MRI EVALUATION OF THE KNEE IN RHEUMATOID ARTHRITIS

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SUMMARY
The knees of forty-three patients suffering from rheumatoid arthritis (RA) were examined using pre- and post-contrast MRI in an attempt to assess the extent and frequency of all abnormalities in the RA knee. Features evaluated by MRI were: synovial thickening, joint effusion, bone destruction, popliteal cysts, periarticular soft tissue swelling, abnormal tendons and bone marrow changes. A scoring system (0–2) was used to determine the relationship between the various signs of RA in order to identify those that may be relevant for the assessment of therapeutic response. It seems that the assessment of inflamed synovium is the major criterion for the determination of disease activity in RA.

KEY WORDS: Knee, MRI, Rheumatoid arthritis

THE ROUTINE diagnosis of rheumatoid arthritis (RA) is made by using clinical (joint count and index), laboratory and radiographic findings [1, 2]. Although this is sufficient for the diagnosis of RA, such an approach has proved to be inadequate for the accurate assessment of the response to therapy. Standard radiographs taken in the early stages of the disease are seldom specific and bone damage is detected only when the disease is relatively advanced [3–5]. Due to excellent soft tissue contrast, MRI has proved itself as a valuable technique to detect changes in all components of the joints affected by RA [5–7]. In addition, the use of gadolinium-based MRI contrast agents has enabled the reliable differentiation between synovial inflammation and effusion [8–11]. Despite the development of elaborate MRI techniques for the assessment of all aspects of the knee pathologies ([7] and references cited therein) an MRI protocol for grading the extent of the various changes associated with RA and their mutual relationship has not yet been proposed. This paper attempts to present an analysis of the extent and frequency of all observable abnormalities in order to identify those that may be relevant for the assessment of therapeutic response based on MRI findings.

PATIENTS AND METHODS
Patients with signs of acute synovitis of the knee (revised ARA criteria [1]) were included in the study if they were at least 18 years old and the duration of their RA was >6 months. Data about acute phase reactants were not available at the time of review. Plain radiographs of the knee were performed 1 day prior to MRI. The Larsen classification system [2] was employed and only patients in stages 0–3 were entered into the study. Based on the above criteria, 43 patients (7 male and 36 female, mean age 54 yr) were examined by MRI.

Patients were imaged with a 1.5T MR imager (Siemens, Magnetom) using an extremity coil with contiguous, interleaved slices and the following spin-echo (SE) sequences: pre- and post-contrast \( T_1 \)-weighted (460/15; \( T_2 \)-W) in both the sagittal and coronal planes, pre-contrast \( T_2 \)-weighted (2000/15.90; \( T_2 \)-W) in the sagittal plane. Gadopentetate dimeglumine (Magnevist®; Schering) was administered i.v. at a dose of 0.1 mmol/kg. Image analysis included evaluation of seven diagnostic parameters (see Results). The severity (extent) of changes was graded on a 0–2 scale (nil/obvious/marked) or a 0–1 scale (present/absent).

RESULTS
All images, plain film and MRI were jointly assessed by two experienced radiologists (L.P. and D.Z.), and a consensus was reached on those cases for which their respective grading evaluations were not in agreement.

Synovial thickening
Two aspects of synovial thickening were considered: (i) the type of synovial proliferation (inflammatory or fibrous) and (ii) the degree of synovial thickening.

Inflammatory proliferation (38 patients) was characterized by low-to-intermediate signal intensity (SI) on \( T_1 \)-W images, high SI on \( T_2 \)-W images and marked SI enhancement on post-contrast \( T_2 \)-W images (Fig. 1). Fibrous proliferation was observed in 37 patients as a nodular, linear, or curvilinear areas of low SI on both \( T_1 \)-W and \( T_2 \)-W images. A third type of proliferation was characterized by low-to-intermediate SI on \( T_1 \)-W, low SI on \( T_2 \)-W and significant enhancement on \( T_2 \)-W post-contrast images. These findings were present in 10 patients and were thought to represent fibrovascular (granulation) tissue.

Normal synovium is virtually invisible on MR images (grade 0). Increased microvascular permeability, characteristic of inflamed synovium, permits excellent delineation of this tissue on post-contrast images. Discrete, thin synovial proliferation was graded as
obvious (grade 1) and pronounced, thick proliferation in all parts of the joint cavity as marked (grade 2). As an additional grading parameter the thickness of inflamed synovium was measured at the level of the former metaphyseal line on both the coronal and sagittal images, as well as the $T_1$ relaxation times within the synovium [12]. Fibrous and fibrovascular proliferation was not graded.

**Joint effusion**

The amount of joint effusion was determined by comparing pre- and post-contrast $T_1W$ sagittal (Fig. 1) and coronal images. Effusion was graded as: grade 0, no signs of effusion; grade 1, small effusion in one or more recesses of the knee; grade 2, marked effusion in all parts of the joint.

The overall correlation between grades of inflamed synovium and joint effusion is remarkably high (74%; Table I); however, two patients with no signs of inflammation had moderate joint effusion, while two patients with inflammation had no effusion.

**Marginal erosions and subchondral cysts**

Twenty-five marginal erosions were detected in 19 patients, and in all cases they contained inflamed synovium. Forty-two subchondral cysts were detected in 22 patients, their diameter ranging from 3 to 22 mm. Subchondral cysts were divided into three groups—inflammatory, fibrous and mixed—according to their contents [4]. The criteria for the first two were the same as for synovial proliferation. Cysts were graded as mixed if they had low SI on $T_2W$ images, low SI in the central part and increased SI on the edge of the cyst on $T_2W$ images and rim enhancement on post-contrast $T_1W$ images (Fig. 1). Twenty-two cysts were inflammatory, 11 were graded as mixed and nine were graded as fibrous. The grading of inflammatory bone destruction was based on following criteria: grade 0, no signs of destruction; grade 1, one erosion or cyst (diameter <8 mm); grade 2, more than one erosion or cyst, or one cyst with diameter >8 (see [4] for explanation). A shortcoming of such an approach is that fibrous cysts were not included; hence the grading reflects the activity of disease and not the overall status of the knee.

The correlation between grades of synovial inflammation and bone destruction (51%; Table II) is less pronounced than with effusion. No bone destruction was seen in patients without synovial proliferation. However, 46% of patients with grade 1 and 16% with grade 2 proliferation did not have bone destruction.

**Popliteal cyst**

Popliteal cysts, with cranio-caudal diameters ranging from 20 to 100 mm (mean 43 mm), were seen in 24 patients. On post-contrast $T_1W$ images, complete or partial rim enhancement was observed, representing inflamed synovium.

**Periarticular soft tissue swelling**

Only minor signs of periarticular soft tissue swelling were found in the popliteal fat. These were numerous focal, linear or curvilinear areas characterized by high
The correlation between grades of inflamed synovium and joint effusion

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The correlation between grades of synovial inflammation and bone destruction

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SI on T2W images, low SI on T1W and minimal increase in SI on post-contrast images.

Tendons

In 35 patients signs of increased thickness of tendons and/or a linear or focal increase in SI on T1W and T2W were shown within the tendon. These changes have been described as signs of degenerative and inflammatory changes in the tendon [13].

Abnormal bone marrow signal

Signs of bone marrow oedema, described in the literature as diffuse areas of low SI on T1W images with a comparable increase of SI on T2W images [14, 15], were not found in this study.

DISCUSSION

All the patients in the present series were defined as being in an acute phase of disease on the basis of clinical evaluation, and all were at an early stage of disease evolution on the basis of the Larsen score and not the duration of disease. The most common and specific finding in the patients was the existence of inflamed synovium (88%). Intra-articular fibrous proliferations were also frequent (86%); however, they were very discrete. They can be used in the assessment of the stage of disease but not in evaluating drug response, since it is unlikely that such lesions would be affected by the therapy. Joint effusion was also present in the majority of patients (88%). Although there were few cases where effusion was present in patients with no signs of inflammation, and vice versa, in most cases the grade of effusion correlated remarkably well with the grade of synovial inflammation.

Destructive bony changes (erosions and cysts) were present in the majority of patients, and in most cases they were filled with inflamed pannus. The development of bone destruction in RA is thought to be the result of direct invasion by synovium. The present results (Table II) confirmed the expected relationship between the grade of inflamed synovium and the extent of bone erosions and cysts.

Clinical knee swelling was apparent in all patients. However, MRI showed only 11 patients with minor signs of periarticular soft tissue swelling. This indicates that inflamed synovium and/or effusion are largely responsible for clinical signs of swelling, and not periarticular swelling per se. Popliteal cysts were present in >55% of patients. The presence and extent of both periarticular soft tissue swelling and popliteal cysts were almost directly correlated with the extent of synovial proliferation (Table III). Hence they do not appear to be important correlates of the degree of disease activity. Signs of tenosynovitis were present in a large number of patients, but were not marked. Hence it is very difficult to establish grading criteria and to use them in the evaluation of the therapeutic response.

In conclusion, the subjective scoring system used here to correlate the extent and frequency of various pathological signs associated with RA seems to demonstrate that the presence of inflamed synovium represents the major criterion in the assessment of the activity of RA. Although a joint effusion seems to represent a reliable sign of disease activity, and can be reliably quantified, these results (Table I) demonstrate that the extent of effusion is related directly to the extent of synovial proliferation. The assessment of bony erosions and their content are important criteria in the evaluation of the stage of the disease and its progression, since bony erosions were detected in the majority of patients. However, the absence of bone destruction in a significant minority of patients (26%) with inflamed synovium (Table II) indicates that the assessment of synovial inflammation remains the most reliable parameter in the early stage of RA. Measurement of the thickness of inflamed synovium is a quantifiable parameter that has been found to be useful in evaluating the progression of RA and drug response in individual patients [11]. However, the use of volume determination of synovial proliferation (3D imaging [16, 17]) as well as qualitative evaluation of the degree of inflammation using dynamic imaging [8, 9] should improve the capability of MRI in the assessment of the activity of joint inflammation and its response to the therapy.
REFERENCES


