CONTRAST-ENHANCED MRI OF RHEUMATIC JOINT DISEASE

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SUMMARY
Early MR diagnosis of inflammatory rheumatic joint disease relies on the detection of the proliferating synovium. Several studies have shown that reliable visualization of the inflamed synovium is dependent upon the enhancement provided by intravenously injected paramagnetic contrast media. This presentation discusses the role of contrast-enhanced MRI in the assessment of inflammatory rheumatic joint disease. It is concluded that the method may aid in early diagnosis, and that it has a great potential in the assessment of disease severity and inflammatory activity.

KEY WORDS: Gadolinium, Joints, MR, Rheumatoid arthritis, Synovitis.

INTRODUCTION
MAGNETIC resonance imaging plays only a minor role in the management of patients with rheumatic joint disease. There are various reasons for this, but availability and cost are probably the major ones. The primary diagnostic imaging tool is still the X-ray plain film with its ability to show early rheumatic changes such as soft tissue swelling and periarticular osteoporosis, and later changes such as bony erosions, destructions and ankylosis. Conventional tomography or computed tomography may supplement the plain films by showing subtle erosions to better advantage, and by differentiating between fibrous and bony ankylosis. Radioisotope scanning may be sensitive to early inflammatory changes, but lacks the specificity and spatial resolution needed for a definite diagnosis. MRI is the only modality with the potential to show all the components of a synovial joint: bone marrow, cortical bone, hyaline cartilage, disk (when present), joint capsule and ligaments. The normal synovium is only a thin membrane, and it is therefore invisible to MRI. However, when thickened due to inflammatory disease, it may be depicted.

Synovial proliferation is the hallmark of rheumatic inflammatory joint disease. The changes shown by X-ray imaging are all secondary to synovial proliferation, and detection of the thickened synovium is therefore a key to an early non-invasive diagnosis. Intravenously injected paramagnetic contrast media containing gadolinium have been shown to enhance the thickened, inflamed synovium. The purpose of this presentation is to discuss the role of gadolinium-enhanced MRI in the evaluation of rheumatic inflammatory joint disease.

CONTRAST-ENHANCEMENT IN SYNOVIAL JOINTS
To appreciate the significance of contrast-enhancement in MRI of rheumatic joint disease, a knowledge of the enhancement in normal joints and non-rheumatic disease is needed.

Normal synovial joints
The soft tissues of a normal synovial joint show no or only minor contrast enhancement. Slight enhancement may be seen in richly vascularized areas, such as the tissue surrounding the posterior attachment in the temporomandibular joint (TMJ) [1]. The normal synovium does not enhance [1, 2], and therefore remains invisible. Small joint effusions may be seen in several normal joints using MRI, and these small effusions will enhance intensely on T1-weighted MR images [1]. This arthrographic effect is time dependent and will be evident within few minutes.

Non-rheumatic joint disease
The arthrographic effect of intravenously injected paramagnetic contrast media may be used to advantage in non-rheumatic joint disease. In disk rupture of the knee, the enhanced joint fluid may increase the conspicuity of the rupture and prove its communication with the joint space [3] (degenerative changes within the disk will not enhance). Post-traumatic and degenerative joint disease may have an element of synovitis, leading to an increased amount of joint fluid. A large effusion will gradually enhance, starting from the fluid layer next to the synovium. The synovium itself is usually not identified, and, if identifiable, should be present only along the joint capsule, i.e. in areas normally having synovium.

Inflammatory rheumatic joint disease
Several studies have shown that the thickened, inflamed synovium and pannus of RA enhances after intravenous injection of gadolinium-containing contrast media [1, 2, 4-9]. Due to the proliferating, growing nature of the synovium, the enhancing tissue will be found also along articular surfaces normally devoid of synovium. There are indications that only hypervascular, inflamed pannus, and not fibrous, 'inactive' pannus will enhance [6]. The contrast-enhancement of inflamed, proliferating synovium is rapid, reaching a maximum in the order of 0.5-1.5 min [6]. Enhancement of joint effusions is slower, similar to what is found in non-rheumatic disease.
MRI IN THE ASSESSMENT OF RA

Fig. 1. Rheumatoid arthritis of the knee in a 24-yr-old woman. (a) T₁-weighted SE image shows increased amount of joint fluid, but has difficulty demonstrating the thickened synovium which is minimally hyperintense compared to the fluid. (b) Gd-enhanced, T₁-weighted, fat-suppressed SE image shows intense enhancement of the synovium.

POTENTIAL ROLES OF CONTRAST-ENHANCED MRI

Early detection of synovial proliferation

In inflammatory rheumatic joint disease, early diagnosis and treatment is important to prevent disabling joint destruction. Synovial proliferation precedes the destructive changes, and early detection of the thickened, inflamed synovium is therefore of great importance. The proliferating synovium may be very difficult or impossible to detect on non-enhanced MR images. In the absence of joint effusion, the thickened synovium may be seen as a soft tissue mass with intermediate signal intensity on both T₁- and T₂-weighted images [1, 10]. A thin layer of proliferating synovium may blend with underlying joint capsule or cartilage, however, and therefore escape detection. In the presence of joint effusion, the thickened synovium may be seen on T₁-weighted images as a rim of tissue with slightly higher signal intensity than the joint fluid (Fig. la), or—probably dependent on the protein content of the fluid—it may be completely invisible due to isointensity with the fluid. It should be noted, however, that a recent report indicates that T₁-weighted non-enhanced three-dimensional gradient echo techniques combined with fat-suppression may show the inflamed synovium with high signal intensity, clearly separable from joint fluid [11]. On T₂-weighted images, the thickened synovium may sometimes be seen with lower signal intensity than the bright fluid; often, however, the synovium is totally indistinguishable from the fluid. This applies to both large joints such as the knee [2, 4–6] and small joints such as the TMJ [1].

Contrast-enhancement has a striking effect on the visualization of the thickened synovium, especially when fat-suppression techniques are applied (Fig. 1b). In the absence of bone abnormalities, the finding of intensely enhancing tissue along the articular surface of a joint may be the only MR indication of inflammatory rheumatic joint disease [1]. The enhancement of both proliferating synovium and joint fluid can sometimes make it difficult to differentiate between the two. The rate of enhancement differs, however, and contrast-enhanced dynamic MRI may therefore separate the fast enhancing synovial tissue from the slower enhancing fluid [4, 6, 8, 9].

Extent and severity of rheumatic joint disease

Synovial volume. The volume of the synovial tissue may be a marker of disease severity, and may also be the most exact measure of the effectiveness of synovectomy, either 'medical' or surgical. There are indications that contrast-enhanced MRI may quantify the synovial volume (in the knee) with acceptable accuracy [7, 8]. Computer programs may enable automatic tracings of the outline of the enhanced synovium and automatic calculation of volumes, making the method feasible even in clinical practice [7].

Inflammatory activity. Inflammation results in increased perfusion and capillary permeability, with increased leakage of intravenously injected contrast media. Several studies indicate a close relationship between the rate of contrast-enhancement of the proliferating synovium and the inflammatory activity [6, 8, 9]. Measurement of enhancement rate may therefore be a means of following the course of disease activity.
during and after treatment. It has been shown in RA of the knee that the enhancement rate decreases markedly shortly after intra-articular injection of steroids [9]. In that particular study, the enhancement rate remained low during clinical remission, but gradually increased prior to return of symptoms, indicating a subclinical increase in synovial inflammatory activity. In cases of clinical relapse, the enhancement rate increased to pretreatment levels. A marked heterogeneity of the contrast-enhancement was also noted, indicating that use of small regions of interest (ROIs) may be unreliable in estimating disease activity. The time-dependent mean signal intensity of the entire synovial membrane in a preselected slice may be a more appropriate measure of disease activity, but requires special computer programs not available with commercial MR scanners.

CONCLUSION

Contrast-enhanced MRI seems to have a unique potential in the diagnosis and follow-up of inflammatory rheumatic joint disease. The method allows early detection of the proliferating synovium, and has the potential of assessing disease severity and inflammatory activity. The main obstacles to routine use of contrast-enhanced MRI in clinical practice are the limited availability of MR scanners and scanning time, and the relatively high costs involved.

REFERENCES