Detection of Erosions in the Rheumatoid Hand; A Comparative Study of Multidetector Computerized Tomography versus Magnetic Resonance Scanning

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ABSTRACT. ***Objective.*** To compare the detection and scoring of erosions in patients with rheumatoid arthritis (RA) using magnetic resonance (MR) and multidetector helical computerized tomographic (CT) scanning.

Methods. Comparative CT and MR scans of the dominant wrist were obtained from 9 patients with RA and clinical examination was performed to assess disease activity. MR and CT scans were scored for erosions and MR scans for bone edema by 2 radiologists using a validated system. Radiographs of the hands and feet were also scored for erosions using the modified Sharp score.

Results. In 117 of 135 (87%) sites there was concordance for erosions between MR and CT scans. At the remaining 18/135 sites (13%), erosions were identified by CT but not MR in 12/135 (9%) and by MR but not CT in 6/135 (4%). Partial volume artefacts on MR images and shifts in slice position were the most common reasons for erosion mismatch between MR and CT. The mean CT bone erosion score was significantly higher than the MR erosion score when individual bony sites were examined ($p = 0.024$), with the greatest difference being at the metacarpal bases. The total bone erosion score also tended to be higher on CT than MR [median scores of 20 (range 0–66) and 12 (0–51), respectively; $p = 0.060$]. MR and CT erosion scores correlated strongly with the total Sharp score ($r = 0.93$, $p = 0.0002$ and $r = 0.94$, $p = 0.0002$, respectively) and with the Disease Activity Score (MR: $r = 0.77$, $p = 0.02$; CT: $r = 0.71$, $p = 0.03$).

Conclusion. Most erosions were detected using both modalities, but erosion scores were higher on CT than MR scans, especially at the metacarpal bases. It is possible that small erosions in some regions are more easily detected by CT because of its ability to clearly delineate cortical bony margins. (J Rheumatol 2005;32:256–67)

Key Indexing Terms:
MAGNETIC RESONANCE IMAGING
RHEUMATOID ARTHRITIS
COMPUTER TOMOGRAPHIC SCANNING
EROSIONS

The detection of radiographic erosions is of crucial importance to evaluation of the patient with rheumatoid arthritis (RA). The presence of erosions in early disease serves as a diagnostic marker for RA[1] and is a sign of poor prognosis, signaling potentially aggressive disease[2]. Recently, magnetic resonance imaging (MRI) has emerged as a valuable tool for prognostication in early RA, providing information on the presence of erosions much earlier than is available from traditional radiographs[3,4] and also revealing features such as bone marrow edema that are not detectable by other means[5]. The extent of early MR bone edema has been shown to predict both radiographic progression and functional status in a cohort of RA patients, suggesting that MR may be useful in directing potent disease modifying therapies to patients most likely to develop debilitating erosive disease[6,7].

While MR scanning has been shown to be very sensitive for detection of erosions, there have been concerns about its level of specificity in view of the potential for other lesions that do not actually involve bone loss (such as regions of focal bone edema) to mimic erosions[8]. Estimating erosion size using MRI can be confounded by a surrounding rim of bone edema, making lesions appear bigger than they actually are on unenhanced T1 weighted sequences[9]. This is because MR requires the presence of mobile protons to produce a signal and cortical bone contains almost no water, and so appears as a low signal line on T1 weighted sequences. Thus, a defect in cortical bone associated with an

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Supported by grants from the Health Research Council of New Zealand, the Arthritis Foundation of New Zealand, the Auckland Medical Research Foundation, Lotteries Health, New Zealand, the Auckland Radiology Group, Sanofi-Winthrop, and the Auckland Regional Rheumatology Research Trust.

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Submitted March 12, 2004; revision accepted September 20, 2004.

erosion is visualized when contrasting tissue (such as inflammatory pannus) occupies the space that was previously bone, producing an intermediate signal. If adjacent bone also has altered signal due to the presence of bone edema (whose direct pathological correlate has not been defined) then the border of the erosion may be obscured. However, contrast-enhanced T1 and T2 weighted sequences are usually able to identify bone edema and pannus and distinguish them from cortical or trabecular bone.

CT and plain radiography image bone in an entirely different way, depending on attenuation of the x-ray beam by tissues of varying density. Cortical bone, being very dense, is readily visible, as is the interface with adjacent soft tissues. Thus, these imaging techniques are capable of clearly delineating the borders of erosions and differentiating bone (whether edematous or not) from inflamed synovium. While plain radiography has traditionally been used as the gold standard for imaging erosions, there are many regions such as the carpus where complex 3-dimensional anatomy is very inadequately depicted using a 2-dimensional technique. This was recognized when the Sharp score was developed for scoring erosive damage in rheumatoid patients, as some areas of the carpus were excluded altogether because of poor visibility[10]. This problem is circumvented by multidetector helical CT, which offers the benefits of multiplanar capability, similar to MRI, with the enhanced cortical definition intrinsic to plain radiography. CT is also significantly less expensive than MRI and is quicker to perform.

Few studies have explored the role of CT in imaging rheumatoid erosions in the wrist[9,11-13]. We compared CT with MR imaging of the wrist for detection of erosions in a group of rheumatoid patients of similar disease duration. Comparisons were also made with plain radiography and clinical indicators of disease activity.

MATERIALS AND METHODS

Patient population and clinical assessments. Patients for this study were a subgroup of those studied longitudinally over a 6 year period as described[6]. Briefly, patients were initially referred to an early arthritis clinic by primary care physicians and specialist rheumatologists from hospital rheumatology outpatient clinics and private practice within the Auckland and Waikato areas of New Zealand, after a media campaign. Approval for the study was granted by the North Health and Waikato Ethics Committees. Enrolment for the study proceeded from 1994 to 1996 and then patients were followed at 0, 1, 2, and 6 years with clinical assessments and radiographs, and at 0, 1, and 6 years with MR scans of the dominant wrist. At the time of enrolment into the study, all had a disease duration of 6 years (range 6–6.5 yrs). Patients were recalled for CT scans of the dominant wrist following clinical assessments and MR scans as described below. CT scans were performed on the same day as MR scans, except in one patient, when the CT scan was 13 days later.

All patients were assessed clinically for disease activity using a tender joint count [temporomandibular, acromioclavicular, sternoclavicular, shoulders, elbows, wrists, metacarpophalangeal (MCP), proximal interphalangeal (PIP), hips, knees, ankles, midtarsal joints, metatarsophalangeal (MTP), and PIP of the foot; maximum possible = 60], swollen joint count (maximum possible = 58, hips excluded), erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP). A 3-variable Disease Activity Score (DAS) was derived according to the method described by van der Heijde, *et al*[14]. Functional outcome was measured using the Health Assessment Questionnaire (HAQ) score and the physical function component of the Medical Outcome Study Short Form-36 score (PF-SF-36)[15].

Of the 10 patients enrolled into this study, one had to be withdrawn as he had had placement of orthopedic screws across the wrist for fixation and this caused an unacceptable degree of metal artefact in resultant MR images. Full clinical, MR, CT, and radiographic data were therefore available in 9 patients. Demographic details are presented in Table 1.

MR scans. An MR scan of the dominant wrist was obtained using a 1.5 Tesla MR scanner (GE Signa Horizon) with a dedicated wrist coil (Medical Devices). The hand was placed in the wrist coil, where it fitted snugly by the patient's side with the palm facing the body, thumb anteriorly. The field of view was 8 cm and included the distal radioulnar, radiocarpal, and midcarpal joints as well as the metacarpal bases. The small field of view was chosen to optimize resolution and did not include MCP joints. Coronal and axial T1 sequences were performed, followed by axial fat-suppressed fast spin echo T2, then coronal fat-suppressed T1 sequences after injection of gadolinium-diethylenetriamine pentaacetic acid (Gd-DPTA; gadodiamide, Nicomed Omniscan), which acts as a contrast agent. An axial fat-suppressed T1 post-Gd-DPTA sequence was also included. A slice thickness of 3 mm was used throughout.

The system used to score MRI scans has been described[3]. Briefly, erosions were defined as focal areas of loss of low signal cortex, with sharply defined margins, identified on both T1 and T2 weighted sequences. The cortex was replaced by well circumscribed intermediate signal tissue on T1, which was intermediate to bright on T2 and enhanced with Gd-DPTA. Erosions were only scored if visible in 2 planes, with a cortical break seen in at least one plane. Erosions were differentiated from intraosseous cysts, which appeared as well circumscribed, rounded lesions within bone without any associated cortical break, as described[16]. MR erosions were scored at 15 sites within the carpus. Erosions were scored on size as 0, 1 (< 4 mm diameter), and 2 (> 4 mm diameter). Erosions at each site were counted (erosion number) and an erosion score per site was obtained (maximum possible erosion score per site = 6). Scores were added to give totals for the carpus (maximum possible erosion score = 90). When erosive damage was so severe that individual erosions could not be counted or scored, the carpal site in question was allocated an arbitrary high score of 6 (equivalent to 6 small erosions or 3 large erosions). Bone marrow edema was identified as a poorly defined area of intermediate signal within bone on T1 weighted images that had high signal on fat saturated (FS) T2 weighted images. It

Table 1. Patient demographics.

Clinical features	
Age, yrs, median (range)	58 (39–68)
F:M	5:4
Ethnic group	7 Caucasian, 2 Pacific Island
Duration of symptoms, yrs, mo	6 y 2 m (6 y 1 m–6 y 9 m)
Seropositive (ever)	9 (100%)
Medications	
NSAID	8 (89%)
DMARD	7 (78%)
Prednisone (3–10 mg)	4 (44%)
Disease activity, median (range)	
Ritchie Index	8 (0–15)
Swollen joint count	4 (0–16)
Tender joint count	16 (0–36)
Pain score	2.6 (0–6.5)
HAQ score	0.4 (0–1.3)
DAS	3.40 (1.39–4.64)
ESR	44 (5–129)
CRP	8 (3–69)

was scored at the same sites as erosions as follows: 0 for none, 1 for minor edema involving < 50% of the bone, 2 for gross edema involving > 50% of the bone marrow. The total bone marrow edema score was obtained from the sum of all scores at 15 sites (maximum possible = 30).

CT scans. A CT scan of the dominant wrist was obtained using a multislice helical CT scanner (Siemens Somatom Volume Zoom 4 Slice). The patient was positioned prone with the dominant arm outstretched, palm facing downwards. The scan included the distal radioulnar, radiocarpal, and midcarpal joints as well as the metacarpal bases. All exposures were standardized at 120 kV with 90 mAs. Axial slices of 0.5 mm thickness were obtained and these were used to reconstruct coronal and axial images with a thickness of 2.5 mm. Scoring of CT scans was performed on the 2.5 mm slices. Erosions on CT were defined as focal areas of loss of cortex with sharply defined margins, seen in 2 planes, with cortical break seen in at least one plane. The scoring system was otherwise identical to that used for MRI.

MRI and CT scans were scored by consensus on different days by 2 musculoskeletal radiologists with previous experience using this scoring system (NS and JC). Individual scores were obtained on a different occasion, at least 6 months separated, to assess interobserver reliability. Scorers were blinded to the other modality and to clinical and radiologic data.

Scoring radiographs. Plain radiographs of the hands and feet (anteroposterior views) were scored separately by 2 observers (NB and DP) using the modified Sharp-van der Heijde method[10]. The mean score for the 2 readers for each patient was used in data analysis. Information regarding reproducibility of these data has been reported[6].

Statistical analysis. Intraclass correlation coefficients (ICC)[17] were calculated to investigate interobserver reliability for MR and CT scoring. Spearman correlations were used to investigate associations between MR, CT, Sharp, and clinical scores. Mixed models that allow for correlations between data from the same patients were used to investigate differences between the presence of erosions and erosion scores on MR and CT scans. Similar models were also used to investigate the proportion of sites with erosions on MR, CT, and radiographs.

RESULTS

Demographics. Nine patients had CT scans and MR scans of the dominant wrist. Patients were assessed clinically on the same day as the MR scan by a rheumatologist (NB) for medication use, disease activity, and function (HAQ and PF-SF-36; Table 1).

Reproducibility of scoring MR scans. Interobserver reliability for MR erosions on independent scoring was high (ICC 0.91, 95% CI 0.68–0.98). When mean scores were compared with consensus scores, there was a high degree of similarity between data sets (ICC for erosions 0.99, 95% CI 0.98–0.99; ICC for bone edema 0.97, 95% CI 0.90–0.99). Interobserver reliability for CT erosions was very high (ICC 0.99, 95% CI 0.96–0.998). There was very little difference between consensus scores and the mean of independent erosion scores (ICC 0.99, 95% CI 0.996–0.999). Thus consensus scoring for MR and CT was felt to be reliable.

Mismatch of lesions at the same bony sites using CT and MR. Overall, we found that both CT and MR identified bone erosions at the same carpal sites on 117 of 135 (87%) occasions. An example is shown in Figure 1. Of the remaining 18/135 sites (13%), erosions were identified more often by CT but not MR in 12/135 cases (9%) and by MR but not CT in 6/135 cases (4%). Cases where mismatches occurred were reviewed separately by a senior registrar in radiology (DP) in consultation with one of the radiologists (NS), and the most likely reason for the mismatch was deduced. These data are shown in Table 2. A common reason for mismatch between MR and CT was felt to be partial volume artefacts on MR, obscuring an erosion that was apparent on CT. Slight alteration in position of image slices also meant that in some cases a small erosion was detected by one modality (more often CT) but not the other. An example is shown in Figure 2, where an erosion was detected at the 4th metacarpal base on CT, but not imaged clearly by MR. Figure 3 shows an example of mismatch, where an erosion with cortical breach was scored on MR, but an intact overlying cortex was observed on CT, suggesting an intraosseous cyst.

Bone sclerosis was a cause of mismatch. In some cases erosion was seen adjacent to a region of sclerosis on CT, but neither erosion nor sclerosis was clearly depicted on MR. Figure 4 shows an example of this in a patient with extensive carpal erosive change, where CT shows a clearly defined erosion involving the medial aspect of the distal radius adjacent to a sclerotic region (circle) with marked joint space narrowing. On MR, both sclerosis and erosion were obscured within a region of low signal on the T1 weighted images and the degree of joint space narrowing is less well defined. Post-gadolinium T1 weighted images show enhancing bone marrow edema that further obscures the enhancing erosion. We examined cases of CT/MR erosion mismatch to determine whether bone edema had been scored instead of erosion on MR, but this was not the case. In all situations where bone edema was scored on MR, there was also erosion scored on both MR and CT.

Bone erosion scores were higher on CT scans compared with MR scans. We explored the possibility that some regions of the wrist might yield a better image by one modality compared with the other. Sites were classified into 3 groups as follows: Group 1: the distal radius and ulna; Group 2: the carpal bones; and Group 3: the metacarpal bases. We investigated the detection of erosions at the 3 separate sites and found a trend toward greater erosion detection by CT compared with MR at the metacarpal bases compared with the distal radius and ulna ($p = 0.067$). The CT bone erosion score was higher than the MR erosion score at all bony sites (Groups 1, 2, and 3), with the greatest ratio between CT and MR being at the metacarpal bases (Figure 5). At Group 1 sites, CT erosion scores were on average 0.67 units higher than MR erosion scores (SE 0.30, 95% CI 0.08–1.28). At Group 2 sites the difference was 0.39 units (SE 0.18, 95% CI 0.04–0.74) and at Group 3 sites the difference was 0.53 (SE 0.13, 95% CI 0.27–0.78). When results were averaged over all 3 bone groups this difference reached significance [mean difference 0.53 (SE 0.13), $p = 0.024$]. The total CT erosion scores for the wrist were also higher than the total MR erosion scores [median scores of 20 (range 0–66) and 12 (0–51), respectively; $p = 0.060$].

Correlations between MR and CT erosion scores and dominant wrist Sharp score. Radiographs of the hands and feet were also available in these patients and had been scored for erosions and joint space narrowing using the modified Sharp score[10]. A total score was obtained from radiographs of both hands and both feet and a local dominant wrist Sharp score was obtained from the region examined by the MR and CT scans[6]. Both MR and CT erosion scores correlated very strongly with the total Sharp score ($r = 0.93$, $p = 0.0002$, and $r = 0.94$, $p = 0.0002$, respectively) and with the local dominant wrist Sharp score ($r = 0.96$, $p < 0.0001$, and $r = 0.92$, $p = 0.0004$; Table 3). However, when erosions detected on radiographs were matched site for site with erosions on CT and MR scans for each patient (this was possible at 6 sites including the 1st metacarpal base, scaphoid, lunate, trapezoid, radius, and ulna), significantly fewer sites were detected on radiographs, emphasizing the greater sensitivity of MR and CT ($p = 0.021$; Table 4). Figure 6 shows comparative CT and MR scans of the wrist plus the equivalent radiograph from one of these patients, illustrating the superiority of MR and CT scanning in revealing erosions at the carpus.

MR and CT scores correlated with clinical scores including the DAS. Table 3 also summarizes correlations between MR and CT erosion scores and the DAS. Again, correlations were very similar for the 2 modalities (MR: $r = 0.77$, $p = 0.02$, compared with CT: $r = 0.71$, $p = 0.03$). Information was also available on function for this group of patients including HAQ and PF-SF-36 scores. In this small group of patients there was no significant association between function and CT or MR erosion scores at the dominant wrist, but a trend was observed toward an association between the MR erosion score and the HAQ score ($r = 0.63$, $p = 0.067$).

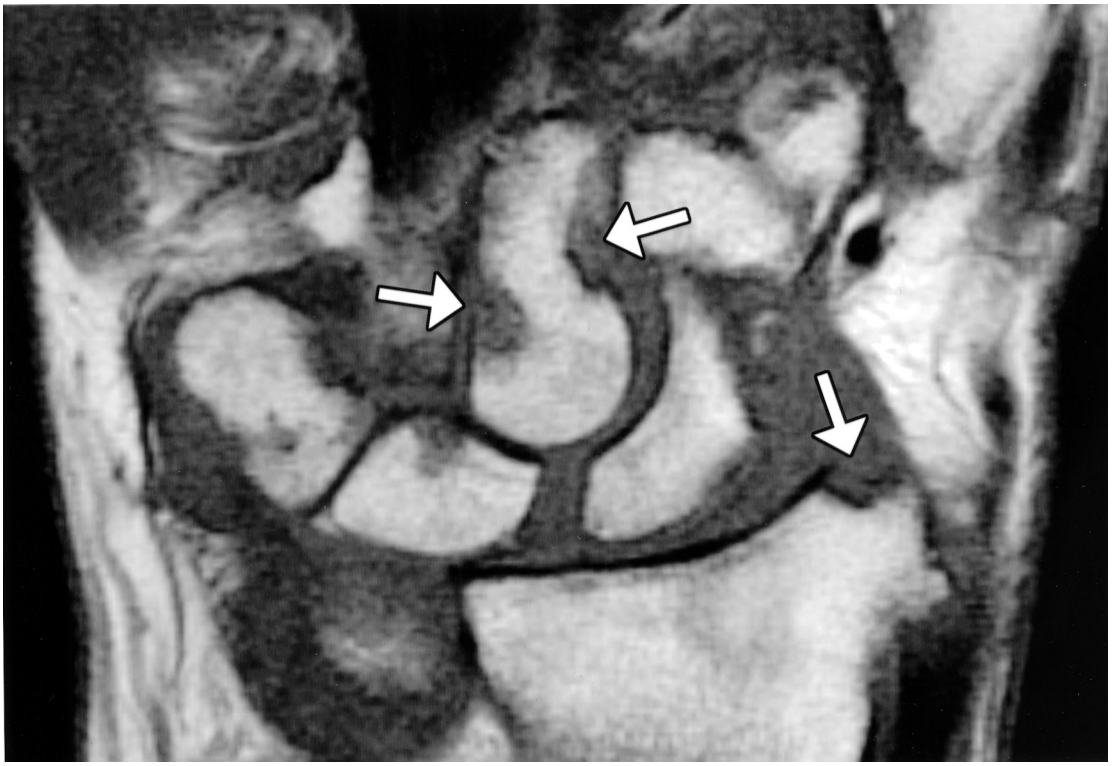
DISCUSSION

An extensive literature now exists on imaging erosions in early RA using MR[3,4,6,18]. Much less information has been published on the comparison between MR and CT in this context. Bedair, *et al*[12] reported (in abstract only) a study of 4 patients with early RA where MR imaging of the wrist was compared with CT, and concluded that MR detected an average of 74% of CT lesions. The total volume of T1 MR lesions was 4 times that of CT lesions, leading the investigators to conclude that MR tended to overestimate erosion size. This figure was reduced when multiple sequences were used. However, the study was flawed by using only 3 representative slices in a very small number of patients, and there was a high degree of interobserver variability in scoring lesions. Data from this study have since been used in an analysis of erosion volume calculated by a computer-assisted "live wire" method for delineating erosion borders[9]. A comparison of erosions at 4 individual carpal bones using CT and MR scanning revealed that there was often a "cuff" of bone marrow edema surrounding erosions as seen on MR scans, which contributed to their apparent size. However, this study used only T1 weighted MR imaging (which shows bone marrow edema as decreased signal) without T2 weighted or post-gadolinium contrast enhanced T1 weighted imaging, which would allow better differentiation of cortical erosions from surrounding bone marrow and soft tissue changes. It is therefore possible that the measured erosion sizes on MR scans were inaccurately high. The same group have reported (in abstract form) 83% concordance between CT and pre- and post-gadolinium MR for the presence of "marrow space abnormality" in 11 patients[13].

In this study we have compared CT scanning with MR for the detection of rheumatoid erosions, utilizing multiple relevant MR sequences (including T1 and T2 weighted and contrast enhanced T1 weighted sequences) that improve the recognition and delineation of erosions by this modality. Consistent with the findings of Bedair, *et al*[12], we observed that erosion scores derived from CT scans of the wrist were significantly higher than erosion scores from MR scans of the same region in the same RA patients. While lesions were identified by both modalities in 87% of cases, there was a mismatch in the remaining 13%, where lesions were twice as often identified using CT than MR. When specific sites of mismatch were analyzed, there was a trend for this to occur more commonly at the metacarpal bases compared with the distal radius and ulna.

What can be concluded about the causes of the relatively small degree of mismatch between CT and MR? We analyzed data to determine whether bone edema on MR might have been mistakenly interpreted as erosion, but there was no evidence of this, as in all instances where bone edema was detected on MR, erosions were observed on both MR and CT. In several instances it was apparent that a small erosion was simply profiled better on the specific CT slice than on the equivalent MR image (an example is shown in Figure 2). This may be because the MR slices were 3 mm thick compared to reconstructed 2.5 mm CT slices and due to the improved spatial resolution of CT within the scan plane.

Partial volume artefacts also seemed to be a frequent cause of CT/MR erosion mismatch where lesions were detected on CT but not MR. This may be due to the ability of MR to image tissues of different signal intensity, producing many more "shades of grey," ranging from the low signal of cortical bone through intermediate signal of pannus to high signal of enhancing synovium on post-contrast T1 weighted images. When 2 tissues of different signal lie adjacent to one another within the same voxel, "averaging" of the signal leads to a partial volume artefact[19]. In some cases this meant that the border of the erosion was obscured on MR. Although partial volume artefacts can also occur on CT, this modality has higher intrinsic contrast at the interface between cortical bone and adjacent soft tissue, resulting in clearer delineation of the erosion border in some instances. However, MR has the advantage over CT of being



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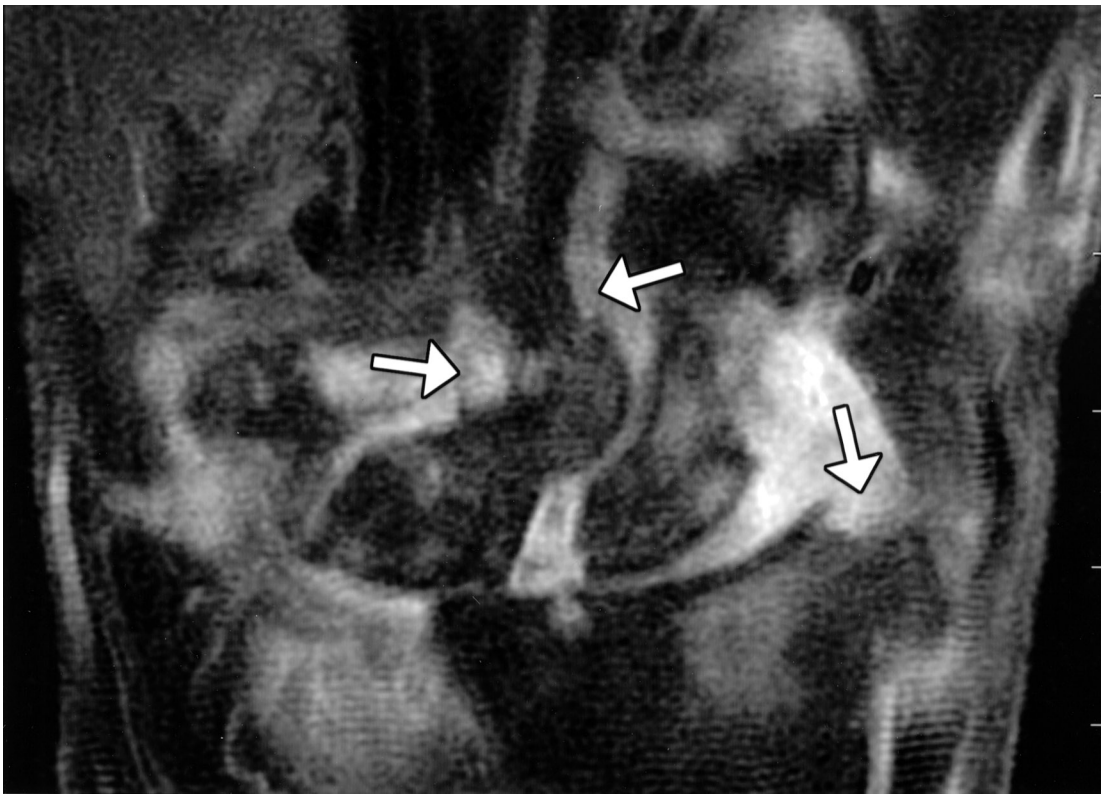

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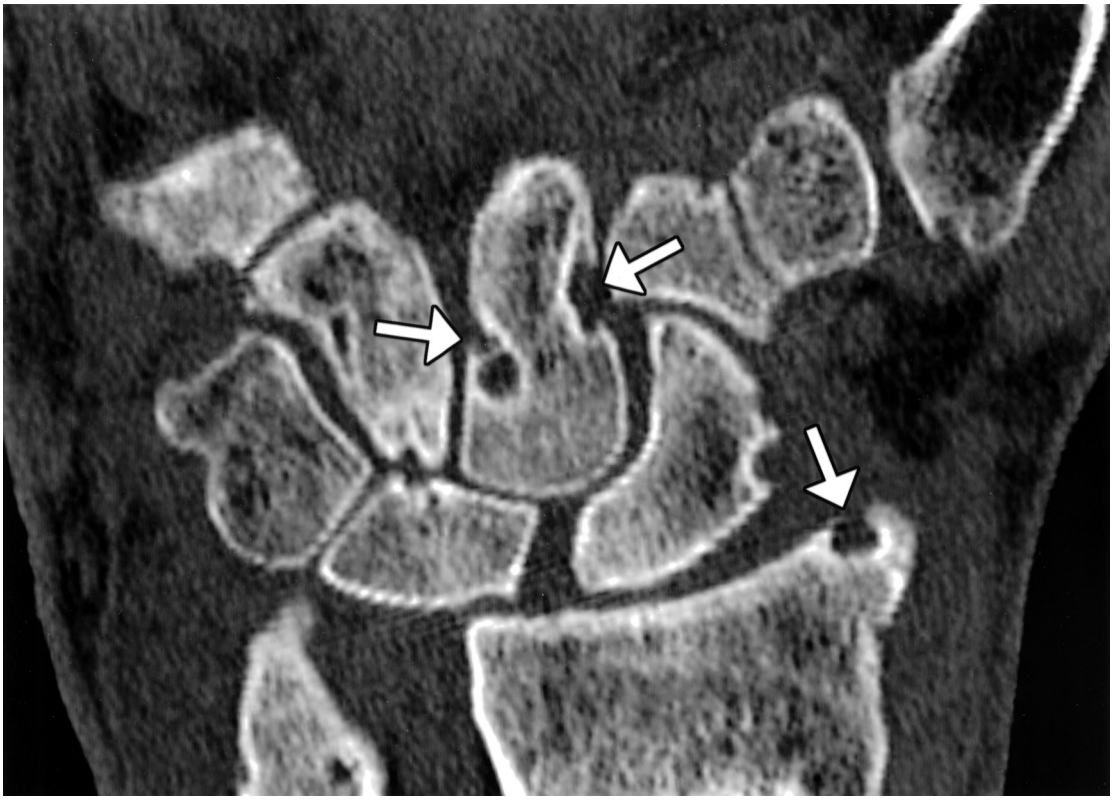

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Figure 1. Matching MR and CT erosions. A. Coronal T1 weighted MR of the wrist in a woman aged 65 years (Patient 5, Table 2), showing multiple erosions at the capitate and the distal radius (arrows). B. Post-contrast T1 weighted image revealing extensive synovitis at the radiocarpal and intercarpal joints, filling the radial erosion and adjacent to the capitate. C. Helical CT scan of a closely matched (although not identical) slice clearly showing erosions on both sides of the capitate as well as the radial lesion.

Table 2. Description of instances of erosion mismatch between CT and MR.

Patient (age/sex)	Disease Duration	Site	Interpretation
Erosion scored on CT but not MR			
1. (45/F)	6 y 2 m	4th MCB	Partial volume artefact MRI (Figure 2)
		2nd MCB	Interpretation error (CT)
2. (58/F)	6 y 1 m	Pisiform	Slice positioning, no lesion seen on MRI
		3rd MCB	Slice positioning
		4th MCB	Partial volume artefact on MRI
3. (68/F)	6 y 2 m	Pisiform	Partial volume artefact on MRI
		4th MCB	Adjacent sclerosis
		5th MCB	Partial volume artefact on MRI
4. (61/M)	6 y 4 m	Triquetrum	Partial volume artefact on MRI
		3rd MCB	Partial volume artefact on MRI
5. (65/F)	6 y 1 m	1st MCB	Interpretation error (MRI)
6. (49/F)	6 y 5 m	2nd MCB	Slice positioning, no lesion seen on MRI
Erosion scored on MR but not CT			
7. (55/M)	6 y 2 m	Hamate	Sclerosis and slice positioning
1. (45/F)	6 y 2 m	Triquetrum	Slice positioning, no lesion seen on CT
		Lunate	No cortical breach on CT, presumed cyst (Figure 3)
		Trapezium	Interpretation error (MRI)
3. (68/F)	6 y 2 m	1st MCB	Partial volume artefact on CT
6. (49/F)	6 y 5 m	Capitate	Interpretation error (CT)

MCB: metacarpal base.

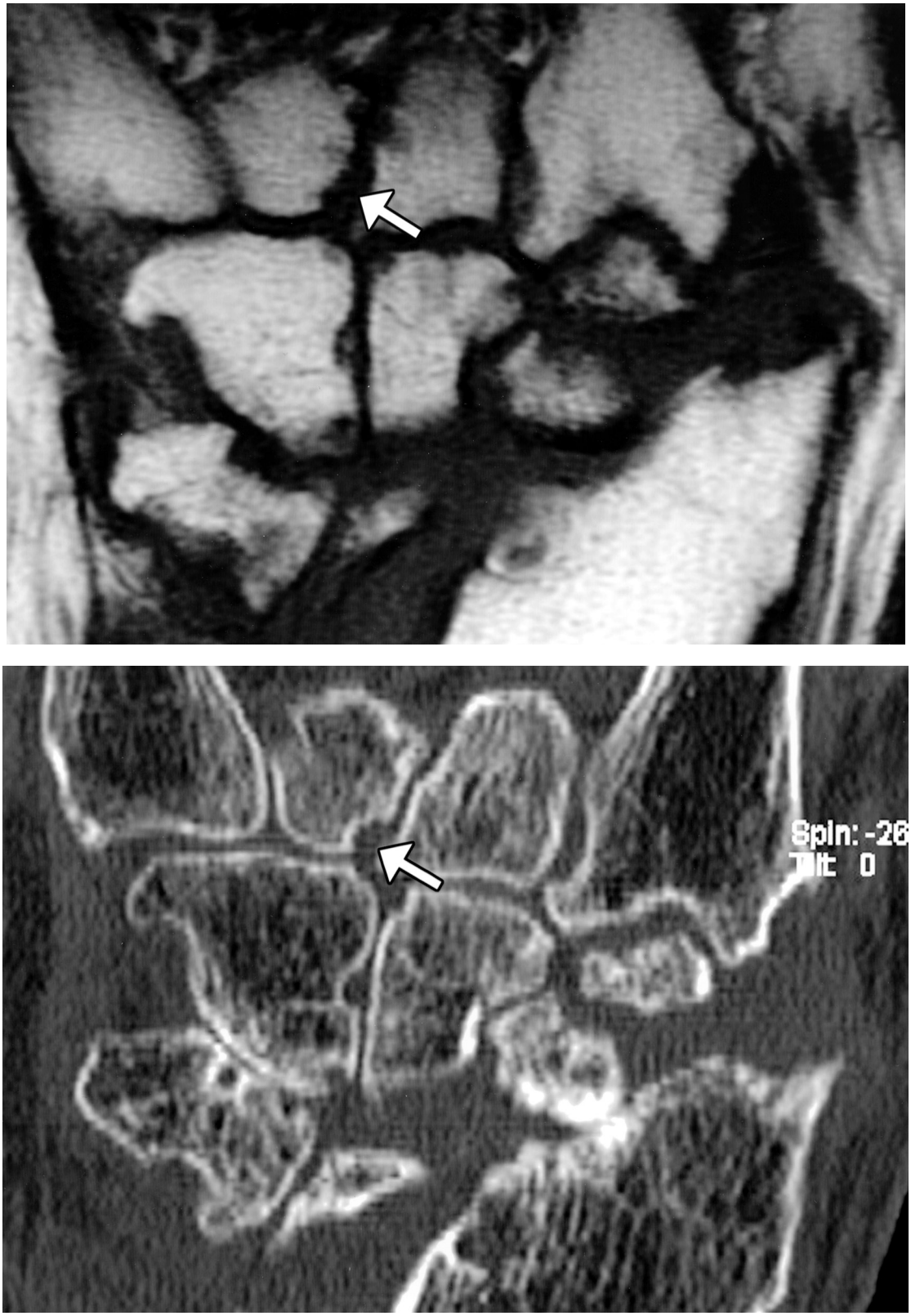
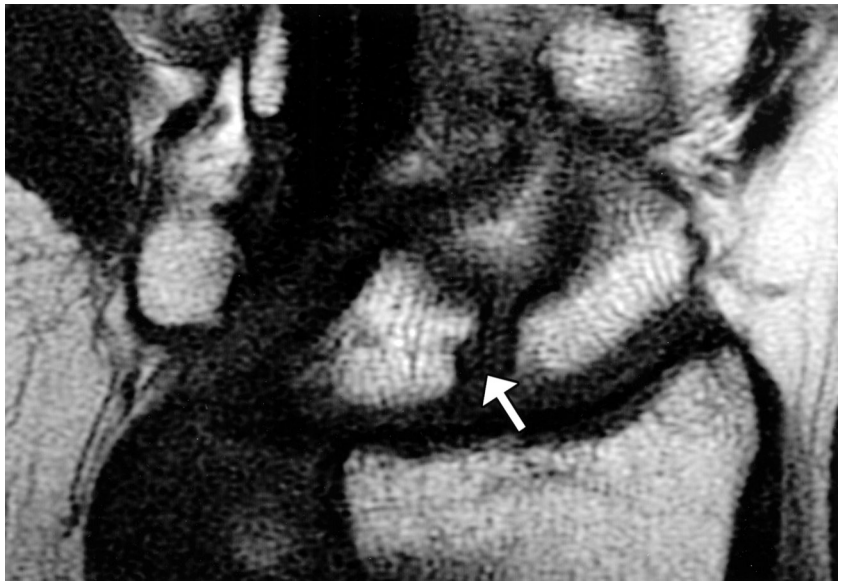


Figure 2. CT and MR erosion mismatch. A. T1 weighted coronal MR scan of the wrist in a 68-year-old woman (Patient 3, Table 2). There was no erosion scored at the 4th metacarpal base on MRI. B. The erosion can be seen clearly on the matching CT scan (arrow).



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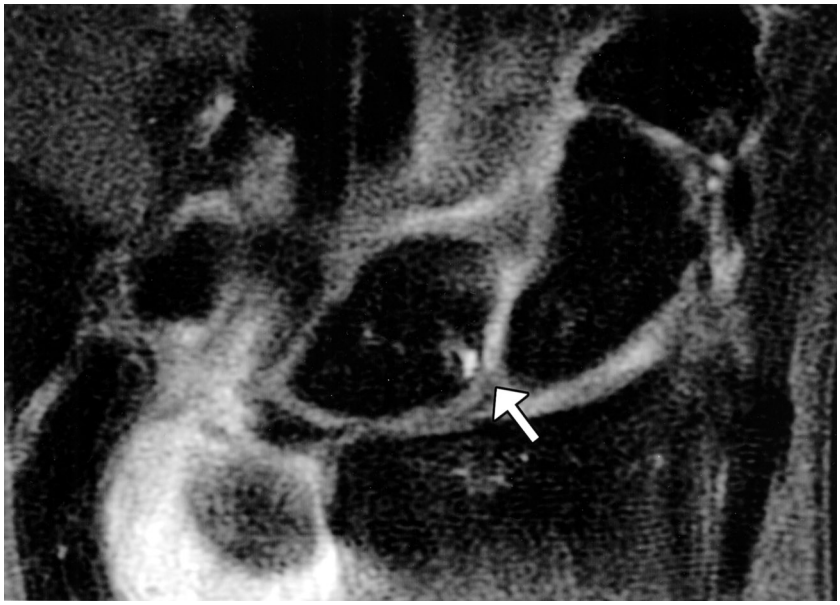

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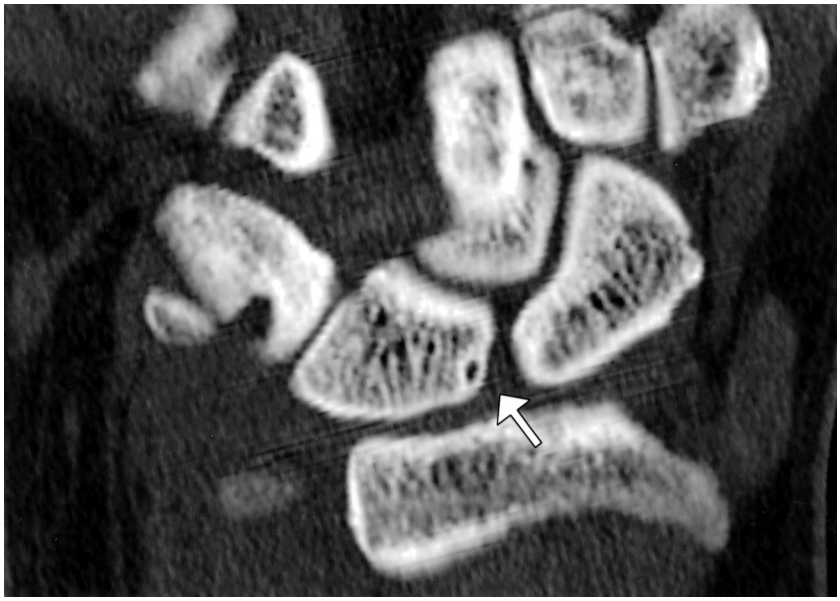
Figure 3. CT and MR erosion mismatch. A. T1 weighted coronal MR image in a 45-year-old woman (Patient 1, Table 2). An erosion was scored at the lunate (no overlying cortex). B. T1 weighted axial post-gadolinium image. The apparent erosion enhances post-contrast. C. Coronal and D. axial helical CT images reveal cortex overlying this lesion, which is therefore an intraosseous cyst on CT criteria.

able to image the contents of an erosion and identify adjacent edema to indicate whether it is "active" (contains enhancing pannus) or "inactive" (contains fibrous tissue or fat)[13].

Another feature that may have contributed to mismatch was bone sclerosis, which is clearly seen on CT but may not be as apparent on MR. When sclerosis due to the presence of dense fibrous tissue is present adjacent to an erosion, it is represented on MR by a region of low signal on all sequences. This may lead to underestimation of the size of the erosion or mask its presence altogether (Figure 4). Braun, *et al* also commented that bone sclerosis is poorly imaged by MR in a different clinical setting, that of the spondyloarthropathic spine. In their recent description of an MR-based scoring system for spinal changes in ankylosing spondylitis, they found that MR interpretation of a chronicity index (which included changes of sclerosis and syndesmophyte formation) was less reliable than the plain radiographic score[20].

In our study, both CT and MR scores correlated well and



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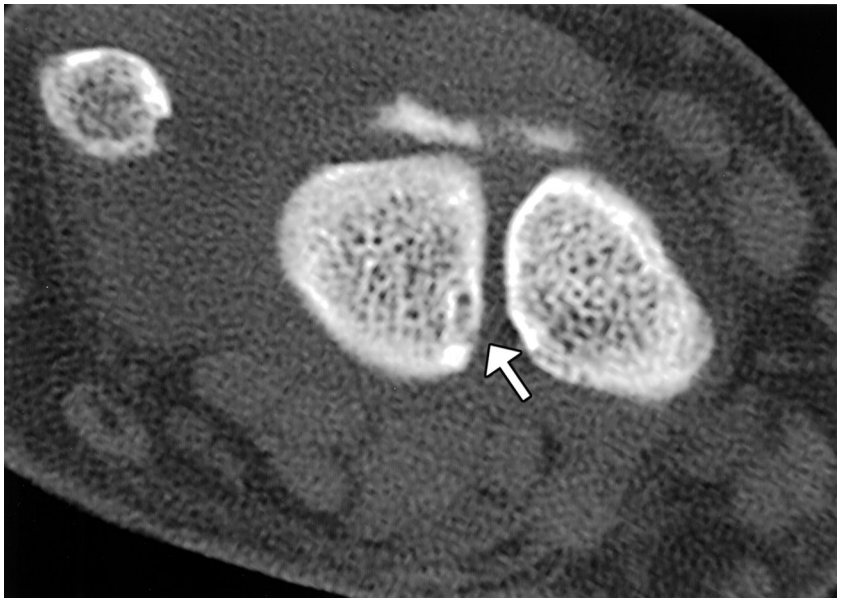

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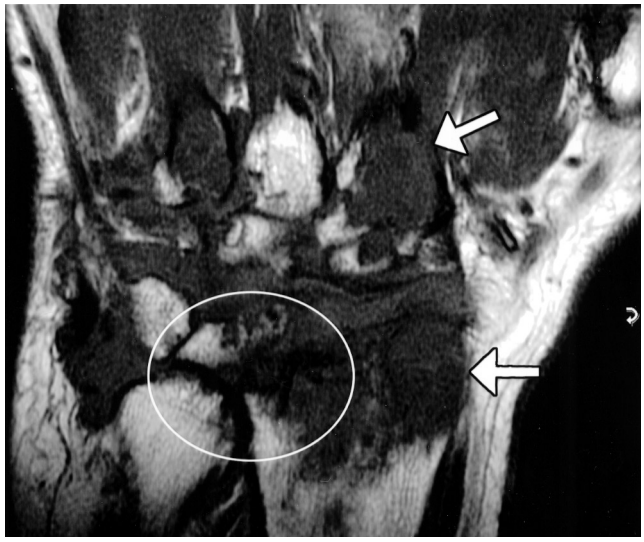
to a very similar extent with radiographic scores. As expected, significantly fewer erosion sites were detected on plain radiographs than on MR or CT scans. Ejbjerg, *et al* recently concluded that detection of MCP radiographic erosions was only possible once MRI-estimated bone erosion volumes reached 20–30% of the metacarpal head (abstract only)[21]. This is consistent with the findings of McQueen, *et al*, who reported MR erosions in 45% of patients with early RA compared with radiographic erosions in only 15%, indicating that MR has a lower threshold for the detection of small early lesions[3]. Less is published relating to CT in this context, but Yu, *et al* described a study of 30 RA patients where CT of the wrist was performed and was found to be more sensitive than plain radiography for the detection of erosions[11].

In our study, MR and CT erosion scores were also significantly and similarly correlated with the DAS, but not with function. An association between the MR erosion score and the DAS has already been reported for the larger cohort from which this group was derived[6]. In that group there was also an association between MR erosion scores and function (including both the HAQ score and the PF-SF-36) at 6 years[7]. The association between the CT erosion score and the DAS we observed has not previously been reported.

Our study has a number of shortcomings. Slice thickness on MR was 3 mm versus 2.5 mm on CT, and this may have contributed to lesions being missed on MR due to partial volume artefact. Although the total number of bony sites where CT and MR erosions were compared was relatively high (at 135), scans were available from only 9 patients and



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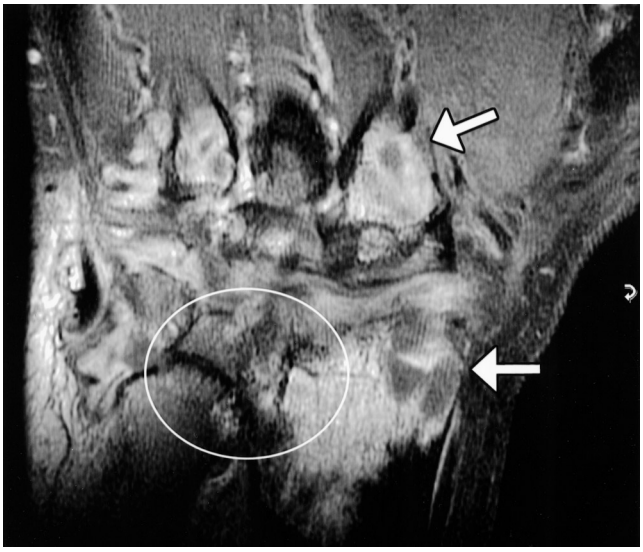

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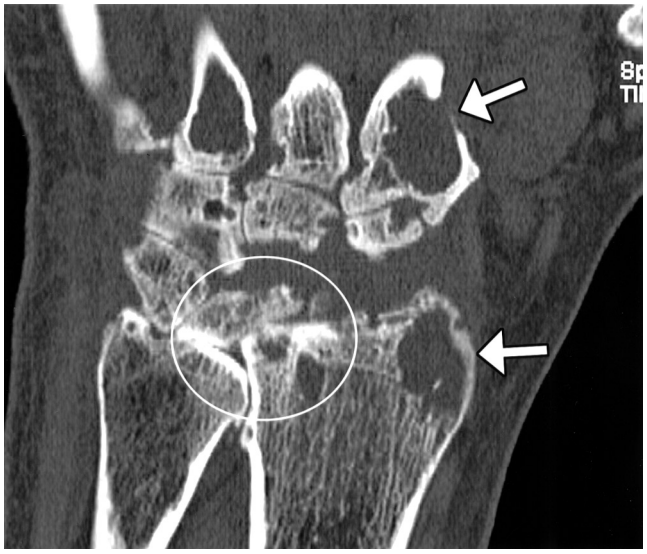


C

Figure 4. CT has better cortical detail. Comparative MR and CT scans of the wrist in a 65-year-old man (Patient 4, Table 2) showing extensive erosive change. A. On the coronal T1 weighted MR scan there is extensive low signal within the distal radius. An area of cortical sclerosis appears as a dark line (circle). Large, poorly defined erosions occupy the radial styloid process (arrow) and 2nd metacarpal base (arrow). B. T1 weighted post-gadolinium coronal image shows an enhancing trabecular pattern within the distal radius, signifying bone edema (circle). There is enhancement with areas of central low signal at the radial styloid and base of 2nd metacarpal, indicating pannus and synovial fluid within erosions (arrows). C. High resolution coronal CT of the same region shows cortical sclerosis plus a small erosion within the medial distal radius, not scored on MR (circle). A border of cortical bone is more clearly depicted adjacent to the large radial styloid erosion (wide arrow) and around the circumference of the 2nd metacarpal base erosion.

further studies of larger patient groups are warranted. Our conclusions are also only applicable to RA patients with medium-term disease (6 years from disease-onset in this group). Thus, it may not be accurate to extrapolate these findings to RA patients with very early or advanced disease. Ideally an erosion study should use a pathological gold standard against which the imaging modalities in question can be compared, but this is clearly impossible for a tissue that is as difficult to access as carpal bone[8]. It is possible that previous scoring of MR scans by the same radiologists could have influenced scoring of CT scans, but this was felt to be unlikely, as CT scans were scored on separate occasions and comparison between MR and CT scans at the time of scoring was not allowed. Finally, review of causes of mismatch involved subjective analysis by a third radiologist, introducing potential bias.

Despite these caveats we have been able to demonstrate

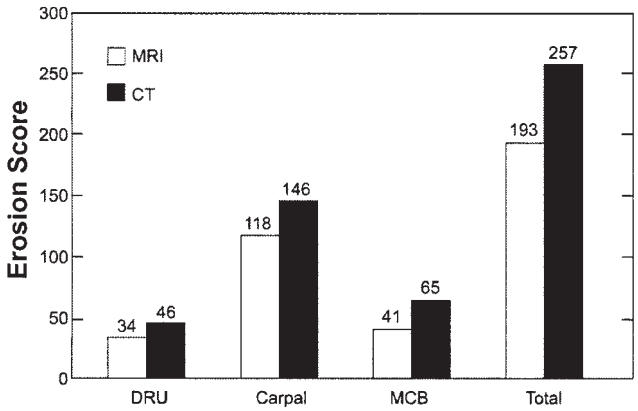
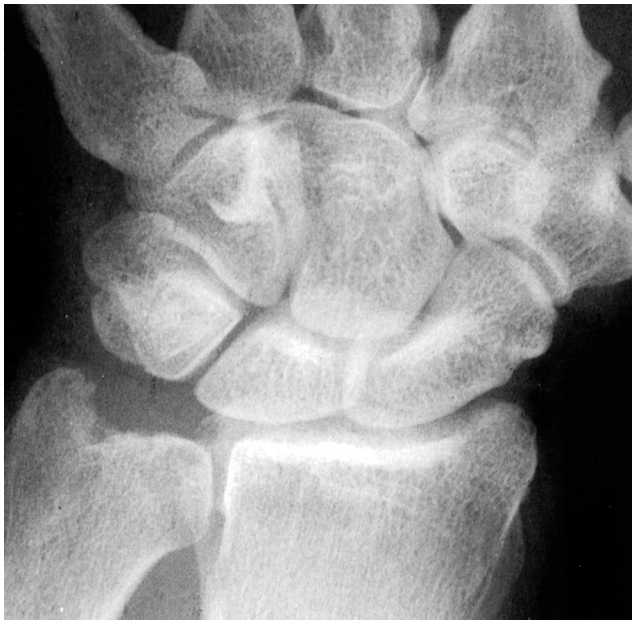


Figure 5. MRI erosion scores compared with CT erosion scores at 3 regions of the wrist. DRU: distal radioulnar joint; Carpal: radiocarpal and midcarpal regions; MCB: metacarpal bases.



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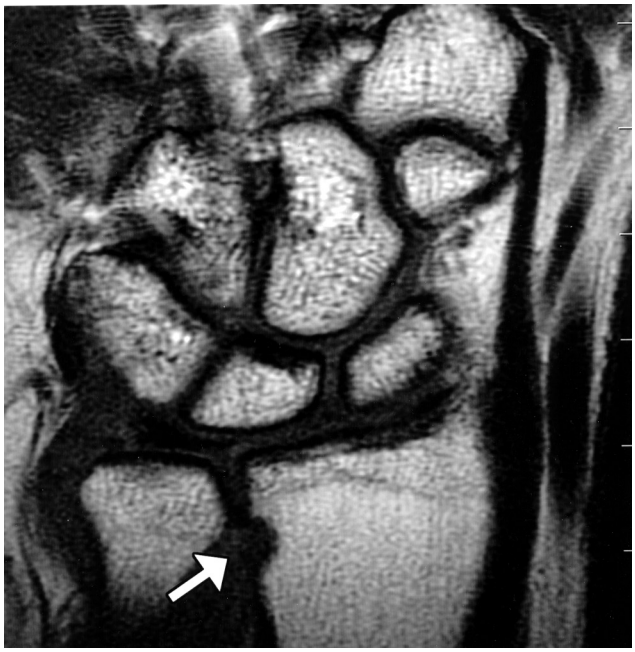

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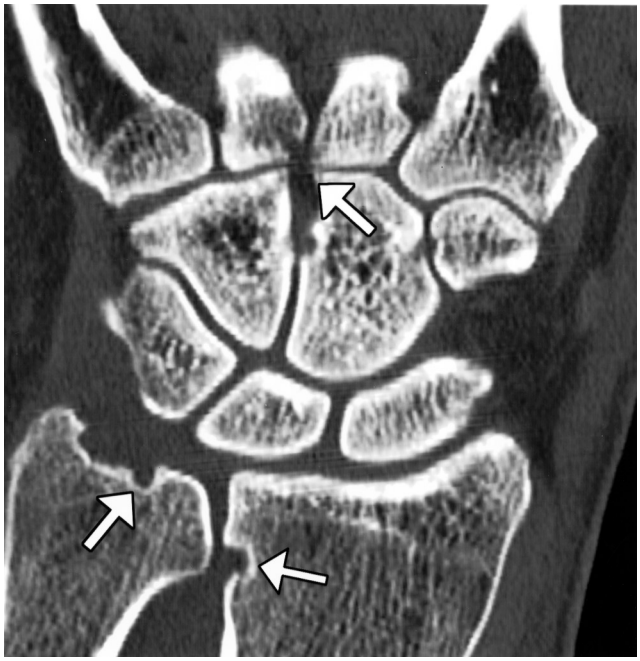

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Figure 6. Comparison of plain radiograph, MR, and CT. Erosions seen on CT and MR images are frequently not depicted on plain radiography. A. Anteroposterior radiograph of the wrist in a 45-year-old woman (Patient 1, Table 2) shows poorly defined cortex at the distal ulna. B. T1 weighted coronal MR image reveals an erosion at the distal radius. Other slices also showed erosion at the distal ulna. C. Coronal CT shows erosions at the distal radius, ulna, and also the base of the 4th metacarpal.

Table 3. Correlations between CT and MR erosion scores and clinical measures.

	MR Erosion Score R (p value)	CT Erosion Score R (p value)
Total Sharp score	0.93 (0.0002)	0.94 (0.0002)
Dominant wrist Sharp score	0.97 (< 0.0001)	0.92 (0.0004)
DAS	0.77 (0.02)	0.71 (0.03)
HAQ	0.63 (0.067)	0.55 (0.12)
PF-SF-36	–0.29 (0.46)	–0.33 (0.39)
CT erosion score	0.97 (< 0.0001)	—

Table 4. Proportion of erosion sites (see text) detected at the carpus by CT, MR, and radiograph.

Imaging Modality	Proportion of 6 Comparable Sites with Erosions	p
CT	0.574	0.021
MR	0.537	—
Radiograph	0.296	—

that excellent imaging of erosions at the wrist is achievable using both MR and helical CT scans. The good correlation between these modalities provides further validation for MR imaging in erosive disease. With advances in technology there is capacity for higher resolution using both CT and MR, with slice thickness well under 1 mm available. Due to better definition of cortical bone and more favorable spatial resolution, CT appears from this study to be slightly superior to MR as a means to score bone erosions at the carpus. In some patients with shoulder disease, the "superman" position required for the CT scan (arm over head, lying prone) may be difficult to sustain, but the total CT scan time for this study was only 3–4 minutes and none of our patients complained of discomfort. MRI does have the advantage that it

allows imaging of inflammatory change within the joint, including synovitis, bone edema, and the "activity status" of erosions. None of these can be detected using CT. These modalities should therefore be regarded as complementary to each other in the identification and quantitation of rheumatoid pathology.

ACKNOWLEDGMENT

The authors acknowledge the assistance of the following clinicians who referred patients for this study: Dr. Mike Butler, Dr. David Caughey, Dr. Nora Lynch, Dr. Alan Doube, Dr. Hamish Hart, Dr. Peter Gow, Dr. Raoul Stuart, Dr. Terry Macedo, Dr. Max Robertson, Dr. Roger Reynolds and the late Dr. Bob Grigor. We are also most grateful to the technical staff at the Auckland Radiology Group and the Auckland City Hospital, Department of Radiology, who supervised the scans.

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