Imaging of Hand in Rheumatoid Arthritis with CR, US and MRI

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Radiology Rounds
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Introduction

- RA most common type of inflammatory Arthritis with prevalence of 1%
- Accurate and early diagnosis of RA and erosive joint damage is imperative
- Early and aggressive treatment is effective in patients with active disease
- It reduces functional deterioration and improves long term outcome

Introduction

- It should be implemented before irreversible damage and functional deterioration occur.
- Imaging techniques useful for selecting pts that benefit the most from early aggressive therapy as well as assessing response to treatment with DMADR’S.

EULAR Guidelines: Mx of early arthritis

Table 4  Final set of 12 recommendations on the management of early arthritis based on both evidence and expert opinion

- Arthritis is characterised by the presence of joint swelling, associated with pain or stiffness. Patients presenting with arthritis of more than one joint should be referred to, and seen by, a rheumatologist, ideally within six weeks after the onset of symptoms.
- Clinical examination is the method of choice for detecting synovitis. In doubtful cases, ultrasound, power Doppler, and MRI might be helpful to detect synovitis.
- Exclusion of diseases other than rheumatoid arthritis requires careful history taking and clinical examination, and ought to include at least the following laboratory tests: complete blood cell count, urinary analysis, transaminases, antinuclear antibodies.
- In every patient presenting with early arthritis to the rheumatologist, the following factors predicting persistent and erosive disease should be measured: number of swollen and tender joints, ESR or CRP, levels of rheumatoid factor and anti-CCP antibodies, and radiographic erosions.
- Patients at risk of developing persistent or erosive arthritis should be started with DMARDs as early as possible, even if they do not yet fulfil established classification criteria for inflammatory rheumatological diseases.
- Patient information concerning the disease and its treatment and outcome is important. Education programmes aimed at coping with pain, disability, and maintenance of work ability may be employed as adjunct interventions.

Combe B, Ann Rheum Dis, 2007; 66: 34-45
EULAR Guidelines: Mx of early arthritis

- NSAIDs have to be considered in symptomatic patients after evaluation of gastrointestinal, renal, and cardiovascular status.
- Systemic glucocorticoids reduce pain and swelling and should be considered as adjunctive treatment (mainly temporary), as part of the DMARD strategy. Intra-articular glucocorticoid injections should be considered for the relief of local symptoms of inflammation.
- Among the DMARDS, methotrexate is considered to be the anchor drug, and should be used first in patients at risk of developing persistent disease.
- The main goal of DMARD treatment is to achieve remission. Regular monitoring of disease activity and adverse events should guide decisions on choice and changes in treatment strategies (DMARDs including biological agents).
- Non-pharmaceutical interventions such as dynamic exercises, occupational therapy, and hydrotherapy can be applied as adjuncts to pharmaceutical interventions in patients with early arthritis.
- Monitoring of disease activity should include tender and swollen joint count, patient’s and physician’s global assessments, ESR, and CRP. Arthritis activity should be assessed at one to three month intervals, for as long as remission is not achieved. Structural damage should be assessed by radiographs of hands and feet every 6 to 12 months during the first few years. Functional assessment (for example, HAQ) can be used to complement the disease activity and structural damage monitoring.

Combe B, Ann Rheum Dis, 2007; 66: 34-45
Radiographic progression

- Early radiographic evidence of erosions independently predict long term radiographic progression
- The number of swollen joints probably correlates better with radiographic progression than the number of tender joints
- Anti CCP Ab is also an independent prognostic factor for Rad progression in early RA

Radiography

- Conventional radiograph is the traditional imaging method used to diagnose, stage and monitor disease progression and treatment response in RA
- Earliest and most frequent involved joints in RA, wrist, MCP, PIP
- Review alternative imaging modalities: MRI, CT, US, Scintigraphy

Guermazi A, Semi in muskolskel Radiol, 2004; 8
Radiography

- Radiographic lucency associated with bone erosion caused by primarily by loss of cortical bone rather than trabecular bone.
- Radiographs are relatively insensitive to trabecular bone loss and therefore to intra-medullary component of bone erosion.
- Radiography is a projectional technique, superposition of overlapping structure can obscure erosion.

## Radiography

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
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<tbody>
<tr>
<td>• Serial films for quantifying the damage</td>
<td>• Geometric distortion</td>
</tr>
<tr>
<td>• Easy to perform</td>
<td>• Erosions obscured due to superimposition</td>
</tr>
<tr>
<td>• Scoring method easy to perform</td>
<td>• No visualization of bone marrow, synovium, soft tissue, and cartilage</td>
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<tr>
<td>• Inexpensive</td>
<td>• Insensitive in early disease</td>
</tr>
<tr>
<td>• Provides a permanent record</td>
<td>• Ionizing radiation</td>
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<tr>
<td>• Widely available</td>
<td></td>
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<td>• Valuable in differential diagnosis</td>
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Guermazi, Semin in Muskskelt Radiol, 2004; 8
Figure 1  A 42-year-old man with RA. Posteranterior radiograph of the wrist shows subtle focal luencies at the base of the scaphoid and capitate (small black arrows). There is also a large erosion at the radial side of the body of the capitate (large black arrow). Because this is a site of normal ligamentous insertion, smaller lesions are sometimes difficult to differentiate from normal cortical irregularities that often present at entheses (black arrowheads). The cortical depression in the midbody of the scaphoid is a normal variant (white arrow), but can be misinterpreted as erosion.
Figure 4  A 48-year-old man with RA. (a) High-quality, single-screen, single emulsion radiograph of the hand obscures a large erosion on the volar aspect of the third metacarpal head because of projectional superimposition of overlying trabecular and cortical shadows.

(b) Despite lower intrinsic spatial resolution, the tomographic viewing perspective of the three-dimensional gradient-echo image with 0.2 Tesla dedicated extremity MRI system clearly delineates the radiographically occult erosion (arrow). There is also synovitis around the metacarpals. (With permission from ref. 52.)
Superimposition

Figure 6  A 42-year-old man with RA. (a) Posteroanterior radiograph and (b) coronal spin-echo T1-weighted MRI of the wrist show multiple carpal erosions in the trapezium, scaphoid, capitate, hamate, and triquetrum. The triquetral erosion (arrow) is not visible on a conventional radiograph because of superimposition of the pisiform.

McQueen, F, Ann Rheum Dis, 2001; 60: 859
Repair phenomenon

- Radiographic features
  - Sclerosis, cortication, filling in of erosions, remodeling and restoration to normal shape
  - Note: sclerotic margin on preexisting erosion suggest repair and new bone erosion suggests progression.
- Indicates the efficacy of treatment
- Difficult to interpret
- Difficult to detect repair phenomenon in trials with longstanding destructive change

Sharp, JT, J Rheumatol, 2003;30:1102
Figure 3  A 71-year-old man with RA treated with methotrexate. Radiographs of the scaphoid at (a) baseline, (b) 3 months, and (c) 6 months show only a vague lucency in the scaphoid bone, which appears unchanged over time. Serial coronal fat-suppressed T2*-weighted three-dimensional gradient-echo (d–f) and T1-weighted spin-echo MRI (g–i) of the scaphoid at 1.5 Tesla clearly delineate a large bone erosion in the distal pole of the scaphoid bone with gradual filling in over time. Additional coronal T1-weighted MRI at 24 months (j) shows complete filling-in of the erosion.
# Ultrasound

## Table 2  Strengths and Weaknesses of Ultrasound

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
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<tbody>
<tr>
<td>Easy to perform</td>
<td>Need for acoustic window</td>
</tr>
<tr>
<td>Multiplanar</td>
<td>Acoustic shadowing</td>
</tr>
<tr>
<td>Real-time</td>
<td>Difficulties in comparing multiple time points in longitudinal studies</td>
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<tr>
<td>Inexpensive</td>
<td>Limited visualization of deep erosions with only narrow connection to the joint surface</td>
</tr>
<tr>
<td>Widely available</td>
<td>Compromise between image resolution and depth of penetration</td>
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<tr>
<td>Immediately accessible</td>
<td>Dedicated small footprint transducer needed</td>
</tr>
<tr>
<td>No ionizing radiation</td>
<td>Special training required</td>
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<tr>
<td>Image soft tissues and bone</td>
<td></td>
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<tr>
<td>Dynamic imaging</td>
<td></td>
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<tr>
<td>May guide aspiration of bone erosion</td>
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Figure 2. A. Longitudinal section through the second metacarpophalangeal joint, demonstrating a cortical defect (straight yellow arrow) on the metacarpal head (M). Curved arrow indicates joint space. P = phalanx. B. Transverse section, confirming the defect as a definite erosion. Straight black arrows indicate identical sections in A and B on the schematic at right.
Fig. 3. US (gray-scale) shows an erosion of the lateral aspect of the fifth metatarsophalangeal joint in a patient with early rheumatoid arthritis, in longitudinal (A) and transverse (B) planes. ER, erosion.
Ultrasound vs. CR

- More sensitive than CR in detecting bone erosion at MCP, PIP, wrist and MTP, especially in early disease\(^1\)
- Greater sensitivity for 2\(^{nd}\), 5\(^{th}\) MCP, 5\(^{th}\) MTP\(^2\)
  - Accessibility with US probe
  - Early involvement
- Higher level of reproducibility
- Detects synovitis and tenosynovitis

Figure 7  A 61-year-old man with RA. (a) Posteroanterior radiograph of the hand shows bone erosions in all the metacarpals except the first. There is also synovitis around the metacarpals. (b) Longitudinal B-mode ultrasound scan shows small bone erosion of the first metacarpal not seen on a conventional radiograph (arrow).
Figure 4. A, Radiograph of the second metacarpophalangeal joint in a patient with established rheumatoid arthritis, demonstrating a borderline abnormality (arrows) toward the central portion of the metacarpal head (M). The abnormality could not be called an erosion since a cortical break could not be seen. B, Longitudinal sonographic image through the same lesion, demonstrating a definite discontinuity of the cortex (arrow) consistent with an erosion. P = phalanx.
US vs. MRI: Erosions

- MRI and MUS detection of bone erosions consistent\(^1\)
- Conflicting results as to which is more sensitive
  - MRI more sensitive at MCP joints \(^1\)
  - US detected more erosion than MRI at MCP and equal at the wrist \(^2\)

1. Hoving J, J Rheumalol, 2004; 31: 663
MRI vs. US: Erosions

Figure 3. Direct comparison of the 3 imaging techniques on a second metacarpophalangeal joint in a patient with early rheumatoid arthritis. A, Radiograph, showing normal results. B, Longitudinal sonographic image, demonstrating an erosion on the radial aspect of the second metacarpal head (M) (straight arrow). Curved arrow indicates joint space. C, Magnetic resonance imaging (T1-weighted spin-echo pulse sequence) coronal view, demonstrating bone marrow defect (arrow) corresponding to the same site as the sonographic erosion. P = phalanx.
Color doppler US

- Synovial vascularity and inflammatory activity
- Correlates well with clinical disease activity
- Correlates well with early synovial enhancement on dynamic MRI in the MCP joints

US: Synovial hypertrophy

US more useful than MRI in detecting joint and tendon sheath effusion

Fig. 4. US (gray-scale [A] and power Doppler [B]) shows synovial hypertrophy of the third metacarpophalangeal joint in a patient with early rheumatoid arthritis in longitudinal plane. SH, synovial hypertrophy.

Hoving J, J Rheum, 2004;31:663
Fig. 5. US (gray-scale [A and B] and power Doppler [C and D]) shows tenosynovitis of the extensor carpi ulnaris tendon in a patient with early rheumatoid arthritis, in transverse (A and C) and longitudinal (B and D) planes. The asterisks indicate tenosynovitis. ECU, extensor carpi ulnaris tendon.
CT scan

CT scan is superior to CR and inferior to MRI and US in detecting small erosions

Table 3  Strengths and Weaknesses of Computed Tomography

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Multiplanar imaging</td>
<td>● Ionizing radiation</td>
</tr>
<tr>
<td>● Good definition of bone anatomy</td>
<td>● Less sensitive than MRI and US</td>
</tr>
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</table>

1. Ostergaard M, Scan J Rheumatol, 2003; 32: 63
CT vs CR

Figure 8  A 59-year-old woman with RA. (a) Posteroanterior radiograph of the hand shows a small radiolucency of the fifth metacarpal with a very thin rim of sclerosis (arrow). (b) Axial CT scan at the level of the head of the first metacarpal shows the radiolucency to be related to a subchondral cyst—possibly an old erosion (arrowhead), and a large erosion of the radial margin of the first metacarpal (arrow).
CT vs CR

Figure 5  A 61-year-old man with RA. (a) Posteroanterior radiograph of the wrist shows erosion in the second metacarpal (arrow) and subtle radiolucencies in the carpal bones. There is also a narrowing of the midcarpal joint. (b, c) Axial CT scans of the wrist show several small erosions in the carpal bones and also the first metacarpal (arrow) not visible on the conventional radiograph because of bone superimposition.

Guermazi A, Semin in Musculoskelet Radiol, 2004; 8: 269
### Table 4  Strengths and Weaknesses of Whole-Body MRI

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Multiplanar tomographic technique</td>
<td>• Biohazards (pacemaker, surgical clips, etc.)</td>
</tr>
<tr>
<td>• Three-dimensional capability</td>
<td>• Claustrophobia</td>
</tr>
<tr>
<td>• Visualization of bone marrow, synovium, soft tissue (as predictors for bone erosion)</td>
<td>• Long examination time</td>
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<tr>
<td>• No ionizing radiation</td>
<td>• High cost</td>
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<td></td>
<td>• Lower availability</td>
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<td></td>
<td>• Magnetic susceptibility artifacts</td>
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<td>• Limited anatomical coverage</td>
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MRI

- Detects erosion, BM edema, synovitis and tenosynovitis early in the disease.
- Erosion detected in high proportion of RA pts (45%) very early on (4 m) when CR is frequently normal (85%)\(^1\)
- MRI of wrist with first presentation of RA can predict radiographic erosions at 2 years \(^2\)

1. McQueen F, Ann Rheum Dis; 1998; 57: 350
MRI

- Bone marrow edema, not visualized on CR, is a pre-erosive sign of arthritic bone damage and may have prognostic value in early RA\(^1\)
- Differentiates well circumscribed bone erosion from ill defined areas of pre-erosive BME
  - Hypointensity on T1 and hyperintensity on T2 and fat suppression and gad enhancement
- The most common site of BME on the wrist are lunate, capitate and triquetrum\(^2\)

1. McQueen F, Ann Rheum Dis, 1998; 57: 350
MRI: BME predicts erosion

Fig. 1  a–c The left hand of a patient with early RA. Comparison of radiograph and MRI. a Plain PA radiograph of the 2nd–5th MCP joints demonstrating normal appearances of the metacarpal heads with no erosions. b T1-weighted coronal MRI shows erosion of the radial aspect of the 3rd metacarpal head (*). c T2 fat suppressed coronal MRI demonstrates oedema (arrows) associated with periarticular inflammatory change (arrowheads)
MRI: BME and Synovitis

Fig. 2 T1-weighted fat-suppressed post Gd-DTPA coronal MRI shows diffuse oedema (black arrows) in the radial aspect of the 2nd metacarpal head with intact overlying cortex. Synovitis (arrowheads) and nonenhancing effusion (white arrows) are present in the 2nd and 3rd MCP joints.

Farrant M, Skel Radiol, 2006
MRI: Synovitis

**Fig. 1a–d** Transverse T1-weighted MR imaging pre- and post-gadolinium (Gd-DTPA) through the MCP joints and wrist in a patient with RA.  
- **a** Pre-Gd-DTPA and  
- **b** post-Gd-DTPA in the same axial section through the MCP joints. The thickened enhancing synovium is clearly shown surrounding the joints and the flexor tendons (*arrowheads*). Some non-enhancing joint fluid is seen within the ring MCP joint (*arrow*).  
- **c** Pre-Gd-DTPA and  
- **d** post-Gd-DTPA in the same axial section through the wrist. Enhancing synovitis is seen at the distal radio-ulnar joint (*arrowheads*) and surrounding the flexor tendons. Non-enhancing fluid is also seen (*arrow*). Further synovitis is seen surrounding the extensor carpi ulnaris tendon, a common site for synovitis in RA (*black arrowhead*)
## Scintigraphy

### Table 6  Strengths and Weaknesses of Scintigraphy

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitive</td>
<td>Poor specificity and resolution</td>
</tr>
<tr>
<td>Good screening modality</td>
<td>High cost</td>
</tr>
<tr>
<td>Whole-body coverage</td>
<td>Long examination</td>
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<td></td>
<td>Ionizing radiation</td>
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Ostergaard M, Scand J Rheum, 1995; 24: 212
Scintigraphy

- Scintigraphy detects inflammation and bone turnover at site of active erosion
- Significant correlation between pathologic finding on 3-phase bone scintigraphy and finding on physical exam and US, but not on MRI and CR
- Scintigraphy is very sensitive, but not specific for synovitis and bone erosion in RA

Grassy W, Ann Rheum Disease, 2001; 60:98
Summary

- MRI shows the greatest sensitivity
  - Detecting and monitoring bone erosion
  - Pre erosive features of RA: BM edema, synovitis and tenosynovitis

- Ultrasound more sensitive for erosions than radiograph and evaluation of synovitis
  - Operator dependency, restricted anatomical coverage are practical limitation to its use

- Scintigraphy is very sensitive, but not specific for synovitis and bone erosion in RA

- Conventional radiography is less sensitive for bone erosion especially in early stage
References

- Combe B, Ann Rheum Dis, 2007; 66: 34-45
- Guermazi A, Semin in Musculoskelet Radiol, 2004; 8:
- Rev Farrant A, Skel Radiol, 2006 part 1
- Rev Farrant A, Skel Radiol, 2006 part 2
- Hoving JL, J Rheumatol, 2004; 31: 663
- McQueen FM, Ann Rheum Dis, 2001; 60: 859