Ultrasound imaging for the rheumatologist XIX. Imaging modalities in rheumatoid arthritis

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Received and accepted on February 4, 2009.

Clin Exp Rheumatol 2009; 27: 3-6.

Key words: Rheumatoid arthritis, x-ray, computerised tomography, ultrasonography, magnetic resonance imaging.

Competing interests: none declared.

Abstract

The field of inflammatory arthritis owes much to the advances in imaging technology which have enlightened not only clinical specialists but also researchers worldwide. The most exciting developments in recent decades have centred upon rheumatoid arthritis (RA) and more specifically the ultrasound (US) and magnetic resonance imaging (MRI) findings at various stages of the natural history of this condition. Investigation of RA using the standard techniques of plain radiography (x-ray) and more sophisticated computerised tomography (CT) have now been superseded by the exponential growth of use of US and MRI and this has been born out by the profusion of scientific papers published on these subjects.

This paper aims to review the array of imaging modalities available as investigative tools to the rheumatologist when presented with various clinical scenarios by patients with RA.

Introduction

The field of inflammatory arthritis owes much to the advances in imaging technology which have enlightened not only clinical specialists but also researchers worldwide. The most exciting developments in recent decades have centred upon rheumatoid arthritis (RA) and more specifically the ultrasound (US) and magnetic resonance imaging (MRI) findings at various stages of the natural history of this condition. Investigation of RA using the standard techniques of plain radiography (x-ray) and more sophisticated computerised tomography (CT) have now been superseded by the exponential growth of use of US and MRI and this has been born out by the profusion of scientific papers published on these subjects.

The necessary elements which any imaging tool must possess to be considered a robust method of investigation in RA include: low cost, minimal risk to patient safety, reproducibility and sensitivity to change longitudinally.

This paper aims to review the array of imaging modalities available as investigative tools to the rheumatologist when presented with various clinical scenarios by patients with RA.

Plain radiography

X-ray investigation in RA can document a wide range of changes according to the stage of the illness and the degree of severity. In the hands the pattern of involvement includes the metacarpo-phalangeal (MCP), proximal inter-phalangeal (PIP) and carpal joints. In the early stages, the plain x-ray findings can be subtle and include soft tissue shadowing around inflamed joints particularly in the hands and feet. Juxta-articular osteopenia may be seen as the inflammatory process progresses, indicative of a hypermetabolic state in the region joint inflammation (1, 2). Often this is followed by loss of joint space linked with focal eburnation of articular cartilage. One of the hallmark features of RA, bone erosion, is a pathognomonic radiographic feature which heralds a poorer prognosis for the patient and functional impairment (3, 4). The presence of joint erosion in early RA is a strong indicator of persistence of an active inflammatory process and is a useful guide to the rheumatologist when treatment options are being considered. It has been demonstrated by several researchers that compared to other imaging modalities, *e.g.* US and MRI, x-ray is an insensitive tool for detection of erosion in the early stages of RA (5-8).

The advance of RA in any one patient may vary between joints and is often non-linear in any single joint (9). The condition also has well documented soft tissue involvement which is not well visualised by x-ray and contributes significantly to the clinical presentation at all stages of the disease (10). Whilst x-rays are standardly performed in all patients with newly diagnosed RA it would appear that the findings are unable to predict overall functional status (11). In later disease, however, the degree of bony involvement is more intimately linked with functional level and degree of disability.

To many clinicians, plain x-ray remains the sole method of charting progression of RA (12). X-ray has several advantages including relatively low cost, widespread availability and reproducibility. There are caveats to this imaging doctrine including the insensitivity to identification of erosion and the paucity of information gathered about soft tissue pathology. The majority of clinical trials in RA employ validated scoring methods all of which concentrate on the characteristic features of RA (13-15). These methods are predominantly used within the research arena as they tend to be impractical for everyday use in clinical practice.

Computerised tomography

Computerised tomography (CT) scanning is rarely used in clinical practice to image patients with RA. Its capabilities do extend however to the accurate detection of bony erosions in RA and it has been shown to be more sensitive than MRI by some investigators (16-20). Some studies in RA have used CT as a gold standard reference tool for bone erosion quantification when compared with other imaging modalities. It is not a sensitive method for demonstrating changes in soft tissues and is therefore inferior to both US and MRI (21). Currently the relatively limited access to musculoskeletal CT coupled with its inherent limitations relating to soft tissue pathology, renders this particular mode of imaging an improbable candidate for further clinical use in RA.

Magnetic resonance imaging

The merits of using magnetic resonance imaging (MRI) in RA have been widely documented in the literature. It not only clearly demonstrates soft tissue changes within synovium and surrounding tissue but also erosive bony changes. There is excellent correlation between histomorphic changes within inflamed joints in RA and the MRI findings (22, 23). In addition MRI can detect oedematous change within bone marrow which appears to herald incipient bone erosion and therefore it is an impressive modality for predicting outcome in RA (24).

MRI scanning in RA requires enhancement with intravenous gadolinium to demonstrate synovitis and therefore standardly a pre- and post- gadolinium enhancement T-weighted scan is performed together with a T2-weighted fat saturated sequence to permit accurate description of bone oedema and erosive change, if present. The Outcome Measures in Rheumatology (OMERACT) group have adopted MRI for an internationally validated semi-quantitative scoring system for bone changes in RA (RAMRIS) (25). This system has been shown to be sensitive to change at all stages of the disease particularly in relation to progression of erosive changes when compared to plain x-ray (26, 27).

Several studies have investigated the prognostic potential of MRI in early RA. Whilst the earliest changes seen with MRI such as bone oedema and synovitis may not be specific to RA when compared to other inflammatory arthritides. Baseline findings on MRI appear to correlate well with the prevalence of erosions in both short term and longer term follow-up in RA (28-30).

The field of MRI development is certainly not a static environment and several innovations have recently been suggested which will impact favourably on patients with RA including newer contrast agents which will concentrate within the synovium for longer periods to allow multiple joint assessment to be performed in the same session and the use of total body MRI as a tool for targeting investigation at the most biologically active joints in RA (31, 32).

In spite of the impressive qualities of MRI in imaging RA the method does have certain important drawbacks. These include limited access to scanners in some centres together with the cost and impracticalities of using it to be a feasible follow-up imaging tool in RA.

Ultrasound

Much has been written about the use of ultrasound (US) in RA in recent decades (33-35). Interest has gathered in momentum as rheumatologists have increasingly been introducing this modality into their daily routine clinical practice as a tool to diagnose, aid therapeutic intervention and monitor disease progression (36, 37). High frequency US provides many of the desirable qualities for an imaging tool in RA including accurate depiction of both soft tissue and bony changes at all stages of the disease process, dynamic capabilities, lack of radiation exposure, reproducibility and relatively low cost. Opponents to the diffusion of US in the hands of rheumatologists themselves have made much of the steep ascent of the US skills learning curve and the anatomical barriers which exist within some joints limiting its use.

US is able to detect a panoply of morphostructural changes in RA. These include inflammation of synovial tissue within joints and adjacent peri-articular structures using both grey scale and power Doppler modes (38-40). Bone erosion in RA is well visualised, even at microscopic level (<1mm diameter). US performs better than plain x-ray in its yield of erosions but appears to be slightly less sensitive than MRI in this respect (41-43). No currently validated system for assessing joints in RA exists although several have been suggested by various investigators. A systematic approach is most often adopted and tailored to the examination of the joints which are symptomatic and those which are most commonly targeted by RA.

Currently, there are limited longitudinal data available concerning the link between baseline US findings in patients with RA and subsequent functional outcomes. In short term follow-up studies, however, there would appear

to be a correlation between the degree of synovial inflammation as documented by grey scale/ power Doppler and subsequent disease activity and radiographic change (44, 45, 48, 49). It has been reported that low grade, subclinical synovitis can be detected in RA patients whose disease activity score (DAS) indicates clinical remission.

Several investigators have employed US as a therapeutic monitoring tool in RA (46-48). These studies have concentrated both on local joint injection therapies and more latterly with systemic immunosuppressive therapy including biologic agents. Results have been variable but do suggest that US may become a valuable method of monitoring RA. Its role in influencing management decisions by the rheumatologist has yet to be investigated.

The role of US in RA is now well embedded in routine rheumatological practice and likely to benefit further from the advances which are continually emerging within the realms of US technology. The advent of three-dimensional (3D) US promises to deliver solutions to the lengthy practical skills acquisition process necessary to perform conventional US (50). The most recent development in US is termed 'Fusion Imaging' (combining US imagery with MRI or CT contemporaneously) which improves diagnostic accuracy by generating imagery which expands on the individual accuracy of each modality (32).

The future of imaging in RA appears bright and likely to continue to guide rheumatological management of this debilitating form of arthritis.

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