MRI in rheumatoid arthritis

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Purpose

To evaluate the present role of magnetic resonance imaging (MRI) in early diagnosis of Rheumatoid Arthritis (RA), its utility in assessing the effectiveness of treatment, in better control and differential diagnosis.

Describe findings of RMI in the RA and a review of literature.
Methods and Materials

Patients: Coming from the La Paz University Hospital, consultants of Rheumatology, in first visit and evolutionary controls that present clinic in peripheral joints (hands and feet), and diagnostic criteria of RA as defined by ARA (American Association of Rheumatology).

Image acquisition and evaluation:

MRI was performed in high-yield (1.5 Tesla) equipment with dedicated wrist coil, in case of hand-magnetic resonance (h-MRI), and employs different types of antenna, adapting them to the feet.

In h-MRI the patient is usually put in a decubitus position facing upwards with the dominant arm at extension, allowing, after setting up the right antenna, to carry out topograms in 3 planes to localize the corresponding planes, from the radioulnar joint distally to the metacarpophalangeal joints (MCP). And the same for the feet.

We obtained axial and coronal planes, T1 weighted sequence, T2 with fat suppression, STIR (Short Tau Inversion Recovery), and T1 with fat suppression after the administration of paramagnetic contrast with intravenous gadolinium.

The methodology employed for the realization of h-MRI recommends obtaining potentiated sequences in T1 and T2 from the radioulnar joint distally to the MCP. The T1 potentiated sequences provide detailed anatomic information of the cortical and trabecular bone, the rheumatoid synovium, and the tendo ligamentary structures. With the administration of intravenous paramagnetic contrast it is possible to differentiate synovial hypertrophy from synovitis (activity). Gadolinium or gadopentetic dimegluminic sodium (Gd-DTPA) are usually employed as paramagnetic contrast and are administered in the contra lateral arm and show, in the cases of active synovitis or tendinosis / it, a reinforcement or increase in the signal due to hypervascularization phenomena. In such cases it is possible to carry out fat suppression in T1, achieving an enhancement in the intensity of synovitis by suppressing the normally hyperintense signal coming from adjacent fatty tissue (Fig. 1).

In selected cases we perform dynamic RMI, 3D, EG(gradient echo), T1 with 7-10 sequences quantifying synovial enhancement and correlation with histological severity of inflammation and clinic marks of the disease activity. (Fig. 2).
Obtaining potentiated images in T2 permits the evaluation of the presence of water and fat present in the bone marrow or subcutaneous tissue as areas with greater signal intensity. Using fat suppression or STIR the hyperintense signal coming from bone marrow and subcutaneous fat is attenuated, allowing for the evaluation of the presence of bone oedema, joint and/or peritendinous effusion. (Fig. 3).

The recommended width for each cut is approximately 3 mm. This is because inferior widths, around 1 mm or less, though more informative regarding small erosions, occasionally can lead to errors in the interpretation of the results, such as mistaking interruptions in cortical bone produced by the entry of nutritious vessels, or ligamentary, or tendinous insertions, with erosion. (Fig. 3) Widths that are larger than 5-10 mm reduce the sensitivity of the MRh for the detection of small erosions.

The recommended planes for examination are coronal and axial, which tend to be sufficient for the study of the hand in RA. It would be possible to include the sagital planes, but it does not provide any interesting details for the study of RA.

An alternative to this method is low-yield extremity-MR (E-MRI) in which the main inconveniences of the conventional equipment, such as discomfort, position of the patient, claustrophobia and, evidently, the high cost of the traditional method. The equipment E-MRI has been shown to be more sensitive than conventional radiology for the detection of bony erosions (95% for MR vs 59% for Rx)\(^5\) and is comparable to the common high-yield method in the evaluation of synovitis and bony erosions.\(^1,5\) The main inconveniences of this technique are a lower resolution of the images, longer test duration and its current inability to carry out fat-suppression sequences necessary for the evaluation of bone edema.\(^6\) The alternative that is employed in these cases usually is the obtainment of T2 potentiated sequences using STIR though, when comparing both methods, MRh has a lower sensitivity in the evaluation of bone edema.\(^5,6\).

Images for this section:

**Fig. 1:** MRI of the hand, axial plane, T1 sequence before and after administering paramagnetic contrast with gadolinium and fat suppression.

A: synovial hypertrophy of the metacarpophalangeal joint. B: active synovitis.

**Fig. 2:** Dynamic RMI, 3D, EG(gradient echo).T1 and fat suppression. With 7-10 sequences quantifying sinovial enhancement.
Fig. 3: MRI of the foot, coronal T2 gradient echo sequence: Effusion synovial in fourth metatarsalphalangeal joint and one small erosion.
Fig. 1: MRI, T1 before and after gadolinium

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Fig. 2: Dynamic RMI, 3D, EG (gradient echo). T1 and fat suppression. With 7-10 sequences quantifying sinovial enhancement.

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Fig. 3: MRI, T2 gradient echo

Fig. 3: Fig. 3: MRI of the foot, coronal T2 gradient echo sequence: Effusion synovial in fourth metatarsalphalangeal joint and one small erosion

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Results

MRI is a multiplanar imaging technique that is nonionizing and non-invasive imaging technique that, as opposed to simple x-rays, allows not only for the evaluation of bone erosions but to establish the degree of synovial membrane affection, the state of tendinous and ligamentary structures, and of cartilage.

Findings of MRI that assess in the early phase the presence of synovitis, bone oedema, periarticular oedema, tenosynovitis, cartilage involvement, early erosions with its definitions by OMERACT (Outcome Measures in Rheumatoid Arthritis Clinical Trials), task force and its use for early diagnosis and prognosis, as well as the application of this technique as a marker of disease activity and therapeutic response.

The OMERACT RAMRIS is a semiquantitative scoring method and not a true quantitative system. Direct measurement of erosion size and the extent of the synovial membrane have been proposed as alternative methods of quantifying damage.

The definitions as proposed by the OMERACT are these:

- Synovitis: Area of the synovial compartment that shows hyperintensity before gadolinium.

- Bone oedema: Poorly limited trabecular bone lesion that shows T2 hypersignal with fat suppression / STIR or T1 hypointensity.

- Erosion: Well-limited yuxtaarticular erosion that shows loss of normal hyposignal of cortical bone and hypersignal of trabecular bone on T1 visible on 2 planes with loss of cortical, bone signal visible at least on 1 plane.

Rheumatoid synovial alterations that can be evaluated using MRI are, among others, hypertrofhy and synovitis.

Hypertrofhy is translated as a widening of the synovium or an increase in its total volume without any signal changes after the administration of paramagnetic contrast; on the contrary, synovitis appears as a hyperintense signal or a reinforcement of T1 sequences after the administration of gadolinium. (Fig. 4)
In tendons that have a synovial sheath, peritendinous effusion is seen as a halo of increased signal in T2 or STIR sequences and tenosynovitis is seen as a hyperintense halo in T1 after gadolinium uptake (Fig. 5).

Bone oedema, evaluated in T2 sequences with fat suppression or STIR as an area of increased poorly delineated signal in the yuxtaarticular trabecular bone (Fig. 6). Corresponds to the presence of water and presents itself in an isolated manner or associated to other lesions, in other words adjacent to joint synovitis, peritendinous inflammation, or erosions. (Fig. 7)

Two examples of injuries of RA on EARLY PHASE (Fig. 8, 9).

In an ESTABLISHED PHASE progression of margin bone erosions and alteration of alignment. (Fig. 10)

In an ADVANCE PHASE off synovitis, bone destruction, ankylosis and complications of treatment. (Fig. 11)

The RMI was useful in detection of joint disease, checking activity, paraarticular extension analysis, the study of complications and to identify predictors of radiographic progression of patients with RA.

X-ray although able to detect structural joint damage in patients with established disease, is not sensitive for the detection of early disease manifestations such as soft tissue changes and bone damage at its earliest stages. In contrast, MRI and ultrasonography (US) allow direct visualization of early inflammatory and destructive joint changes in RA. Consequently, increasing interest has been directed towards these imaging techniques as objective tools for the detection and monitoring of joint and soft tissue inflammation and bone damage.

Computed tomography (CT) is favoured by its tomographic viewing perspective. Thereby, the projectional superimposition seen in X-ray, that can obscure erosions and mimic joint space narrowing, is avoided. However, CT involves ionizing radiation and its sensitivity to RA soft tissue changes is markedly inferior to MRI and US, and the modality is very rarely used in clinical practice.

MRI has obvious advantages, including the increased level of detail of soft tissue and cartilage changes and lack of ionizing radiation, but it is more costly, less accessible, more time consuming and requires sedation in patients with claustrophobia.
Images for this section:

Fig. 4. MRI of the hand, coronal T1 fat suppression with gadolinium: Synovitis of the metacarpophalangeal and interphalangeal joints.

Fig. 5. MRI of the hand, axial T1 before and after administering gadolinium and fat suppression and STIR sequences: Tenosynovitis.

Fig. 6. MRI of the foot, axial T2 and coronal STIR sequences:

Hypersignal. in the bone marrow of metatarsal heads because of bone oedema, and small amount of joint effusion.

Fig. 7. MRI of the foot, axial and coronal T1 sequences. Yuxtaarticular erosion in the fourth metatarsal head.

Fig. 8. MRI of the hand, coronal T1 gradient echo sequence before and after administration of gadolinium coronal and axial T1 fat suppression sequences: Tenosynovitis in early phase.

Fig. 9. MRI of the foot, coronal STIR and axial T2 fat suppression sequences:

Bone oedema and small erosion in metatarsal head, being accompanied with synovitis in early phase.

Fig. 10. MRI of the foot, coronal T2 fat suppression and T1 sequences. Detect structural joint damage with looses of cartilage and erosions in patients with RA in established phase.

Fig. 11. MRI of the foot, sagital T1 and T2 fat suppression sequences. Complications of treatment RA. Osteoporosis and stress fracture.
Fig. 4: MRI of the hand, coronal T1 fat suppression with gadolinium: Synovitis of the metacarpophalangeal and interphalangeal joints.

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Fig. 5: Fig. 5. MRI of the hand, axial T1 before and after administering gadolinium and fat suppression and STIR sequences: Tenosynovitis.

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**Fig. 6: Bone oedema**

**Fig. 6:** Fig. 6. MRI of the foot, axial T2 and coronal STIR sequences: Hypersignal in the bone marrow of metatarsal heads because of bone oedema, and small amount of joint effusion.

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**Fig. 7: Bone erosion**

![MRI images showing bone erosion](image)

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Fig. 10: MRI of the foot, coronal T2 fat suppression and T1 sequences. Detect structural joint damage with looses of cartilage and erosions in patients with RA in established phase.

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Fig. 11: MRI of the foot, sagittal T1 and T2 fat suppression sequences. Complications of treatment RA. Osteoporosis and stress fracture.

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Conclusion

The RMI is useful in early diagnosis and RA forecast; in assessing progression of disease from the bone marrow edema to erosion. It is increasingly important in clinical management as a mark of activity and therapeutic response, providing relevant findings for the diagnosis and evolution of RA.

The RMI presents advantages and drawbacks in relation to other imaging techniques as X-ray, US and CT.
References


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