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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.⁵⁻⁸ 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).^{3 4 13-16} 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

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Table 1 Joints studied by magnetic resonance imaging

Patient No	Both feet				One hand		Both thumbs
	Tarsal bones	MTP	IP-1	PIP	Wrist bones	MCP	MCP-1, CMC-1
1	—	—	—	—	—	—	×
2	—	—	—	—	×	×	—
3	—	—	—	—	×	×	—
4	—	—	—	—	×	×	—
5	—	—	—	—	×	—	—
6	×	×	×	×	—	—	—
7	×	×	×	—	—	—	—
8	×	×	—	—	—	—	—
9	×	×	—	—	—	—	—

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

Patient No	Cysts	Other abnormalities		
		Enhancing pannus	Joint effusion	Enhancing J surface
1	Both MCP-1 joints	Near normal CMC-1 joint	—	—
2	MCP-2, MCP-3, radius capitate bone	At erosions of MCP-2 and MCP-3	Around normal ulna	—
6	IP-1 joints, MTP-1, joints, PIP joints	At erosions of both MTP-1 joints	—	IP-1 R, ankle R

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.

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

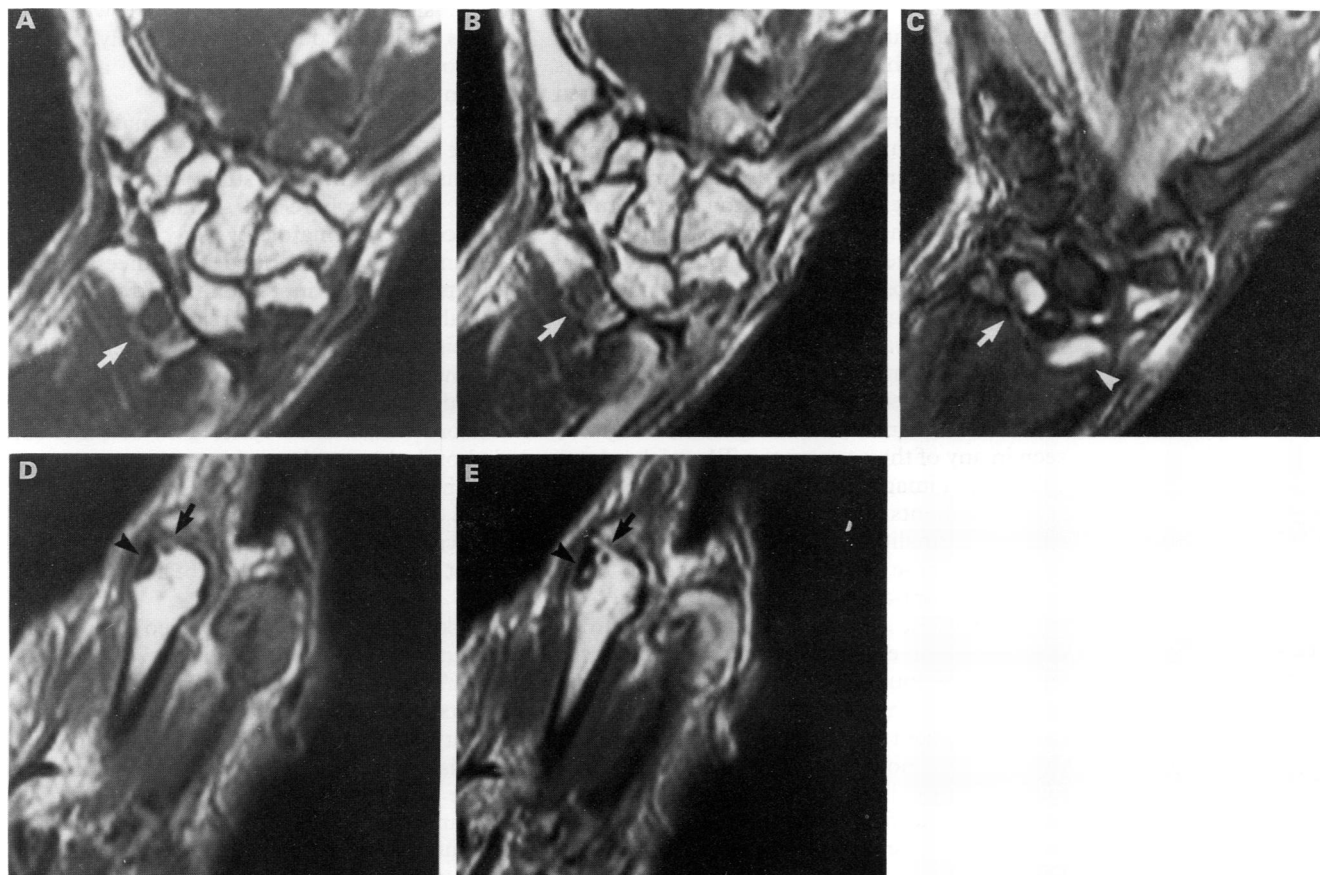
Both feet of four patients and a hand of five patients were examined; the joints radiographed are summarised in table 1.

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 with 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



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).

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 intraosseously 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.⁵⁻⁸ 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.^{2-4 26} The occurrence of occasional rheumatoid cysts with a high signal intensity on the T1 weighted images has been described previously^{4 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 al*⁴ 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 al*³ 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-

osseous bone cyst. It may be possible that these earlier descriptions of enhancement of the signal intensity after Gd-DTPA administration in rheumatoid 'cysts' were actually of lesions which were not truly intraosseous.

The intraosseous location of the cysts on our magnetic resonance images is consistent with the findings of other workers.^{2 26 28} Séguin *et al*²⁶ reported a patient with cystic RA in whom many cysts in the foot were located intraosseously on radiographs, by computed tomography, and by magnetic resonance imaging.

Moore *et al*² described in detail the development and progression of cysts in one patient with RA by magnetic resonance imaging. They measured T1 values in the bone marrow, joint space, and cysts twice, two years apart. The cysts were intraosseous, defined by an outline of cortical bone, and no connection with the joint space was found. The high T1 values found in the cysts were significantly higher than those of the joint space and bone marrow, and were characteristic of a fluid filled cyst. During follow up the cysts increased in size. Sometimes a communication developed between the cyst and the joint space. In these instances the T1 values of the cysts became equal to those of the joint space.

The sequence of development of the cysts in RA described by these workers (that is, truly intraosseous cysts originally, some of which form a communication with a joint space in the course of the disease) is in agreement with our own findings in patients with cystic RA.¹ In contrast, our findings do not support the theory that cysts in RA develop from previous erosions, through invagination of the proliferating synovium.^{6 29 30}

Our finding of few or no other abnormalities around the joints with intraosseous cysts in RA is consistent with other reports. The absence of joint abnormalities in other reports was proved by either a histological specimen (of a giant intraosseous cyst in the femoral neck, with a normal articular cartilage and joint synovium³¹), or on the basis of conventional radiographs.^{1 32-36} To our knowledge we are the first to describe Gd-DTPA enhanced magnetic resonance imaging of the intraosseous periarticular cysts in patients with RA without other abnormalities at the same joint.

We conclude that Gd-DTPA enhanced magnetic resonance imaging of bone cysts in patients with RA proves their truly intraosseous location, without a connection with the joint space, as well as their content, namely pure fluid rather than hyperaemic synovial proliferation. The bone cysts in patients with cystic RA may be the only joint abnormality.

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