PICTORIAL ESSAY

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

PL Munk, LO Marchinkow, WC Torreggiani, MJ Lee

Department of Radiology, Vancouver General Hospital, University of British Columbia, Vancouver, Canada

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%. 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. 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. Large amounts of bone and cartilage can be destroyed, and advanced disease can produce a dramatic radiographic appearance. Plain radiographic changes are, for the most part, irreversible, although reports of partial healing have appeared. By the time radiographic changes are seen, the disease is far advanced.

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...
highly time-consuming. 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.

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

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**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.
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).
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. The ultrafiltration process will eventually cause enhancement of the effusion also, although this takes many minutes. 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.

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.

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).

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

**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...
Rheumatoid Arthritis: MRI Features

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. 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