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PICTORIAL ESSAY

# Rheumatoid Arthritis: Survey of Magnetic Resonance Imaging Features in the Musculoskeletal System

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## ABSTRACT

***Rheumatoid arthritis is the most common inflammatory arthropathy worldwide, but may be less prevalent in Asian populations. The spectrum of magnetic resonance imaging findings encountered in the musculoskeletal system in this disease are discussed. The role of magnetic resonance imaging in rheumatoid arthritis lies, not in diagnosis, but in evaluation of the integrity of structures affected by the disease process. Magnetic resonance imaging is more sensitive to synovial changes than is radiography, and may permit quantification of changes in disease activity, as well as evaluation of the effects of drug therapy, and of complications of the disease and its treatment.***

***Key Words:*** *Arthritis, rheumatoid, Bursa, synovial, MRI, Musculoskeletal system, Spine, Synovial membrane, Tendons*

## INTRODUCTION

Rheumatoid arthritis is the most common inflammatory arthropathy worldwide. It afflicts approximately 0.5 to 1% of the North American population, with 4 to 5% of people over the age of 55 suffering from this disorder. While not rare among Asians, the disease may be less prevalent among this group, with one study in Hong Kong Chinese indicating a prevalence as low as 0.35%.[1] Among patients with rheumatoid arthritis, 40% become significantly disabled. In this essay we demonstrate the spectrum of MRI findings that may be encountered in the musculoskeletal system in association with this disease process.

## CLINICAL FEATURES

Patients with rheumatoid arthritis have an abnormal proliferation of synovium, known as pannus, within the joint, frequently associated with effusions. The diagnosis is based on a variety of subjective or non-specific parameters, including stiffness, fatigue, pain and tenderness, and joint swelling, as well as laboratory measures such as erythrocyte sedimentation rate (ESR) and rheumatoid factor.[2] Numerous medical treatments have been devised, including anti-inflammatory agents, antimalarial agents, and gold salts, as well as more toxic compounds such as methotrexate. Response to therapy has been assessed by clinical parameters and laboratory findings. Unfortunately, imaging has played a relatively minor role in the diagnosis of early disease, and is relatively insensitive as a method for assessment of therapeutic response.

## RADIOGRAPHY AND OTHER NON-MRI IMAGING TECHNIQUES

The plain radiographic findings of rheumatoid arthritis have been extensively studied and are well documented. Classical findings include osteopenia, articular erosions, and joint space narrowing (typically symmetrical), as well as soft tissue swelling. Radiographic findings tend to appear within the first 2 years in 90% of patients with active rheumatoid arthritis.[3] Large amounts of bone and cartilage can be destroyed, and advanced disease can produce a dramatic radiographic appearance.[4] Plain radiographic changes are, for the most part, irreversible, although reports of partial healing have appeared.[5] By the time radiographic changes are seen, the disease is far advanced.[3]

Plain films are also difficult to use for study purposes, in that the scoring systems used to grade radiographic findings have limited reproducibility, and evaluation is

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highly time-consuming.[6] Radiographic scoring has also been shown to be prognostically insensitive, and does not necessarily correlate well with functional health status.

Arthrography is now seldom used to assess joints affected by rheumatoid arthritis, because less invasive techniques such as ultrasound can provide similar information about effusions, pannus formation, and integrity of tendons. CT is especially helpful if bone evaluation is required, although with contrast-enhanced examinations, pannus and fluid can be readily demonstrated.

## MAGNETIC RESONANCE IMAGING

With the advent of MRI, it has become possible to visualise cartilage directly, including early bone and marrow changes. In addition, ligaments and tendons, as well as joint effusions and abnormal synovium (or pannus), can be visualised. Disease changes can be detected early, before osseous changes are seen.[2,3]

A variety of different imaging sequences can be used in examining patients with rheumatoid joints. The following sequences are typically utilised in our department: T1-weighted spin-echo (SE) [TR 400 ms/TE 18 ms] ± gadolinium; standard or fast inversion-recovery with fat suppression (TR 3500 ms/TI 150 ms/TEef 16 ms); and 3-dimensional Fourier transform (3DFT) spoiled gradient recalled acquisition in the steady state (GRASS) with fat suppression (TR 60 ms/TE 10 ms, flip angle 70°). Dynamic images can be obtained using spoiled GRASS (TR 40 ms/TE 11 ms, flip angle 70°), which permits images to be taken less than 12 seconds apart.

Postcontrast sequences benefit from use of fat saturation if available, but this is not essential. T2-weighted images will produce an arthrographic effect when fluid is present. These sequences allow all important joint structures typically affected by rheumatoid arthritis to be readily visualised. Sequences utilised will vary according to the equipment available and user preferences. We use gadolinium-DTPA at a dose of 0.1 mmol/kg to a maximum of 20 mL.

Surface coils should be used routinely, in order to provide the best detail and uniform fat saturation. Axial (transverse) images should always be obtained, and it is recommended that either a sagittally- or coronally-oriented sequence be performed in addition (depending on the body part being examined). Slice thickness will vary from 2 to 3 mm for a small joint (e.g. the temporomandibular joint) to 5 mm for larger joints.

## IMAGING FEATURES

### Synovium and Effusions

In normal joints, synovium either cannot be seen, (as with the SE sequences), or can be visualised only as a thin line (3DFT spoiled GRASS). Abnormalities of the synovium are the earliest lesions seen in rheumatoid arthritis (Figure 1). The fact that the synovium is highly

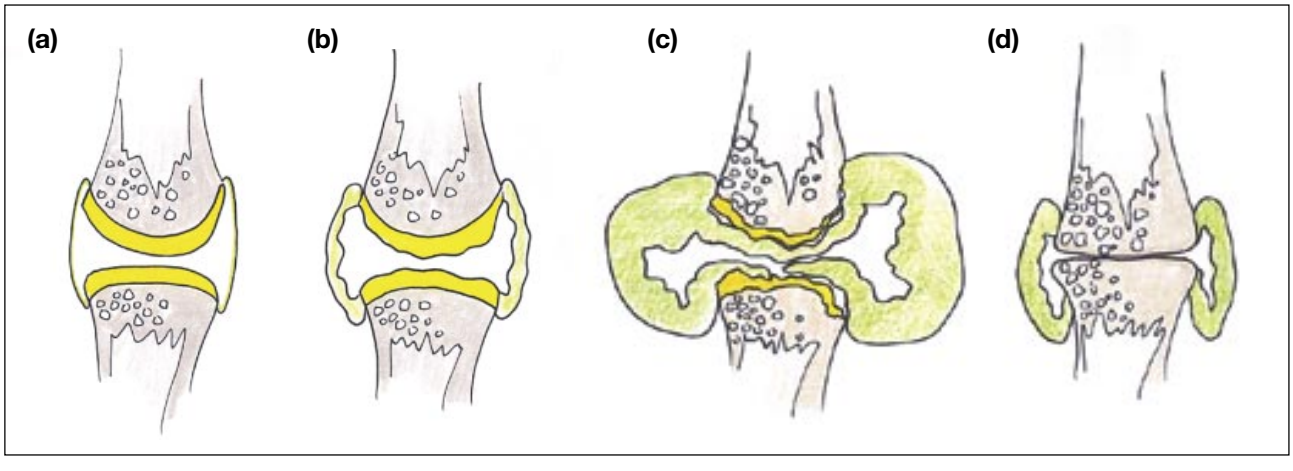


**Figure 1.** Diagrammatic representation of stages in rheumatoid arthritis (RA). (a) Diagrammatic representation of a synovial joint. The cartilage surface of the joint is shown in yellow, with the capsule of the joint being outlined by a thin greenish line representing normal synovium; (b) early RA. The synovium is thickened and has an irregular and nodular appearance. Also note that the surface of the joint demonstrates slight irregularity of the hyaline cartilage due to release of proteolytic enzymes; (c) advanced RA. Gross hypertrophy of the synovium is now apparent and the synovium has migrated across the hyaline cartilage surface. The cartilage is grossly irregular and dramatically thinned, and at times may be completely denuded, with erosion and invasion of underlying bone; (d) end-stage burnt-out RA. Synovial hypertrophy has regressed. However, the normal joint structures have been badly damaged, and superimposed osteoarthritis has developed. Cartilage has been completely destroyed.

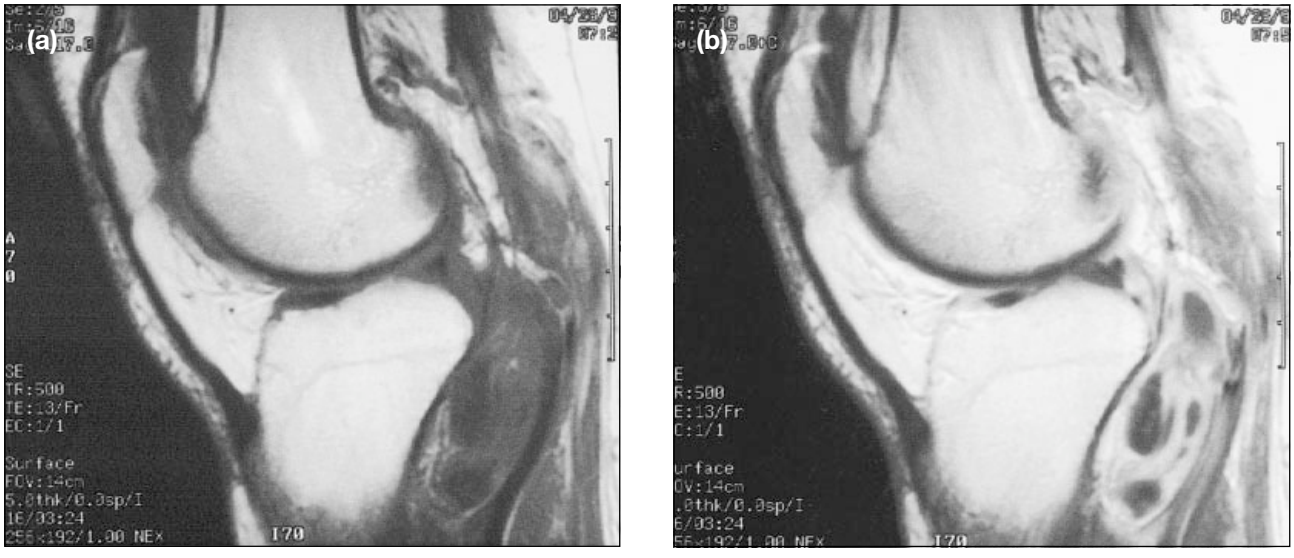


**Figure 2.** Rheumatoid arthritis of the knee. (a) Pre- and (b) postcontrast-enhanced images of the knee (TR 500 ms/TE 13 ms). On precontrast images, fullness is identified in both the suprapatellar region and the region of the popliteal fossa, where a large low signal intensity cyst, which appears inhomogeneous, can be identified. In (b), following administration of intravenous gadolinium, pronounced enhancement is apparent — particularly in the popliteal cyst, which shows pronounced thick irregular enhancement surrounding pockets of non-enhancing synovial fluid. Changes are also present in the suprapatellar bursa, where thickening of the synovium is apparent (arrows).

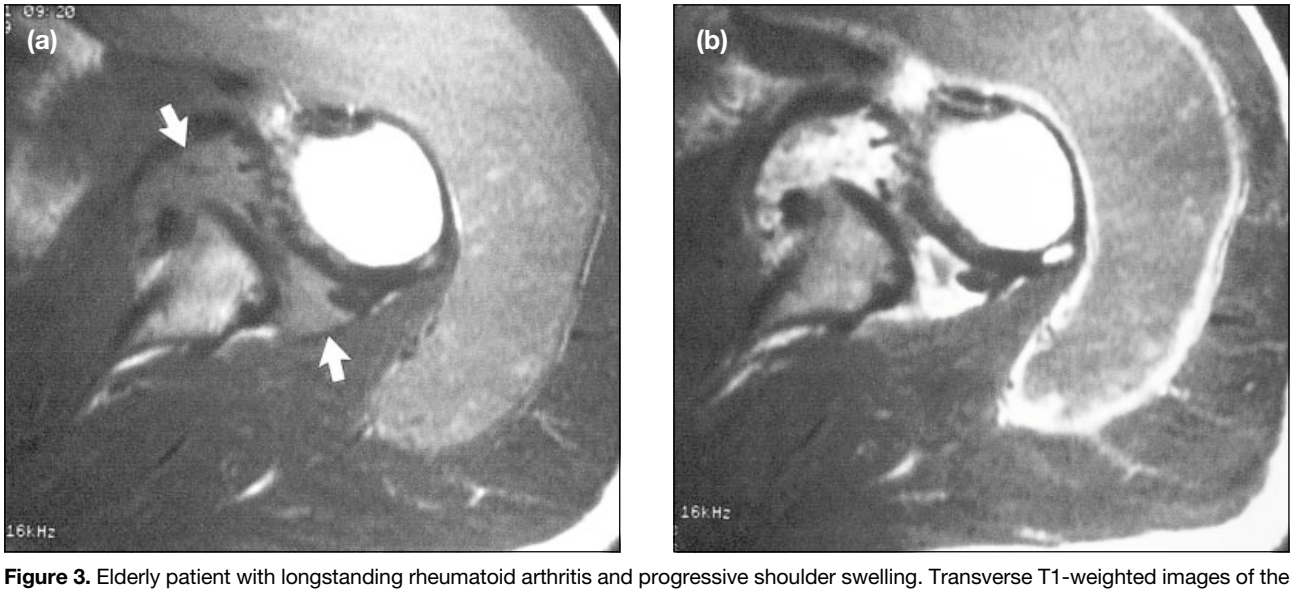


**Figure 3.** Elderly patient with longstanding rheumatoid arthritis and progressive shoulder swelling. Transverse T1-weighted images of the shoulder (TR 400 ms/TE 19 ms). On precontrast images (a), distension of the glenohumeral joint, with bulging of the anterior and posterior recesses of the capsule, can be discerned (arrows). In addition, a large area of slightly increased signal intensity is noted anteriorly and laterally, representing a grossly distended subacromial subdeltoid bursa. Note numerous small rice bodies outlined by the effusion. On postcontrast images (b), the glenohumeral joint shows pronounced enhancement, with only a few tiny pockets of non-enhancing synovial fluid. In this instance, almost the entire volume of the joint represents pannus. On the other hand, the subacromial subdeltoid bursa is filled predominantly with a large quantity of synovial fluid, although some thickening and nodularity of the synovial membrane, particularly posteriorly, can be discerned.

vascular can be used to advantage if contrast agents are employed. Synovium becomes thickened and increasingly nodular as the disease progresses (Figure 2). As the synovium proliferates, the joint becomes filled with synovium, and the abnormal synovium begins to migrate across the hyaline cartilage surfaces of the joint, eventually producing erosions. With further progression, the bone and bone marrow can become invaded. Destruction of surrounding capsular structures and tendons can also occur.

The proliferation of synovium is usually also associated with an effusion that consists of an ultrafiltrate of plasma. The amount of effusion versus the amount of abnormal synovium can vary significantly, even within different areas of the same joint (Figure 3). With

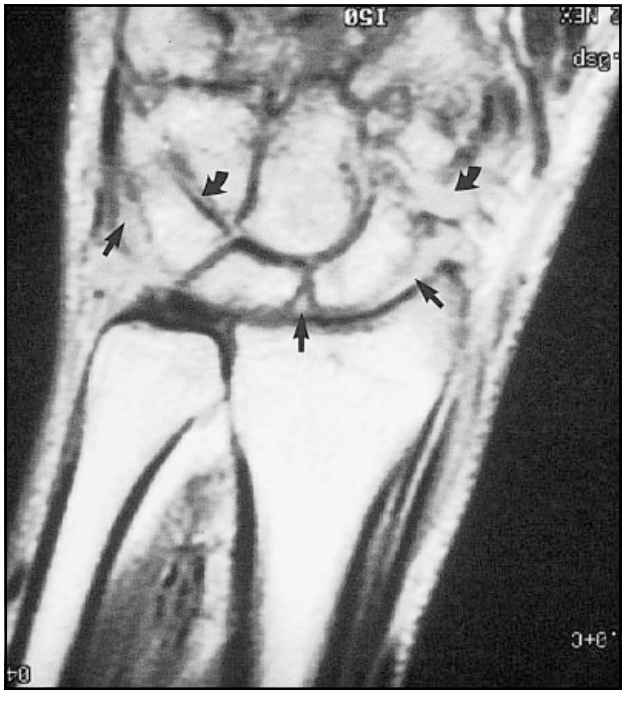

**Figure 4.** Postcontrast-enhanced coronal T1-weighted image of the wrist (TR 400 ms/TE 19 ms). All joint spaces are filled with enhancing material (arrows), with no discernible fluid remaining.

conventional SE imaging, the proliferation of synovium can at times be only vaguely differentiated on non-contrast–enhanced sequences. Resolution is somewhat improved if fat saturation is employed, and becomes very vivid if intravenous gadolinium is administered (Figure 4). Imaging of the highly vascular synovium is dramatically enhanced within seconds of the bolus of contrast medium reaching the joint, levelling to a plateau in much less than 1 minute.[7] The ultrafiltration process will eventually cause enhancement of the effusion also, although this takes many minutes.[8] Recently, 3DFT spoiled GRASS with fat saturation has been utilised, and allows ready evaluation of synovium without administration of gadolinium.

Small filling defects in the synovium are commonly seen. These represent either rice bodies (non-fibrinous bodies seen in any chronic inflammatory process) or — in most instances — blood clots.[9]

Patients with active rheumatoid arthritis frequently show virtually no fluid within the joint, accounting for the difficulty experienced in tapping effusions without benefit of imaging guidance. As rheumatoid arthritis becomes more advanced and the process becomes less active, the abnormal synovium becomes increasingly fibrous, and the rate and degree of enhancement diminishes.[8]

## Fractures

It must be emphasised that pannus is an aggressive tissue, and can burrow through cartilage and far into bone. Hyperaemia associated with the inflammatory process leads to further demineralisation. The already weak bone is therefore prone to pathological fracture — either frank fracture or insufficiency fracture. This is of particular concern in these patients, who often have relatively reduced activity already, and are frequently elderly.

## Tendons and Bursae

Abnormal synovium can also proliferate along tendon sheaths, producing compression syndromes at such sites as the carpal or tarsal tunnel (Figures 5 and 6). Within the shoulder, an impingement syndrome can be produced as the bursae become filled with fluid and pannus. In addition to the space-occupying effect of abnormal synovium, it may also erode through tendon and ligaments, producing rupture and leading to joint instability (Figure 7).[7]

## Spine

Synovial joints also occur within the spinal axis; the atlantoaxial joint is an area of particular clinical focus. The atlantoaxial joint contains synovium that can undergo the same changes as at other sites. This may result in erosion of the stabilising ligaments of the atlantoaxial articulation, thereby producing instability leading to cord compromise. Pannus may also erode the bone and produce compression of the thecal sac, thereby directly compromising the cord (Figure 8).[10,11]

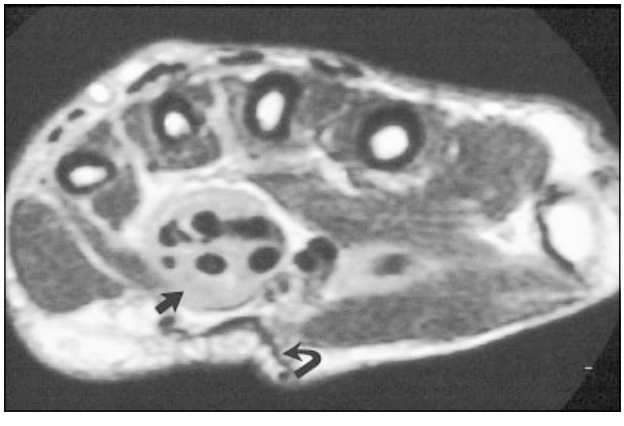

**Figure 5.** Patient with longstanding rheumatoid arthritis and carpal tunnel syndrome (postcontrast-enhanced axial T1-weighted image [TR 380 ms/TE 19 ms]). The tendons in the carpal tunnel are completely surrounded by a large quantity of enhancing pannus (arrow), producing bulging of the soft tissues anteriorly. Patient had previously undergone a carpal tunnel release (curved arrow). The dorsal tendon sheath shows no evidence of pannus or fluid distension.

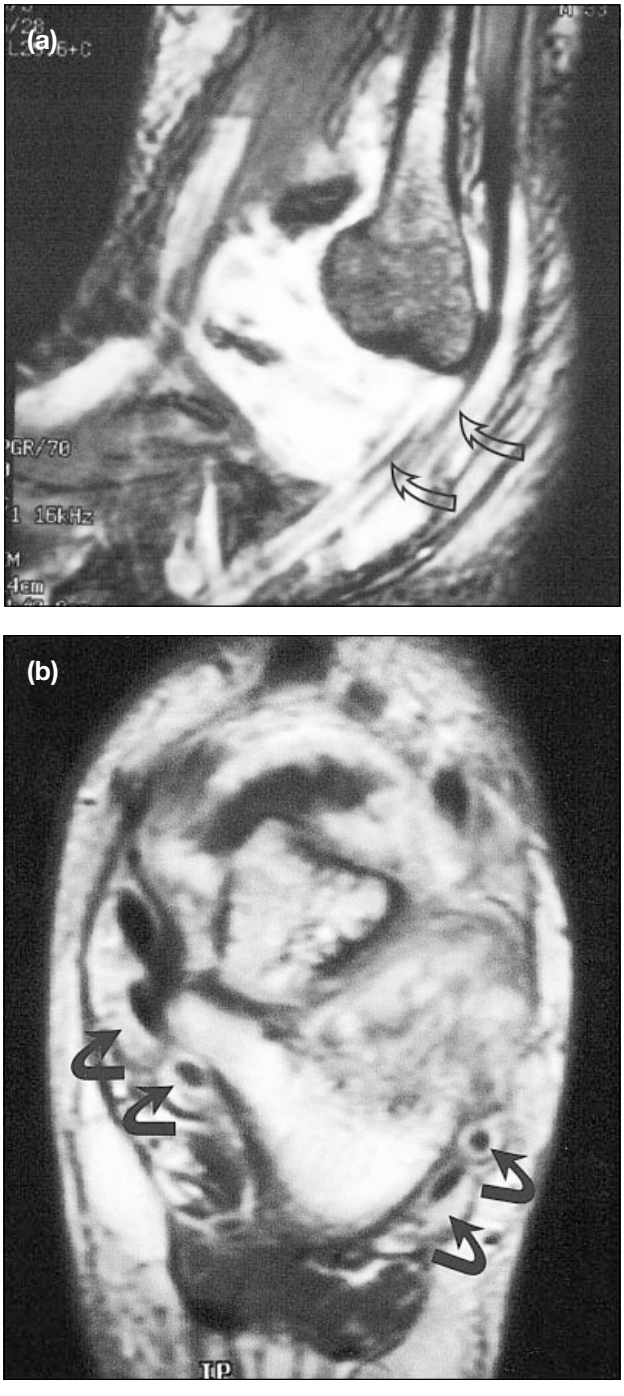


**Figure 6.** Patient with increasing restriction of ankle movement due to rheumatoid arthritis. Postcontrast-enhanced images: (a) sagittal spoiled GRASS (TR 60 ms/TE 12 ms, flip angle 70°) and (b) coronal T1-weighted (TR 420 ms/TE 19 ms). In (a), a large quantity of brightly-enhancing synovium can be appreciated around the lateral malleolus and surrounding the peroneal tendons (curved arrows). In (b), the tendon sheaths are filled with enhancing synovium (curved arrows). These findings promote the development of tarsal tunnel syndrome, as well as rupture of tendons.

Facet joints may also become unstable in a similar fashion, leading to instability at other sites within the spinal axis.

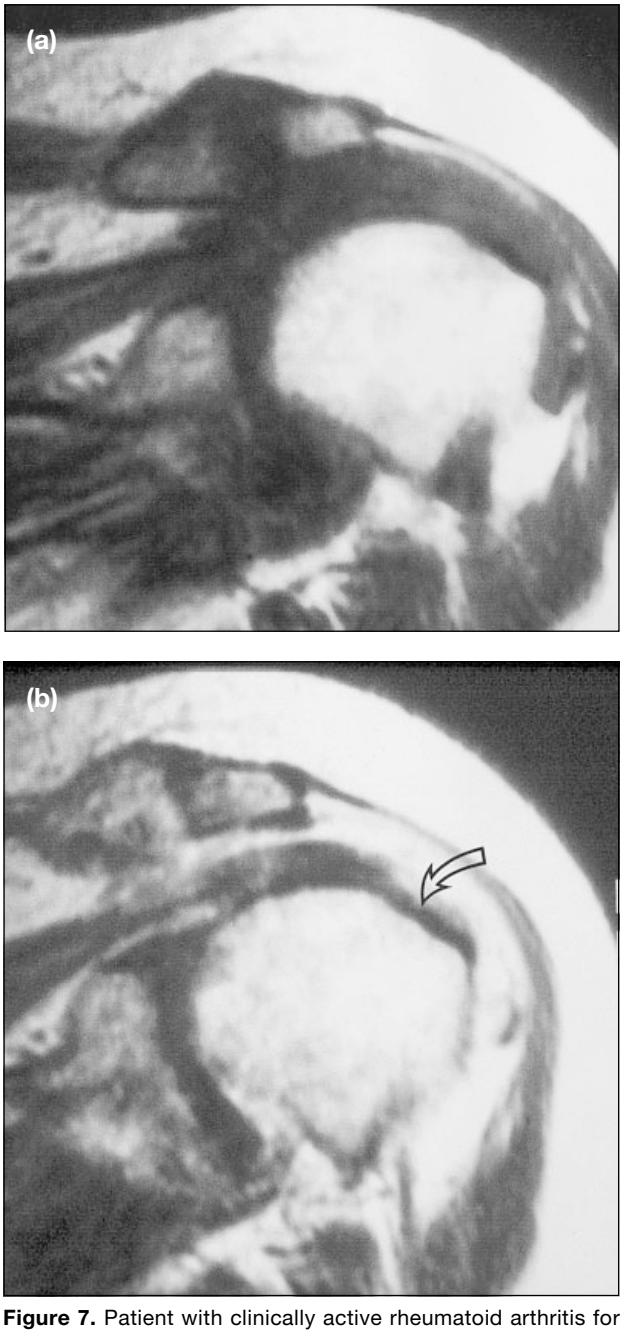


**Figure 7.** Patient with clinically active rheumatoid arthritis for approximately 2 years: oblique coronal T1-weighted images [TR 600 ms/TE 14 ms] (a) without and (b) with gadolinium. The acromiohumeral space is well preserved. The rotator cuff appears grossly intact. Following infusion of gadolinium (b), a large degree of enhancement is noted in the subacromial subdeltoid bursa. The cuff is markedly thinned (curved arrow) where synovium has invaded and destroyed tendon.

## CONCLUSION

The role of MRI is in general not for the diagnosis of rheumatoid arthritis, as this can usually be arrived at clinically. Its role lies in the evaluation of the integrity of structures that are affected by the disease process. MRI, especially dynamic rapid imaging MRI, may be helpful in evaluation of the vascularity of abnormal

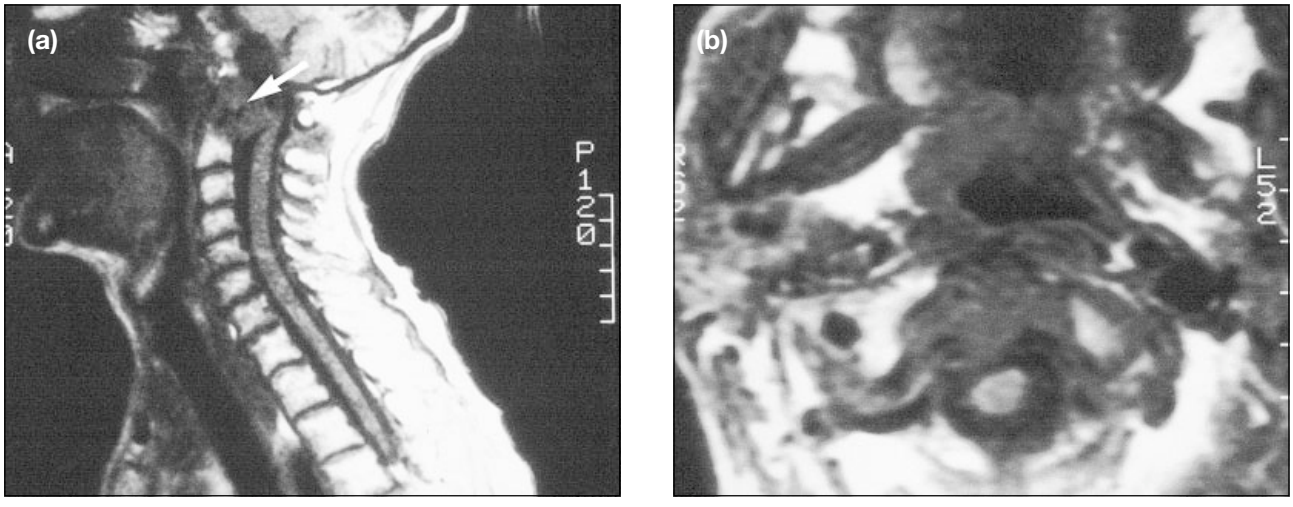


**Figure 8.** Patient with multiple joints affected by rheumatoid arthritis; T1-weighted images: (a) sagittal and (b) axial (TR 400 ms/TE 18 ms). In (a), an area of low signal intensity posterior to the odontoid peg can be appreciated, obliterating the CSF space anteriorly to the spinal cord (arrow). In (b), an anteriorly located nodule of pannus situated slightly to the right of midline can be seen protruding into the spinal canal, producing a slight mass effect on the spinal cord.

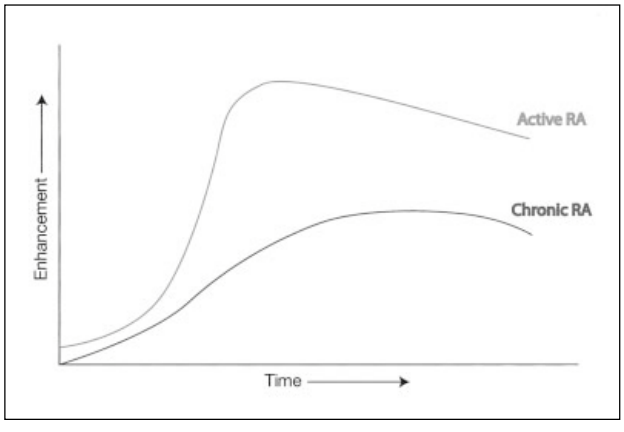


**Figure 9.** Differences in enhancement patterns in active versus chronic rheumatoid arthritis (RA). With chronicity, pannus becomes increasingly fibrotic and less vascular.

synovium, which may potentially prove to be a useful tool in drug therapy trials (Figure 9). MRI is more sensitive to changes in synovium than radiography, and enhancement rates may provide a useful quantitative measure of changes in disease activity.[8,12-15] MRI has also proven useful in the evaluation of complications arising from rheumatoid arthritis and its therapy. Examples include avascular necrosis (due to vasculitis and steroid therapies used in treatment of the disease), and insufficiency fractures.

## REFERENCES


1. Lau E, Symmons D, Bankhead C, MacGregor A, Donnan S, Silman A. Low prevalence of rheumatoid arthritis in the urbanized Chinese of Hong Kong. J Rheumatol 1993;20: 1133-1137.
2. Sugimoto H, Takeda A, Hyodoh K. Early-stage rheumatoid arthritis: prospective study of the effectiveness of MR imaging for diagnosis. Radiology 2000;216:569-575.
3. Gilkeson G, Polisson R, Sinclair H, et al. Early detection of carpal erosions in patients with rheumatoid arthritis: a pilot study of magnetic resonance imaging. J Rheumatol 1988;15: 1361-1366.
4. Gasson J, Gandy SJ, Hutton CW, Jacoby RK, Summers IR, Vennart W. Magnetic resonance imaging of rheumatoid arthritis in metacarpophalangeal joints. Skeletal Radiol 2000;29:324-334.
5. Rau R, Herbon G. Healing phenomena of erosive changes in rheumatoid arthritis patients undergoing disease-modifying antirheumatic drug therapy. Arthritis Rheum 1996;39:162-168.
6. Iannuzzi L, Dawson N, Zein N, Kushner I. Does drug therapy slow radiographic deterioration in rheumatoid arthritis? N Engl J Med 1983;309:1023-1028.
7. Rominger MB, Bernreuter WK, Kenney PJ, Morgan SL, Blackburn WD, Alarcon GS. MR imaging of the hands in early rheumatoid arthritis: preliminary results. Radiographics 1993; 13:37-46.
8. Gaffney K, Cookson J, Blake D, Coumbe A, Blades S. Quantification of rheumatoid synovitis by magnetic resonance imaging. Arthritis Rheum 1995;38:1610-1617.
9. Chung C, Coley BD, Martin LC. Rice bodies in juvenile rheumatoid arthritis. AJR Am J Roentgenol 1998;170:698-700.
10. Aisen AM, Martel W, Ellis JH, McCune WJ. Cervical spine involvement in rheumatoid arthritis: MR imaging. Radiology 1987;165:159-163.
11. Stiskal MA, Neuhold A, Szolar DH, et al. Rheumatoid arthritis of the craniocervical region by MR imaging: detection and characterization. AJR Am J Roentgenol 1995;165:585-592.
12. König H, Sieper J, Wolf KJ. Rheumatoid arthritis: evaluation of hypervascular and fibrous pannus with dynamic MR imaging enhanced with Gd-DTPA. Radiology 1990;176:473-477.
13. Reiser MF, Bongartz GP, Erlemann R, et al. Gadolinium-DTPA in rheumatoid arthritis and related diseases. Skeletal Radiol 1989;18:591-597.
14. Yamato M, Tamai K, Yamaguchi T, Ohno W. MRI of the knee in rheumatoid arthritis: Gd-DTPA perfusion dynamics. J Comput Assist Tomogr 1993;17:781-785.
15. Tamai K, Yamato M, Yamaguchi T, Ohno W. Dynamic magnetic resonance imaging for the evaluation of synovitis in patients with rheumatoid arthritis. Arthritis Rheum 1994;37: 1151-1157.