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Pictorial Essay

Magnetic Resonance Imaging in Rheumatoid Arthritis and Related Disorders

Masataka UETANI, Rashid HASHMI, Nobuya NAKAHARA, Makoto OCHI, Kuniaki HAYASHI

Department of Radiology, Nagasaki University School of Medicine

In this pictorial essay we outline the role of MRI in the work-up of RA and related disorders, and discuss its strengths and limitations with the help of representative case presentations. MRI provides detailed information about the involvement of bones, joints and soft tissue, which may not be evident on radiography. Moreover, MRI often reveals changes consistent with the early inflammatory changes in the synovium and bone marrow. Contrast enhancement study, especially with fat-suppression technique, can be useful in providing objective and quantitative parameters to determine a disease activity and an effect of treatment.

Key Words: rheumatoid arthritis, MR imaging, contrast enhancement, synovitis

Introduction

Conventional radiography has an established role in the assessment of rheumatoid arthritis (RA) and related disorders; however, it is not sensitive for the detection of early changes. Irreversible structural damage to joints can be minimized or prevented if early diagnosis and suppression of inflammatory process are made at an early stage. Magnetic resonance imaging (MRI) is emerging as a complementary imaging modality to radiography. Because of its high soft tissue contrast, structural and inflammatory changes of the joints are seen with greater clarity and detail. However, the exact place of MRI in the diagnostic algorithm is still undecided.

In this pictorial essay we outline the role of MRI in the work-up of RA and related disorders, and discuss its strengths and limitations with the help of representative case presentations. For the ease of description, we divided the role of MRI under three categories listed below:

- Evaluation of the extent of disease
- Early detection of the disease
- Evaluation of disease activity

Address Correspondence: Masataka Uetani, M.D.
Department of Radiology, Nagasaki University School of Medicine, 1-7-1 Sakamoto, Nagasaki 852-8501, Japan
TEL: +81-95-849-7354 FAX: +81-95-849-7357
E-mail: uetani@net.nagasaki-u.ac.jp

Evaluation of the Extent of Disease (Figures 1-8)

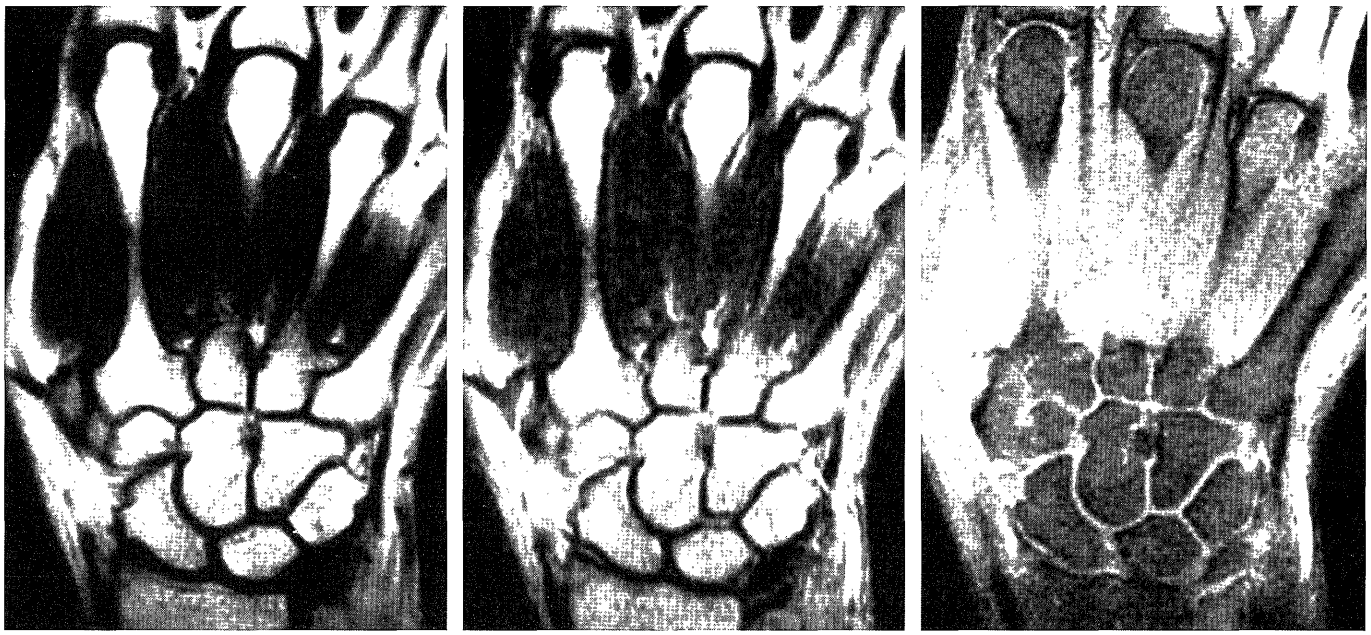
Conventional radiography demonstrates bone or cartilage loss in relatively advanced stage of RA. It can also assess the distribution pattern of polyarticular involvement, which is important for the differential diagnosis in rheumatoid disorders. However, conventional radiography is not suited for the evaluation of synovial or soft tissue lesions and is prone to errors caused by superimposition. MRI has been shown to be more sensitive than conventional radiography in evaluating the extent of disease in and around a joint, because it can provide tomographic images with good contrast resolution that is adequate for the assessment of bone, cartilage, tendons, ligaments and synovium (1, 2). Contrast enhancement (CE) using gadolinium-DTPA shows enhancement effect of the proliferated hypervascular synovium (pannus), which can be easily differentiated from joint fluid or other surrounding structures (3-7). Enhancement effect is also seen in bone erosions, subchondral cystic changes, marrow edema, tenosynovitis, enthesopathy and bursitis. Fat-suppression technique is essential for distinguishing those enhancing lesions from normal bone marrow and periarticular fat (8-11).

Evaluation of multiple joints by MRI is difficult, as each joint should be studied separately to obtain high-resolution images of intraarticular structures. This is one of the limitations of MRI in the evaluation of polyarticular disorders like RA. Motion analysis of the joint is also limited in MRI because of the dimension of the magnet bore and supine position of the patients. In case of atlanto-axial joint involvement, for example, MRI is valuable for the evaluation of spinal cord

compression secondary to pannus formation (12), but it often fails to detect subluxation without flexion of the neck (Fig.8). The atlanto-axial subluxation is evaluated much more easily with conventional flexion-extension radiographs than MRI.

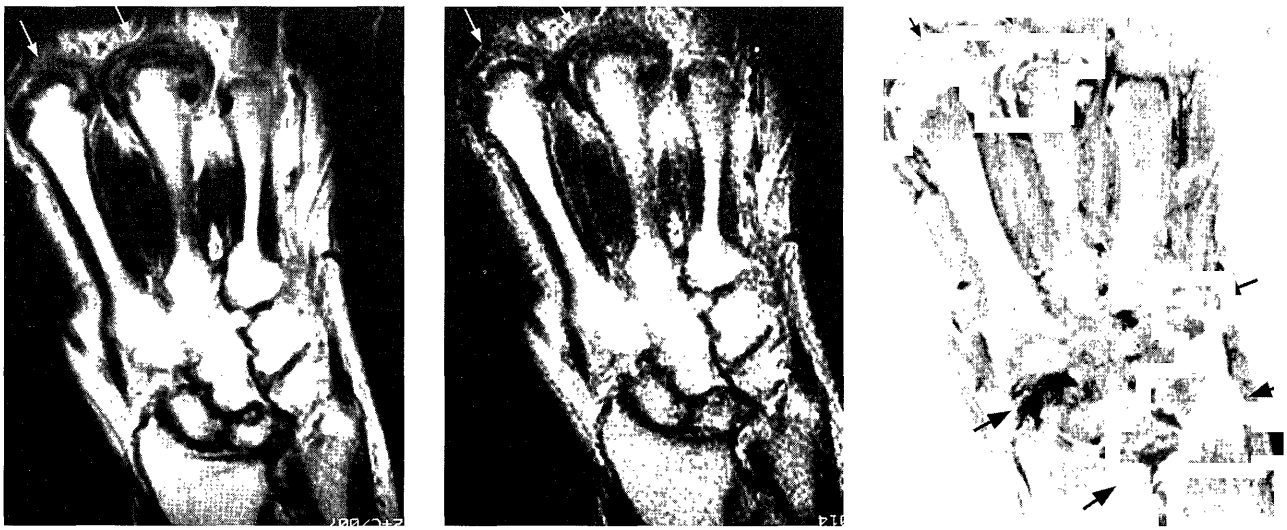
Early Detection of the Disease (Figures 9, 10)

Early RA refers to disease in which patients do not yet have the clinical evidence of joint damage or radiologic signs of cartilage loss and/or bone erosion. Diagnosis of RA at this stage is important as substan



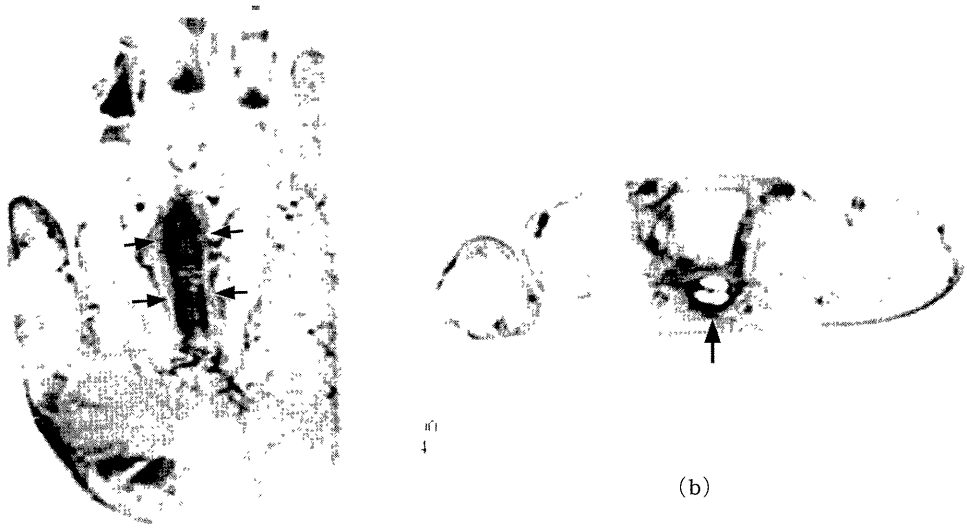
(a) (b) (c)

Fig.1. Normal wrist of a 27 years old woman:
T1-weighted image (a), T2-weighted image (b), contrast-enhanced T1-weighted image without fat-suppression (c) and contrast-enhanced T1-weighted image with fat-suppression (d) of a normal wrist. Contrast enhancement is not seen in the normal synovium. Normal articular cartilage shows moderately high signal intensity on fat-suppressed T1-weighted images. The vessels show linear enhancement.



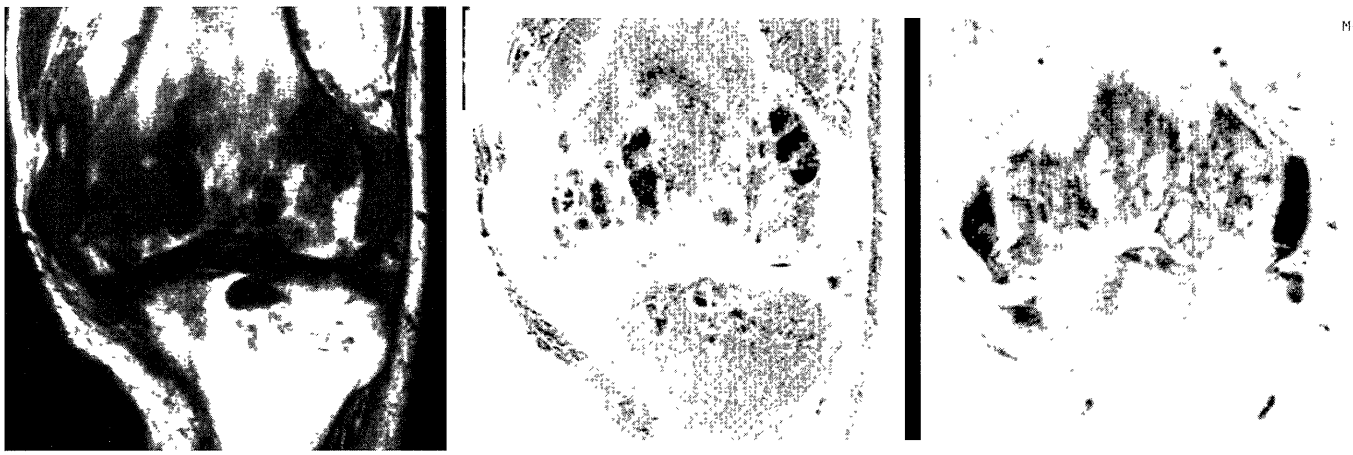
(a) (b) (c)

Fig.2. RA of the wrist: 56 years old woman with a long history of RA.
Synovial thickening (thin arrows) is seen at the MP joints as low signal on both T1 (a) and T2 (b) weighted images. In addition to MP joints, synovial enhancement (thick arrows) is seen in the carpal joints on contrast-enhanced image with fat-suppression (c).



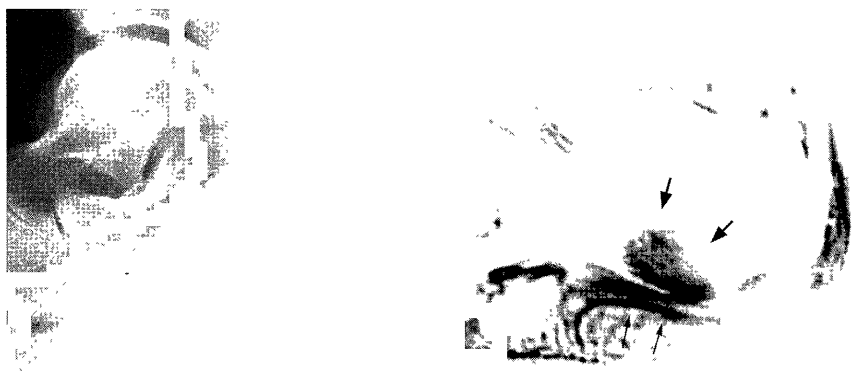
(a) (b)

Fig.3. Tenosynovitis: 67 years old male with history of pain in the right hand.
Contrast-enhanced coronal (a) and axial (b) images with fat-suppression show enhancement along the flexor tendon of the middle fingers (arrows).



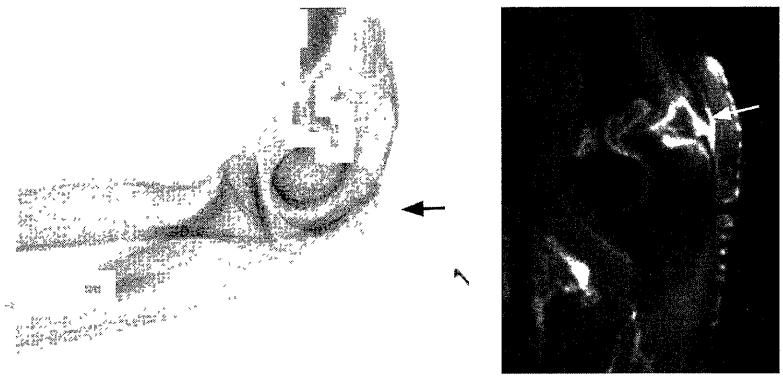
(a) (b) (c)

Fig.4. Bone erosions and cystic changes: 43 years old female with RA involving knees.
Multiple bone erosions and cystic changes are seen on T1-weighted image (a), T2-weighted image (b) and contrast-enhanced image with fat-suppression (c). Enhancement effect is seen in the bone marrow and thickened synovium.



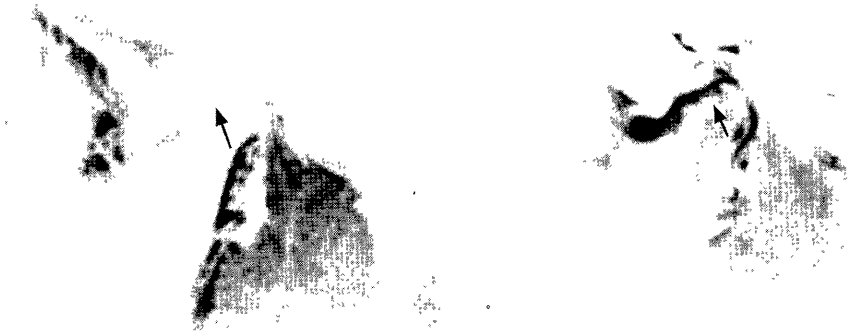
(a) (b)

Fig.5. Enthesopathy at the insertion of plantar aponeurosis: 43 years old female with heel pain.
Plain radiograph (a) is unremarkable. Contrast-enhanced image with fat-suppression (b) shows marked enhancement at the attachment of plantar aponeurosis (thin arrows) and adjacent bone marrow (thick arrows).



(a) (b)

Fig.6. Bursitis: 53 years old female with elbow pain.
Radiograph (a) shows erosion of the olecranon (arrow) with swelling of adjacent soft tissue. Contrast-enhanced image with fat-suppression (b) shows enhancement of the subtendinous bursa (arrow) of triceps tendon causing bone erosion.



(a) (b)

Fig.7. Temporomandibular joint involvement in RA: 18 years old female with pain and difficulty in opening the mouth.
Erosion of the mandibular condyle (arrow) and synovial enhancement is well depicted on T1-weighted image (a) and contrast-enhanced T1-weighted image with fat-suppression (b)

(a) (b) (c) (d)

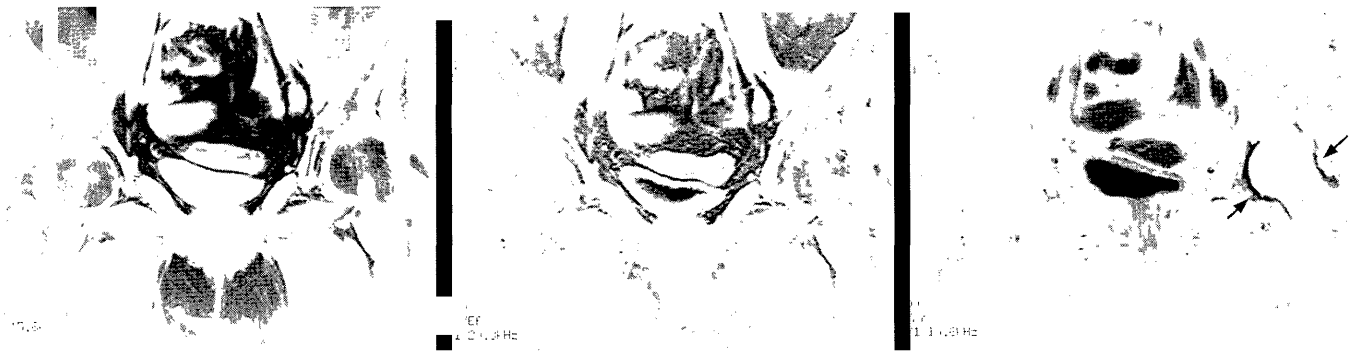
Fig.8. Atlantoaxial (AA) joint involvement: 50 years old female with RA.
Conventional radiography (a) shows AA subluxation. T1 (b) and T2 (c) weighted images are unremarkable. Contrast-enhanced image with fat-suppression (d) shows thickened synovium in the AA joint (arrows). AA subluxation is not evident on MR images acquired in the supine position with the neck in extension.

tial joint damage can be prevented or forestalled by the therapeutic intervention (13). Synovial inflammation is an essential pathologic abnormality in early RA. However, abnormalities in conventional radiography, which include marginal erosions, joint-space narrowing and osteoporosis, are seen in late stage and do not necessarily indicate the presence of synovial inflammation.

On MRI, two techniques can be used for the detection of active synovitis; one is T2-weighted imaging with fat-suppression and the other is contrast-enhanced imaging with fat-suppression. In a comparative study of these two techniques, it was concluded that active synovitis is better seen on contrast-enhanced imaging with fat-suppression. In recent studies, the advantages of using contrast-enhanced MR imaging for the detection of synovial inflammation have been increasingly recognized (8-11). Sugimoto and colleagues established their MRI criteria of active synovitis in RA that include periarticular contrast enhancement of the wrist or the metacarpophalangeal and/or proximal interphalangeal joints of both hands (10). They revealed that the diagnosis of RA is improved by using their MRI criteria. However, it should be noted that synovial inflammation itself is a non-specific pathological finding. It is known that 50% of patients with non-specific polysynovitis alone have a self-limiting process and not RA. Therefore, diagnosis of RA should be made according to not only MR findings but also clinical features.

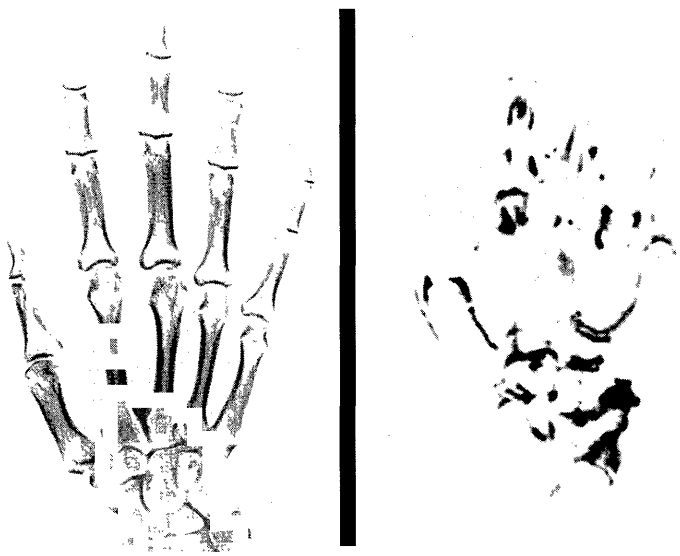
Evaluation of Disease Activity (Figures 11-13)

MRI with contrast enhancement is now considered to be a more objective method for assessment and monitoring of the disease activity and therapeutic response. The degree of contrast enhancement of the



(a) (b) (c)

Fig.9. Early involvement of the hips: 68 years old female with left hip
No definite abnormality is seen on T1 (a) and T2 (b) weighted images. Contrast-enhanced image with fat-suppression (c) shows enhancement of the synovium suggesting synovial inflammation (arrows).



(a) (b)

Fig.10. Early RA changes in the wrist: 25 years old female with wrist pain.
Radiograph (a) is unremarkable except for periarticular osteoporosis. Contrast-enhanced image with fat-suppression (b) shows marked synovial enhancement in multiple joints.

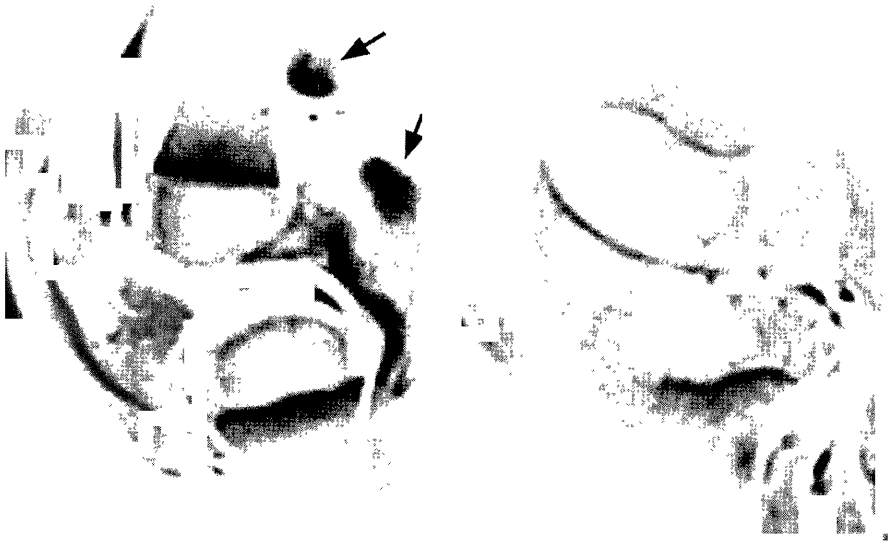
synovium has been shown to correlate with the inflammatory activity of the synovitis and is significantly reduced after successful treatment by antirheumatic drug (13). Different methods have been tried to quantify the degree of involvement of synovium to determine the disease activity and outcome of treatment based on Gd-DTPA enhanced MRI. However, every method has certain drawbacks and limitations.

i) Scoring method

Scoring of the synovial enhancement can be easily obtained, but it is difficult to establish completely objective criteria. We developed a semiquantitative scoring method to determine the degree of synovial enhancement of the wrist, using the following criteria: 0, no enhancement; 1, enhancement in the joint margin, not extending across the articular surface; 2, enhancement extending across the articular surface without bone erosions; 3, enhancement at bone erosion (11). The total score in 13 articulations in the wrist correlated well with values of C-reactive protein (CRP) levels, but not radiographic stage (11). Ostergaard and col-

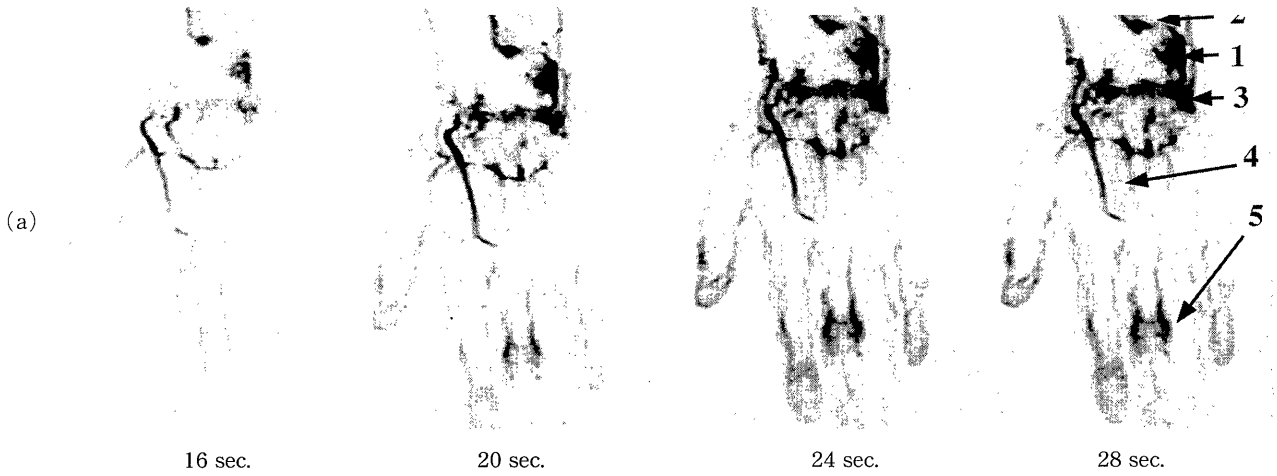
(a) (b)

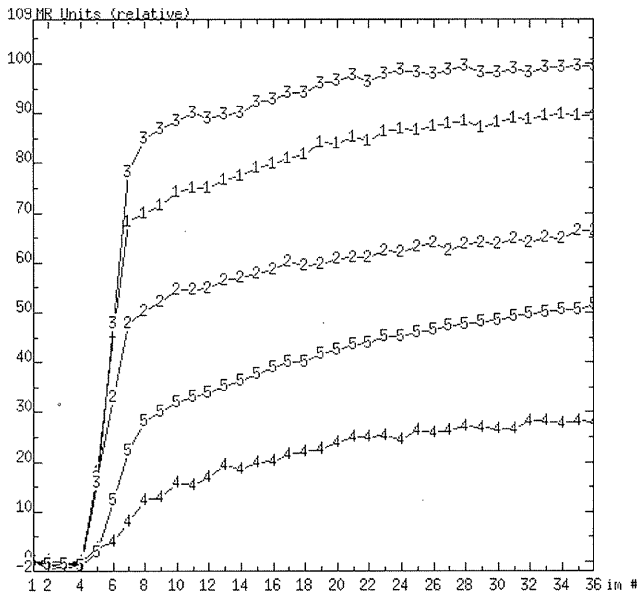
Fig.11. Good response to therapy: 41 years old female with history of RA.
Initial study (a) shows enhancement of the synovium and bone marrow. On follow-up study (b) acquired one and half year later when patient was clinically asymptomatic, enhancement effect has reduced considerably.



(a) (b)

Fig.12. Good response to therapy: 5 years old male with JRA.
Initial study of the knee (a) shows marked synovial and bone marrow enhancement Note the enlargement of the popliteal lymph nodes (arrows). Follow-up study (b) acquired about 2 years later shows reduction of the synovial and bone marrow enhancement. Lymph node enlargement is not evident.





(b)

Fig.13. Dynamic study: 25 years old female with early RA.
Representative images at 16, 20, 24 and 28 seconds in dynamic study (a) show increasing enhancement of the inflamed synovium. Time intensity curves (b) derived from the dynamic study can be useful to calculate parameters indicating disease activity.

leagues used a similar scoring method (synovial hypertrophy score) and found that the score was highly correlated to synovial volume (14).

ii) Volumetric calculation

Efforts to calculate the volume of synovium have been attempted by several investigators (15-17). Synovial volume is said to correlate well with the clinical parameters and may be a useful marker for monitoring and prediction of treatment outcome. However, use of quantification in routine clinical practice is limited as it is time consuming and determination of exact outline of inflamed synovium is technically difficult. This limits the reproducibility of quantitative techniques.

iii) Dynamic study

In dynamic study, sequential images are acquired immediately after rapid intravenous injection of contrast material. It can quantify the rate of synovial enhancement and has a potential to detect the synovial inflammatory activity (18-20). The rate of early enhancement is reported to be correlated with histologic features of active inflammation, particularly vessel proliferation and mononuclear leukocyte infiltration (21).

Conclusion

MRI findings of rheumatoid disorders are non-specific. However, in the evaluation of patients with rheumatoid disorders, MRI provides detailed information about the involvement of bones, joints and soft tissue, which may not be evident on radiography. Moreover, in patients with clinical suspicion of the disease and unremarkable radiographs, MRI often reveals changes consistent with the early inflammatory changes in the synovium and bone marrow. Contrast enhancement study may provide objective and quantitative parameters in defining a

disease activity and a state of remission in RA after therapy; however, the clinical utility of these measurements remains to be verified.

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