The OMERACT Psoriatic Arthritis Magnetic Resonance Imaging Scoring System (PsAMRIS): Definitions of Key Pathologies, Suggested MRI Sequences, and Preliminary Scoring System for PsA Hands

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ABSTRACT. This article describes a preliminary OMERACT psoriatic arthritis magnetic resonance image scoring system (PsAMRIS) for evaluation of inflammatory and destructive changes in PsA hands, which was developed by the international OMERACT MRI in inflammatory arthritis group. MRI definitions of important pathologies in peripheral PsA and suggestions concerning appropriate MRI sequences for use in PsA hands are also provided. (J Rheumatol 2009;36:1816–24; doi:10.3899/jrheum.090352)

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Magnetic resonance imaging (MRI) has gained increasing acceptance as an outcome measure in rheumatoid arthritis (RA) clinical trials, being used to evaluate synovitis, bone edema, and bone erosions. The OMERACT RA MRI score (RAMRIS)[1] is now frequently used to quantify these features, which reflect joint inflammation and damage.

The advantages of MRI mean that the use of MRI in clinical trials of other inflammatory arthritides has also grown. MRI is also now being used to measure clinical trial outcomes in other inflammatory arthritides including ankylosing spondylitis (AS)[2]. The MRI features of peripheral joint pathology in psoriatic arthritis (PsA) have been described, but there is no well-accepted, semiquantitative scoring system for outcome assessment. To compare MRI outcomes between individual trials, it is important that a standardized semiquantitative scoring system be developed, incorporating the MRI features that have been described in PsA[3].

Since 2004, the OMERACT MRI in inflammatory arthritis group have focused on developing a scoring system for MRI of the peripheral joints in PsA, and at the OMERACT 8 meeting in Malta, May 2006, pilot/initial data were presented[3] and a research agenda agreed on[4]. At a 2-day meeting of the group in Barcelona in 2007, MRI definitions of key PsA pathologies were agreed by consensus. Further, it was decided which features should be assessed in the next version of a scoring system for PsA hands, and an updated version of the scoring system was devised. Subsequently, 2 multicenter reading exercises have been performed, separated by a group meeting in November 2007 for minor adjust-

ments based on experiences achieved in the first of these 2 exercises. Results from these exercises are reported by McQueen, *et al* in this issue[5].

Our article describes the MRI definitions of the key pathologies in peripheral PsA, suggests appropriate MRI sequences for use in PsA hands, and presents the updated OMERACT psoriatic arthritis magnetic resonance image scoring system (PsAMRIS-H) for evaluation of inflammatory and destructive changes in PsA hands. We present the joint regions to be scored (Figure 1), the PsAMRIS score sheet for PsA hands (Figure 2), and images of the pathologies assessed (Figures 3-8).

MRI DEFINITIONS

The proposed MRI definitions of important pathological features that may occur in peripheral PsA are described below. Synovitis, tenosynovitis, periarticular inflammation, bone edema, bone erosion, and bone proliferation were included in the PsAMRIS hand scoring system (PsAMRIS-H). It is recognized that other features, including peritendonitis, tendonitis, and tendinopathy, may also be present. These were, however, excluded from the hand-scoring system for reasons of feasibility and to improve reproducibility of the scoring system (see Discussion). However, we provide the definitions of these features, because they were made to be generally applicable to peripheral PsA.

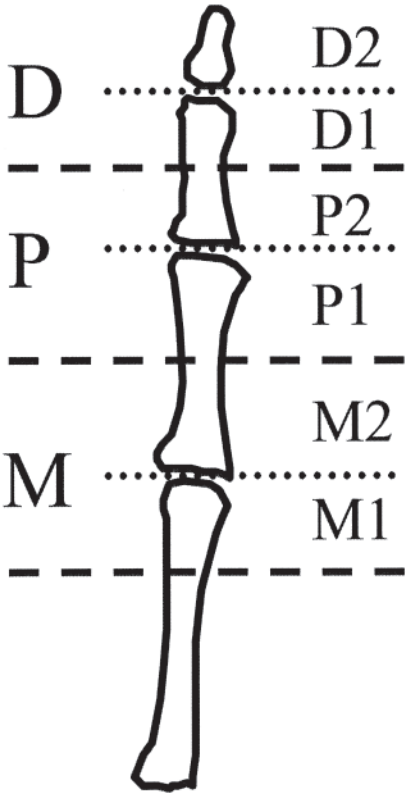

Figure 1. Regions to be scored in the OMERACT PsA MRI scoring system for hands. Regions are delimited at the midpoint of phalangeal bones (marked with dashed lines): D: distal interphalangeal (DIP) joint region; P: proximal interphalangeal joint (PIP) region; M: Metacarpophalangeal (MCP) joint region. Each region is subdivided into 2 subregions (D1, D2, P1, P2, M1, M2) by a transverse line through the joint space (dotted lines).

Synovitis (Figure 3)

An area in the synovial compartment that shows increased post-gadolinium (post-Gd) enhancement* of a thickness greater than the width of the normal synovium.

*Enhancement (signal intensity increase) is judged by comparison between T1-weighted (T1w) images obtained before and after intravenous (IV) gadolinium (Gd) contrast.

Tenosynovitis (Figure 4)

Signal characteristics consistent with increased water content* or abnormal post-Gd enhancement** adjacent to a tendon, in an area with a tendon sheath.

*High signal intensity on T2-weighted (T2w) fat-saturated (FS) and short-tau inversion recovery (STIR) images, and low signal intensity on T1w images.

**Enhancement is judged by comparison between T1w images obtained before and after IV Gd contrast.

Periarticular inflammation (Figure 5)

Signal characteristics consistent with increased water content* or abnormal post-Gd enhancement** at extraarticular sites including the periosteum ("periostitis") and the entheses ("enthesitis"), but not the tendon sheaths***.

*High signal intensity on T2w FS and STIR images.

**Enhancement is judged by comparison between T1w images obtained before and after IV Gd-contrast.

***Defined as tenosynovitis.

Bone edema (Figure 6)

A lesion* within trabecular bone, with signal characteristics consistent with increased water content** and often with ill-defined margins.

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

**High signal intensity on T2w FS and STIR images, and low signal intensity on T1w images.

Bone erosion (Figure 7)

A sharply marginated bone lesion, with typical signal characteristics*, which is visible in 2 planes with a cortical break seen in at least one plane**.

*On T1w images: loss of normal low signal intensity of cortical bone and loss of normal high signal intensity of marrow fat.

**This appearance is nonspecific for focal bone loss. Other lesions may mimic erosions, but are generally distinguishable with associated imaging and clinical findings.

Sheet for PsAMRIS scoring of MRIs of PsA hands (Version of July 24, 2008)

Patient name and ID:_____Date of MRI timepoint 1:_____ Date of MRI timepoint 2:_____

Centre where MRI was performed: _____

Scorer's name: _____ Date of scoring:_____ Centre where MRI was evaluated: _____

Sequences scored: _____

		2. finger		3. finger		4. finger		5. finger	
M. MCP JOINT REGION									
Time-point		1	2	1	2	1	2	1	2
Synovitis *(score 0-3)*									
Flexor tenosynovitis *(score 0-3)*									
Periarticular inflammation	Volar								
(score 0 or 1)	Dorsal								
Bone oedema	Proximal (M1)								
(score 0-3)	Distal (M2)								
Bone erosion	Proximal (M1)								
(score 0-10)	Distal (M2)								
Bone proliferation *(score 0 or1)*									
P. PIP JOINT REGION									
Time-point		1	2	1	2	1	2	1	2
Synovitis *(score 0-3)*									
Flexor tenosynovitis *(score 0-3)*									
Periarticular inflammation	Palmar								
(score 0 or 1)	Dorsal								
Bone oedema score	Proximal (P1)								
(score 0-3)	Distal (P2)								
Bone erosion	Proximal (P1)								
(score 0-10)	Distal (P2)								
Bone proliferation (score 0 or 1)									
D. DIP JOINT REGION									
Time-point		1	2	1	2	1	2	1	2
Synovitis *(score 0-3)*									
Flexor tenosynovitis *(score 0-3)*									
Periarticular inflammation	Palmar								
(score 0 or 1)	Dorsal								
Bone oedema score	Proximal (D1)								
(score 0-3)	Distal (D2)								
Bone erosion	Proximal (D1)								
(score 0-10)	Distal (D2)								
Bone proliferation *(score 0 or1)*									

Please score as described below. Write NA for not possible to assess. Feel free to give additional comments, e.g. note particular location if considered relevant.

Synovitis: To be scored 0-3 per M, P, and D regions. Grading scale: Similar to RAMRIS.
Flexor tenosynovitis: To be scored 0-3 per M, P, and D regions.
Grading scale: Per maximal thickness of enhancing/bright signal on T1 weighted post-contrast /STIR or T2 weighted FS images, as follows: Grading scale: 0: none; 1: <½ tendon thickness; 2: >= ½ and <1 tendon thickness; 3: >= 1 tendon thickness
Periarticular inflammation: To be scored 0-1 in dorsal part and 0-1 in palmar part of each M, P, and D region. Grading scale: 0: absent; 1: present.
Bone oedema: To be scored 0-3 per M1, M2, P1, P2, D1, and D2 regions. Grading scale: Similar to RAMRIS
Bone erosion: To be scored 0-10 per M1, M2, P1, P2, D1, and D2 regions. Grading scale: Similar to RAMRIS.
Bone proliferation: To be scored 0-1 in each M, P, and D regions. Grading scale: 0: absent; 1: present.

Space for Comments:_____

_____

Figure 2. PsA MRI scoring system for hands (PsAMRIS-H) score sheet.

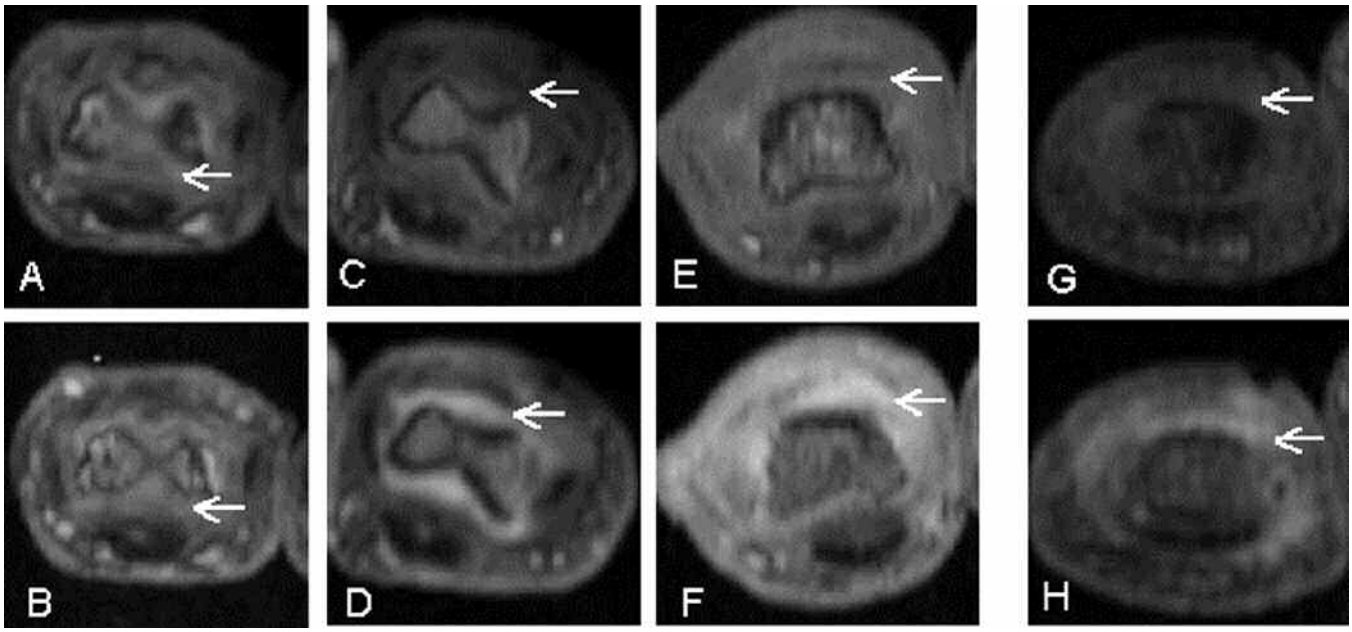

Figure 3. Synovitis in PIP joints (a-b: grade 1; c-d: grade 2; e-f: grade 3) and DIP joints (g-h). Images are in the axial plane (upper row: pre-contrast T1-weighted; lower row: post-contrast T1-weighted).

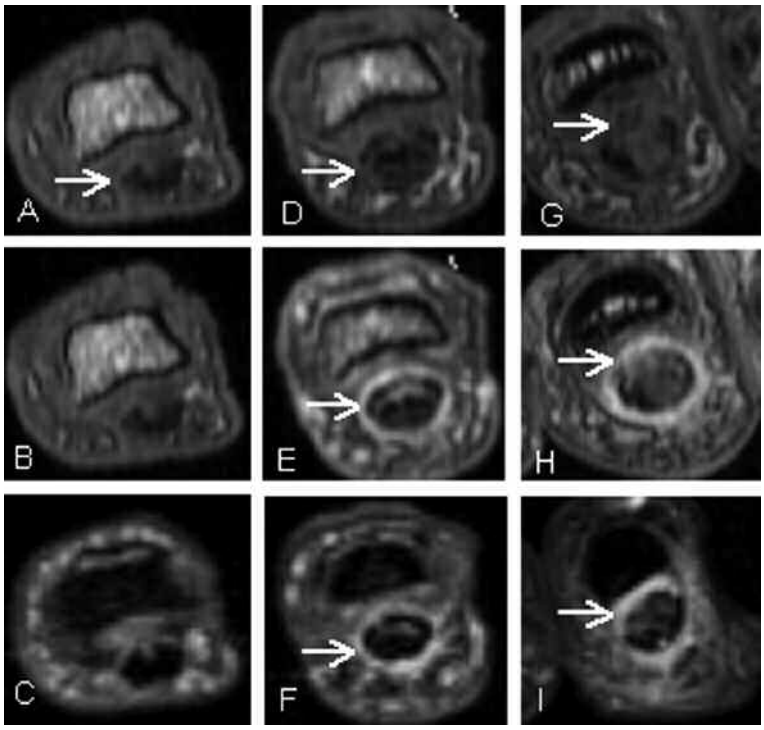

Figure 4. Tenosynovitis (a-c: grade 0; d-f: grade 1; g-i: grade 2) assessed at the level of the PIP joints. Images are in the axial plane (upper row: pre-contrast T1-weighted; middle row: post-contrast T1-weighted; lower row: STIR).

Bone proliferation (Figure 8)

Abnormal bone formation in the periarticular region, such as at the entheses (enthesophytes) and across the joint (ankylosis).

Peritendonitis

Signal characteristics consistent with increased water content* or abnormal post-gadolinium enhancement** adjacent to a tendon, in an area without a tendon sheath.

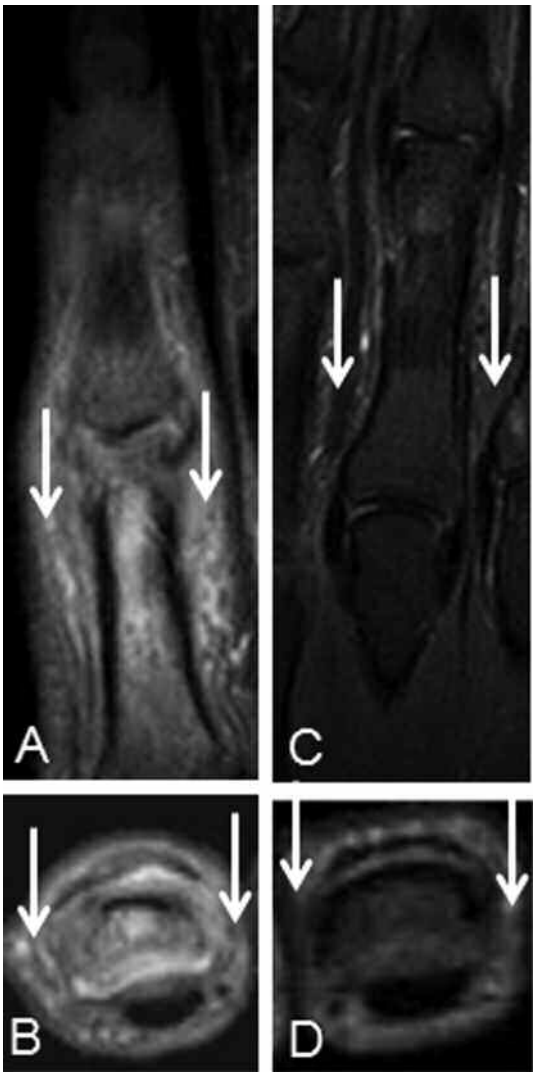

Figure 5. Periarticular inflammation (a-b: present; c-d: absent). Images are STIR images (upper row: coronal plane; lower row: axial plane).

*High signal intensity on T2-weighted FS and STIR images, and low signal intensity on T1-weighted images.

**Enhancement (signal intensity increase) is judged by comparison of T1-weighted images obtained before and after IV gadolinium-contrast.

Tendonitis

Abnormal thickening and/or signal characteristics consistent with increased water content* or abnormal post-gadolinium enhancement** inside a tendon.

*High signal intensity on T2-weighted FS and STIR images

**Enhancement (signal intensity increase) is judged by comparison of T1-weighted images obtained before and after IV gadolinium-contrast.

Tendinopathy

Morphological abnormality (abnormal thickening, attenuation, or complete disruption) and/or signal characteristics consistent with increased water content* or abnormal post-gadolinium enhancement** inside a tendon.

*High signal intensity on T2-weighted FS and STIR images.

**Enhancement (signal intensity increase) is judged by comparison of T1-weighted images obtained before and after IV gadolinium-contrast.

Preliminary scoring system of PsA hands

The preliminary MRI scoring system of PsA hands is provided below. Features to be included, areas to be assessed, and scaling (definitions of grades of pathology within this scoring system) are described.

Regions. Features described further below will be assessed in different regions of the fingers, as indicated in Figure 1. Regions are delimited at the midpoint of phalangeal bones (marked with dashed lines): D: distal interphalangeal (DIP) joint region; P: proximal interphalangeal joint (PIP) region; M: metacarpophalangeal (MCP) joint region. Each region is subdivided into 2 subregions (D1, D2, P1, P2, M1, M2) by a transverse line through the joint space (dashed lines).

Features and grading scale. *Synovitis*. To be scored 0–3 at M, P, and D regions (Figure 2). Grading scale: score 0 is normal, while 1–3 is mild, moderate, severe, by thirds of the maximum potential volume of enhancing tissue in the synovial compartment (as per RAMRIS[1]).

Bone erosion. To be scored 0–10 at M1, M2, P1, P2, D1, and D2 regions (Figure 2). Grading scale: 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. The "assessed bone volume" is from the articular surface (or its best estimated position if absent) to a depth of 1 cm (as per RAMRIS[1]).

Bone edema. To be scored 0–3 at M1, M2, P1, P2, D1, and D2 regions (Figure 2). Grading scale: the scale is 0–3 based on the proportion of bone with edema, compared to the "assessed bone volume," judged on all available images: 0: no edema; 1: 1–33% of bone edematous; 2: 34–66%; 3: 67–100% (as per RAMRIS[1]).

Flexor tenosynovitis. To be scored 0–3 at M, P, and D regions (Figure 2). Grading scale: the maximal thickness of enhancing/bright signal tenosynovium is to be assessed on T1w post-Gd or STIR or T2w FS images, as follows: 0: none; 1: < 1/2 tendon thickness; 2: ≥ 1/2 and < 1 tendon thickness; 3: ≥ 1 tendon thickness.

Periarticular inflammation. To be scored 0–1 separately at dorsal and palmar aspects of each M, P, and D region. Grading scale: 0: absent; 1: present.

Bone proliferation. To be scored 0–1 at M, P, and D regions. Grading scale: 0: absent; 1: present.

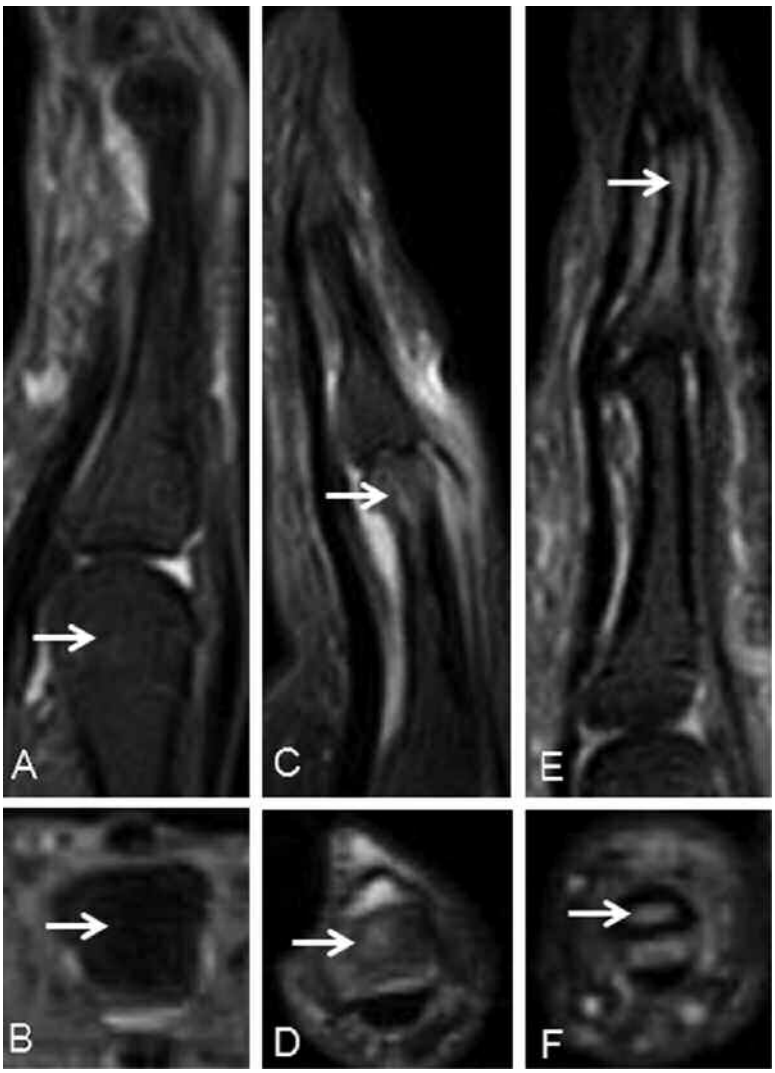

Figure 6. Bone edema (a-b: absent; c-d: present in phalangeal head; e-f: present in phalangeal head and diaphysis. Images are in sagittal (upper row) and axial (lower row) planes.

Basic MRI sequences for visualization of PsAMRIS-H features

Suggested basic sequences. T1w images before and after IV Gd contrast are required for imaging synovitis, tenosynovitis, periarticular inflammation, bone proliferation, and erosions. Sequences should be obtained in 2 planes or using a 3-dimensional (3-D) sequence with small isometric voxels in one plane, with subsequent reconstruction in other planes. A T2w FS sequence or a STIR sequence, preferably in 2 planes (optimally axial and sagittal for imaging the fingers) is also required. This will confirm inflammatory change (synovitis, tenosynovitis, periarticular inflammation) and is required to image bone edema.

Sequences: Points to consider

T1w images. To achieve optimal resolution, the slice thickness should be 1 mm or less and pixel size ≤ 0.5 × 0.5 mm. The use of IV Gd improves imaging of inflammatory change, but could be omitted if the aim is purely to detect bone erosions, bone edema, and/or bone proliferation. It is recommended not to use fat suppression for the T1w images, as failed/partially failed fat suppression is frequent when imaging the small finger joints, increasing the risk of uninterpretable images, compared with conventional T1w MRI.

T2w FS/STIR images. Detection of inflammatory changes using STIR/T2w FS images, i.e., without the use of Gd-contrast injection is possible, but in RA, this sequence has been shown to have lower sensitivity and greater interreader variability for scoring synovitis than post-Gd T1w sequences[6]. These problems are likely to have more influence when imaging the very small finger joints such as the PIP and DIP joints, so inclusion of a T1w post-Gd sequence is currently recommended.

Figure 7. Bone erosion in MCP (a-b), PIP (c-d), and DIP (e-f) joints. Images are T1-weighted (b with fat suppression) in coronal (upper row) and axial (lower row) planes.

DISCUSSION

While PsAMRIS-H has been designed using RAMRIS as a template, there are some fundamental differences between RA and PsA that may influence the scoring of certain features. For example, DIP joint inflammation (Figure 3) and damage (Figure 7) are clinically important in PsA. However, because of the small size of these joints, it could be argued that DIP scores should be scaled down, as the burden of inflamed synovium/extent of bone erosion will be less for a DIP joint than for an MCP joint. Although this was recognized as a reasonable concern by the working group, it was felt that introduction of scaling would complicate the scoring system unduly and prejudice feasibility, so identical scores for all components were included regardless of joint size.

Scoring the small PIP and DIP joints also introduces potential problems in terms of reproducibility, as it is much more difficult for readers to detect pathology at these very small joints, increasing the likelihood of error. In particular, this is a problem for scoring bone erosions, as the above definition requires that these be detected in 2 planes, and axial images of DIP joints often lack resolution because of their small size (Figure 7). The group discussed whether the definition of erosion should be "loosened" to allow lesions to be scored from just one plane, improving sensitivity, but this was rejected, in view of the potential loss of specificity. This issue could be reconsidered for specific trials, depending on their aim and setting, but would require specific, additional testing applying the changed definition. It was decided to analyze data from OMERACT PsA MRI Exercises 2 and 3[5] on a joint-by-joint basis to determine whether any features should be omitted at DIP joints because of scoring difficulties.

Another issue was raised regarding the scoring of erosions: in very advanced PsA, particularly in the arthritis mutilans form, erosion can be extensive, causing loss of bone stock well below the 1 cm line below the joint, previously the reference for scoring erosions. While this was agreed to be a reasonable concern, these situations are relatively rare, and lowering the reference line, for example, to a mid-diaphyseal position, would change the metrics of the scoring system substantially. While it might identify the

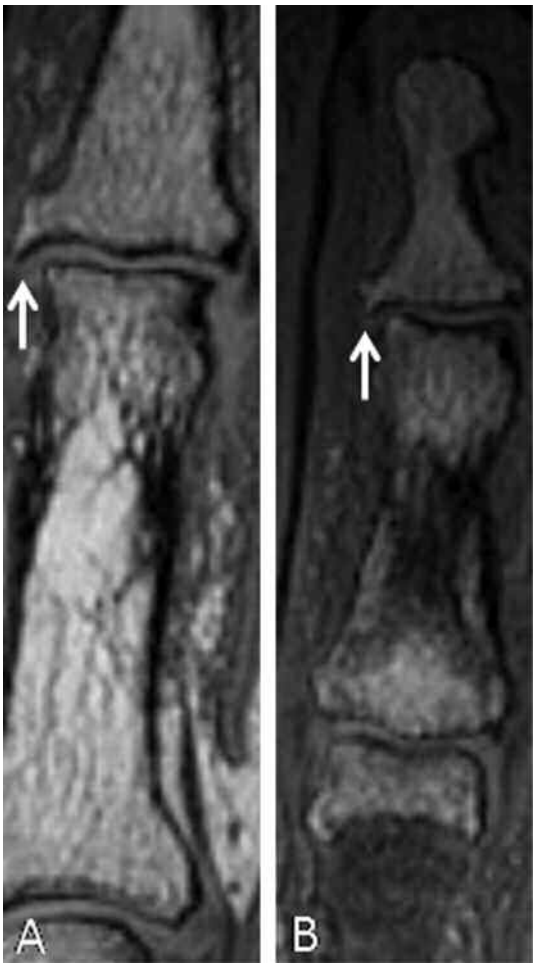

Figure 8. Bone proliferation in PIP (a) and DIP (b) joints. Images are T1-weighted and obtained in the coronal plane.

extreme degree of erosion in a patient with arthritis mutilans, it would lead to most PsA patients, whose erosions occur in the metaphysis, having very low scores, and this would greatly reduce the score's sensitivity to change in a longitudinal setting. Therefore, it was decided that PsAMRIS-H should incorporate the same method for scoring erosions as the RAMRIS system, with lesions scored 0–10 according to the volume of bone lost from a region extending to 1 cm below the joint line.

Scoring bone edema at DIP and PIP joints can also be problematic, because inhomogeneous fat saturation, causing increased signal that resembles bone edema (a false-positive), is more likely to occur when the region being imaged is away from the center of the magnet in an MRI scanner. This is a problem for imaging the fingers in general, and particularly the ends of the fingers. Thus, readers must take care to check the adequacy of fat saturation of the entire image before scoring for the presence of bone edema.

In OMERACT PsA MRI exercise 1[3], the different patterns (localization) of bone edema that can occur in PsA were differentiated as subchondral, entheseal, and diaphyseal (Figure 6), but agreement between readers was poor (as for example subchondral and entheseal regions overlap to a large extent at the small finger joints) and these categories were dispensed with for exercises 2 and 3[5]. Clearly, in future studies, where this information is deemed to be useful, it could be recorded in addition to the PsAMRIS-H bone edema score.

New domains included in PsAMRIS-H, compared to the RAMRIS[1], include bone proliferation, tenosynovitis, and periarticular inflammation. Bone proliferation (Figure 8) is a feature of PsA, but is not unique to this disease and occurs frequently in osteoarthritis (OA) as well as the other spondyloarthropathies (SpA). Whether its inclusion will add to the ability of PsAMRIS to define disease severity remains to be seen. If present as part of concomitant OA, its inclusion might suggest PsA disease progression when this was not actually occurring. Despite these concerns, the group chose to include this feature at this stage as it represents an important part of PsA pathology.

Tenosynovitis was not included in the formal RAMRIS system[1], but an MRI tenosynovitis score for use in RA has recently been published[7]. Tenosynovitis is an important feature of PsA and may occur alone or as part of dactylitis[8]. In Exercise 1[3], tendinopathy was scored at the flexor and extensor tendons of the fingers and the exercise incorporated a score for tendonitis, tenosynovitis, and edema/enhancement at tendon insertions. Interreader reliability was found to be poor, so the definiton of this feature has been revised for the current iteration of PsAMRIS-H so that only flexor tenosynovitis is scored. Optimal detection of tenosynovitis requires that there is visualization on 2 planes, one of which is a sagittal plane, to image the entire ray of the finger, and the other preferably being axial. It was recognized that regions of bright signal on sagittal T2w and STIR images can appear between the flexor tendon and the bone in some normal controls, potentially leading to false-positives. Sometimes this increased signal may represent periostitis, which can also be a feature of PsA. To avoid confusion, and ensure maximum reproducibility, it was decided tenosynovitis should be assessed using both T2w FS/STIR and post-Gd T1w sequences and include axial images (Figure 4).

Periarticular inflammation is an important part of the pathology of PsA and may help differentiate SpA, including PsA, from RA using MRI[9]. This feature incorporates inflammation of the soft tissue part of the enthesis (enthesitis) as well as other non-bony inflammation outside the joint capsule (including periostitis and soft tissue edema; Figure 5). In Exercise 1[3], there were difficulties scoring periarticular inflammation, because readers had different definitions of the region in question. Following group discussions, the definition has been revised and a decision made to score this feature on the palmar and dorsal aspects of each segment of the finger. This may appear overinclusive, but the score can

be collapsed to a briefer version depending on its performance in the following exercises.

Whether contrast enhancement is required for PsAMRIS-H is an important consideration, in view of concerns over the development of nephrogenic sclerosing fibrosis in patients with renal impairment[10]. Using a contrast-enhanced sequence also adds to the time required for the MRI examination and requires the placement of an IV line. In RA, omission of Gd-enhanced sequences lowered the sensitivity for synovitis, compared to Gd-enhanced MRI[6]. The current recommendation for PsAMRIS-H is that Gd-enhanced sequences are included, for better assessment of inflammatory change, but only for those patients with entirely normal renal function as per American College of Radiology recommendations for safe MR practices[11].

CONCLUSION

We have presented MRI definitions of important pathologies in peripheral PsA, suggestions concerning appropriate MRI sequences, and a preliminary OMERACT psoriatic arthritis magnetic resonance image scoring system for evaluation of inflammatory and destructive changes in PsA hands. Exercises 2 and 3[5] have demonstrated the use of this scoring system for grading PsA pathology in cross-sectional and longitudinal trial settings.

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