

The importance of timing of post-contrast MRI in rheumatoid arthritis - a study of MRI-determined synovial membrane volumes and joint fluid enhancement during the first 60 minutes after intravenous gadolinium-DTPA

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Introduction

Contrast-enhanced magnetic resonance imaging (MRI) allows estimation of inflammatory and destructive disease manifestations in rheumatoid arthritis (RA) (1). Volumes of inflamed synovial membrane can be estimated (2,3). These MRI-determined volumes have been shown to be closely related to histopathological signs of synovitis (4) and preliminary data indicate a prognostic value with respect to progressive joint destruction (5). Various volume quantification methods have been introduced. A semi-automatic "enhancement threshold" method, based on computerized counting of voxels with a certain post-contrast signal intensity increase, has been used by several groups (3,6-8). It has been debated how late after contrast injection reliable assessment of synovitis can be achieved, because gradual joint fluid enhancement, due to leakage of contrast from the synovial membrane, may compromise the differentiation of synovium and fluid. The aim of the present study was, by repetitive MRI every 1.45 minutes during 1 hour after intravenous gadolinium-DTPA (Gd), to study the gradual joint fluid enhancement and to investigate the resulting effect on synovial membrane volumes measured by the "enhancement threshold" method. Hereby, the importance of the timing of post-Gd MRI in RA could be assessed.

Material and methods

Patients. Five patients with RA (fulfilling American College of Rheumatology 1987 criteria) and clinical signs of knee joint synovitis, i.e. joint swelling and tenderness, were included.

MRI: A 1.5 tesla Siemens Magnetom with a dedicated knee coil was used. Sagittal and axial T1-weighted spin echo MR-images were obtained. At the same time as 0.05 mmol Gd/kg b.w. was injected i.v., the axial sequence was restarted and repeated every 1.75 minutes for 60 minutes. Parameters of this sequence were: TR/TE/slice thickness/acquisitions/FOV/matrix/pixel size=750ms/15ms/5mm/1/180mm(rectangular)/200x256/0.74x0.74mm). At each time point the synovial membrane volume was determined by the "enhancement threshold" method.

Determination of synovial membrane volumes by the "enhancement threshold" method: By means of image processing software, a rough manual outlining of the areas including synovial tissue on axial images was performed. Extraarticular enhancing tissues, particularly vessels, were excluded. Secondly, a segmentation algorithm was applied, which showed and counted voxels fulfilling the following criteria: a: A relative post-Gd signal intensity increase >45%; b: A post-Gd absolute synovial signal intensity >300 (corresponding approximately to the mean pre-Gd synovial membrane signal intensity minus 2 SD. This criterion was included to avoid noise from low-intensity voxels). Finally, volumes were calculated by multiplication with the voxel size.

Determination of synovial membrane volumes by manual outlining: From the image set recorded 4 minutes post-Gd, the volume was also measured by manual computer-assisted synovial membrane outlining (see (2) for details).

Results

Visual image analysis revealed immediate, marked enhancement of the synovium, followed by gradual enhancement of the joint fluid, starting close to the synovium in the periphery of the joint and subsequently approaching central joint fluid areas (Figure 1).



Fig. 1: Axial MRI through the medial parapatellar recess, a. before, and b. 7.5 min. c. 19.75 min and d. 54.75 min after i.v. Gd. Increasing fluid enhancement is seen.

However, the synovium-effusion borderline did not appear blurred within the initial 15 post-Gd minutes, i.e. within the normal time-frame of post-Gd imaging in RA. Volumes of knee joint synovial membrane, as measured by the enhancement threshold method 5.75 minutes post-Gd ranged from 13 - 37 cc (median 19 cc). The course of the volumes are given in Figure 2. While volumes at 2.25 minutes post-Gd were significantly lower than volumes at all other time points (Wilcoxon-Pratt), there were no other significant volume changes during the 1-hour follow-up, when all 5 patients were considered together. Figure 2 illustrates interindividual differences. The reason for the lack of significant volume changes, despite the gradual joint fluid enhancement, is probably that the fluid seldomly exceeded the enhancement threshold and, furthermore, that the synovial membrane signal intensity gradually decreased as Gd washed out. Lower volumes were found by the threshold method than by the time-consuming manual method, indicating that the enhancement threshold may have been too high.

Conclusions

Visual assessment of the synovium-fluid borderline in arthritic knee joints appeared unchanged and thus reliable within the normal time-frame of post-Gd imaging. Despite fluid enhancement, synovial membrane volumes measured by an enhancement threshold method did not change significantly within 60 minutes after i.v. Gd, probably mainly because joint fluid did not reach the same high enhancement level as did the inflamed synovium in the first minutes after contrast injection.

MRI-determined synovial membrane volumes may offer reliable, detailed information on synovitis in rheumatoid arthritis.

References

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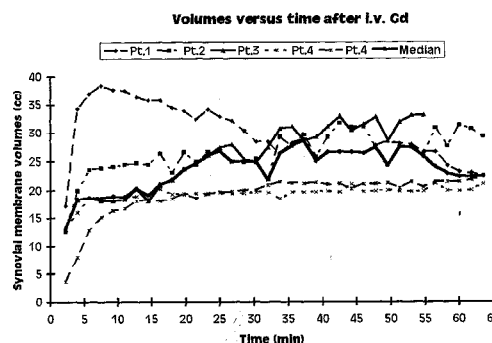


Fig. 2: The course of the synovial membrane volume, as estimated by the "enhancement threshold" method, within the first 60 minutes after i.v. Gd.