

An introduction to the EULAR–OMERACT rheumatoid arthritis MRI reference image atlas

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This article gives a short overview of the development and characteristics of the OMERACT rheumatoid arthritis MRI scoring system (RAMRIS), followed by an introduction to the use of the EULAR–OMERACT rheumatoid arthritis MRI reference image atlas. With this atlas, MRIs of wrist and metacarpophalangeal joints of patients with rheumatoid arthritis can be scored for synovitis, bone oedema, and bone erosion, guided by standard reference images.

OMERACT group,^{16–18} an RA MRI scoring system (OMERACT 2002 RAMRIS) for evaluation of inflammatory and destructive changes in RA hands and wrists was presented at OMERACT 6 in Brisbane, Australia, in April 2002. OMERACT 6 participants endorsed the OMERACT 2002 RAMRIS as a standard comparator for new/alternative MRI methods for RA assessment and encouraged its further testing in longitudinal studies.¹⁹ Recent data have documented good intraobserver and interobserver agreements among trained, calibrated readers^{20–21} and indicate an improved sensitivity to change for erosive joint damage by using this MRI score as compared with radiography.^{6–22} The evidence for the validity of MRI for assessment of joint inflammation and destruction in RA is reviewed elsewhere.^{23–24}

Structural joint damage, a major outcome in rheumatoid arthritis (RA), has traditionally been measured by scoring methods applied to radiological images.¹ However, only the late signs of preceding disease activity can be visualised by radiography. Magnetic resonance imaging (MRI) can detect RA erosive change with greater sensitivity than conventional radiography, particularly in early disease.^{2–4} In addition, MRI allows direct visualisation and assessment of synovitis, the primary lesion in RA, and of bone oedema, a finding unique to MRI and a probable forerunner of bone erosions.^{5–6} Given these advantages, MRI has a major potential as an outcome measure in RA clinical trials but standardised, validated, and feasible assessment systems are needed.

Our group felt that the performance and generalisability of RAMRIS scoring could be improved by availability of a set of standard reference images (atlas), as synovitis scores in particular may be difficult for new readers to conceptualise. Therefore, it was decided to focus the group's efforts on developing the reference image atlas presented in this supplement for use as a guide to scoring of RA joint pathology, based on the OMERACT 2002 RAMRIS method.

THE OMERACT AND EULAR MRI IN RA WORKING GROUPS

Since 1998, an international Outcome Measures in Rheumatology Clinical Trials (OMERACT) MRI in RA working group has aimed to develop MRI scoring systems to assess RA inflammation (activity) and damage, which would satisfy the elements of the OMERACT filter (truth, discrimination, and feasibility).⁷ The group's work has mainly focused on semiquantitative assessments of RA wrist and metacarpophalangeal (MCP) joints. The wrist and MCP joints were prioritised because of their frequent involvement in RA (including early RA), the fact that these joints are included in traditional clinical and radiological scoring systems in RA, and the large amount of MRI data on these joints.^{8–12} MRI definitions of important RA joint pathologies and a core set of basic MRI sequences to be used for imaging of the RA joint have been suggested by the group, in order to increase comparability between future studies.¹³ Furthermore, based on a series of studies performed by an European League Against Rheumatism (EULAR) MRI in RA working group,^{14–15} and particularly the

SCORING USING THE EULAR–OMERACT RA MRI REFERENCE IMAGE ATLAS

The OMERACT MRI in RA definitions of important joint pathologies and scoring system¹³ are summarised in table 1. Examples of score sheets, which can be used when scoring MCP and wrist joints, are provided in fig 1.

The methodology of the development of the atlas is described in detail in the following paper by Bird *et al.*²⁵ Next, the atlas itself is presented^{26–27}:

- a complete series of all grades of synovitis in the MCP joints and in each of the wrist joint areas (distal radioulnar joint, radiocarpal joint and intercarpal-carpometacarpal joints); and
- a selection of grades of bone erosions and bone oedema in the two MCP joint bones (metacarpal head and phalangeal base) and five selected wrist joint bones (distal radius, scaphoid, lunate, capitate, metacarpal base).

Abbreviations: EULAR, European League Against Rheumatism; MCP, metacarpophalangeal; MRI, magnetic resonance imaging; OMERACT, Outcome Measures in Rheumatology Clinical Trials; RA, rheumatoid arthritis

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Score sheet for the OMERACT RAMRIS

using the EULAR-OMERACT RA MRI reference image atlas

MCP JOINTS

MRI ID: _____ Scorer's name: _____

Centre where MRI was performed: _____

Image set (e.g. baseline or follow-up): _____

Sequences scored: _____

Scoring of synovitis

	MCP-joints			
	2	3	4	5
Synovitis (0-3)				

Scoring of bone erosion and bone oedema

Bone erosion is scored 0-10, according to the proportion (in increments of 10%) of bone involved:

0: 0%, 1: 1-10%, 2: 11-20 %,, 10: 91-100%

Bone oedema is scored 0-3, according to the proportion (in increments of 33%) of bone involved:

0: 0%, 1: 1-33%, 2: 34-66 %, 3: 67-100%

Score from the articular surface (or its best estimated position if absent) to a depth of 1 cm.

		MCP joints			
		2	3	4	5
Bone erosion 0-10	Proximal				
	Distal				
Bone oedema 0-3	Proximal				
	Distal				

Score sheet for the OMERACT RAMRIS

using the EULAR-OMERACT RA MRI reference image atlas

WRIST JOINTS

MRI ID: _____ Scorer's name: _____

Centre where MRI was performed: _____

Image set (e.g. baseline or follow-up): _____

Sequences scored: _____

Scoring of synovitis

	Distal radio-ulnar joint	Radio-carpal joint	Intercarpal-CMCJ
Synovitis (0-3)			

Scoring of bone erosion and bone oedema

Bone erosion is scored 0-10, according to the proportion (in increments of 10%) of bone involved:
0: 0%, 1: 1-10%, 2: 11-20 %,, 10: 91-100%

Bone oedema is scored 0-3, according to the proportion (in increments of 33%) of bone involved:
0: 0%, 1: 1-33%, 2: 34-66 %, 3: 67-100%

For carpal bones, score the whole bone. For long bones, score from the articular surface (or its best estimated position if absent) to a depth of 1 cm.

	Base of metacarpal				
	1	2	3	4	5
Bone erosion (0-10)					
Bone oedema (0-3)					

	Trapezium	Trapezoid	Capitate	Hamate
Bone erosion (0-10)				
Bone oedema (0-3)				

	Scaphoid	Lunate	Triquetrum	Pisiform
Bone erosion (0-10)				
Bone oedema (0-3)				

	Distal radius	Distal ulna
Bone erosion (0-10)		
Bone oedema (0-3)		

Figure 1 Examples of score sheets that can be used for scoring (A) metacarpophalangeal and (B) wrist joints using the OMERACT 2002 rheumatoid arthritis magnetic resonance imaging scoring system (RAMRIS). The layout of the score sheet can be modified—for example, according to the features and joints that are to be examined in a specific patient material.

Table 1 OMERACT MRI in RA group recommendations of a core set of basic MRI sequences, MRI definitions of important RA joint pathologies, and an RA MRI scoring system (OMERACT 2002 RAMRIS).¹³

A. Core set of basic MRI sequences

It is suggested that future MRI studies that intend to assess inflammatory as well as destructive changes in RA joints should at least include the following:

- Imaging in two planes* with T1 weighted images before and after intravenous gadolinium contrast†
- A T2 weighted fat saturated sequence or, if the latter is not available, a STIR (short tau inversion recovery) sequence

*Can be acquired by obtaining a two dimensional sequence in two planes, or a three dimensional sequence with isometrical voxels in one plane allowing reconstruction in other planes.

†Intravenous gadolinium injection is probably not essential if only destructive changes (bone erosions) are considered important.

B. Definitions of important RA joint pathologies

- Synovitis: an area in the synovial compartment that shows above normal post-gadolinium enhancement* of a thickness greater than the width of the normal synovium
- MRI bone erosion: a sharply marginated bone lesion, with correct juxta-articular localisation and typical signal characteristics†, which is visible in two planes with a cortical break seen in at least one plane‡
- MRI bone oedema: A lesion¶ within the trabecular bone, with ill defined margins and signal characteristics consistent with increased water content§

* Enhancement is judged by comparison of T1 weighted images obtained before and after intravenous gadolinium contrast.

†An T1 weighted images this is loss of normal low signal intensity of cortical bone and loss of normal high signal intensity of trabecular bone. Quick post-gadolinium enhancement suggests presence of active, hypervascularised pannus tissue in the erosion.

‡ Other focal bone lesions, including metastases must obviously be considered but are generally distinguishable with associated imaging and clinical findings.

¶ May occur alone or surrounding an erosion or other bone abnormalities.

§ High signal intensity on weighted fat saturated and STIR images, and low signal intensity on T1 weighted images.

C. Scoring system (OMERACT 2002 RAMRIS)

- Synovitis: is assessed in three wrist regions (the distal radioulnar joint; the radiocarpal joint; the intercarpal and carpometacarpal joints) and in each MCP joint. The first carpometacarpal joint and the first MCP joint are not scored. The scale is 0–3. Score 0 is normal, and 1–3 (mild, moderate, severe) are by thirds of the presumed maximum volume of enhancing tissue in the synovial compartment
- Bone erosions: each bone (wrists: carpal bones, distal radius, distal ulna, metacarpal bases; MCP joints: metacarpal heads, phalangeal bases) is scored separately. The scale is 0–10, based on the proportion of eroded bone compared to the “assessed bone volume”, judged on all available images—0: no erosion; 1: 1–10% of bone eroded; 2: 11–20%, etc. For long bones, the “assessed bone volume” is from the articular surface (or its best estimated position if absent) to a depth of 1 cm, and in carpal bones it is the whole bone
- Bone oedema: each bone is scored separately (as for erosions). The scale is 0–3 based on the proportion of bone with oedema, as follows—0: no oedema; 1: 1–33% of bone oedematous; 2: 34–66% of bone oedematous; 3: 67–100%

The final paper by McQueen *et al* describes the common and important pitfalls involved in scoring MR images of RA wrist and MCP joints.²⁸

To use the atlas adequately, the reader is obviously required to have a detailed understanding of the relevant joint anatomy, the RA disease process, the MRI appearance of RA joints using common sequences, and the main pitfalls when assessing them. Furthermore, the “requirements” of the OMERACT RAMRIS¹³ (see table 1) and the content of the atlas^{25–28} should be known. Calibration with a trained reader is recommended. Given these requirements, scoring of hard copy or digital MR image sets of wrist and MCP joints can be performed guided by the standard reference images of MCP joints²⁶ and wrist joints²⁷ provided in this supplement.

We suggest that when using this atlas, the reader compares the relevant images with the images in this atlas. Synovitis is scored from 0 to 3 in each area to be evaluated (see table 1). The MRI set to be assessed should be compared with the axial precontrast and postcontrast T1 weighted reference images and the joint assigned the score of the best possible match.

This is similar to the Larsen method for scoring radiographs.⁹ In the atlas, examples of both the “low” and the “high” end of the spectrum of the individual grade are provided to illustrate the range of the grade (see Bird *et al*²⁵ for details).

Bone erosion is graded by percentage volume (0–10, by 10% volume increments) of the assessed bone as described in the OMERACT RAMRIS (see table 1). All coronal slices covering the bone must be assessed to estimate the percentage of the total volume occupied by the erosion. Even though only a subset of bones are illustrated in the atlas, we recommend that all bones in the wrist and MCP joints should be scored. The reference images in the atlas can be used for guidance and calibration.

Bone oedema is graded by percentage volume (0–3, by 33% volume increments) of the assessed bone as described in the OMERACT RAMRIS (table 1). As for erosion, all slices covering the bone need to be taken into account. It should be emphasised that oedema, in case erosion and oedema are concurrently present, is scored as a proportion of the estimated original bone volume, not of the remaining bone.

All bones of the wrist and second to fifth MCP joints should be scored, not just the subset illustrated. The atlas reference images can be used for guidance and calibration.

Sum scores of synovitis, erosion, and oedema can be calculated by summation of individual joint scores, as a total sum or separately in the evaluated wrist and second to fifth MCP joints, respectively. For synovitis, the possible range of sum scores of unilateral second to fifth MCP joints, wrist joint, and both are 0–12, 0–9, and 0–21, respectively. The corresponding values for bone erosion are 0–80, 0–150, and 0–230 and for bone oedema 0–24, 0–45, and 0–69, respectively.

In conclusion, we hope we have provided a user friendly tool for teaching new readers and improving calibration for all who use MRI outcomes in RA clinical trials.

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