Skeletal Radiol (1998) 27:244–249

ARTICLE

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MRI of fractures of the distal radius: comparison with conventional radiographs

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Abstract *Objective.* To compare the evaluation of fractures of the distal radius with MRI and conventional radiographs. To demonstrate the ability of MRI to detect unsuspected soft tissue derangement accompanying this common injury.
Design and patients. Twenty-one consecutive inpatients admitted following fracture of the distal radius underwent preoperative evaluation with both conventional radiographs and MRI. In each case, analysis was made of both the osseous and soft tissue injury. MRI findings were compared with those identified on conventional radiographs and at subsequent surgical fixation.
Results. Of 21 patients with fractures of the distal radius, 20 had extension to the radiocarpal articulation, 14 had distal radio-ulnar joint extension and 5 had avulsion of the ulnar styloid.Occult carpal bone fractures accompanying fracture of the distal radius were identified in two patients: one of the capitate and the other of the second metacarpal base. Ten patients (48%) had associated soft tissue injury: six patients had scapholunate ligament rupture, two patients had disruption of the triangular fibrocartilage, one patient had extensor carpi ulnaris tenosynovitis and one patient had a tear of a dorsal radiocarpal ligament. Of five patients with ulnar styloid avulsions, none had evidence of triangular fibrocartilage tears.
Conclusion. MRI affords better evaluation of osseous injury accompanying distal radial fractures than conventional radiographs. Intra-articular soft tissue injury accompanies distal radial fractures in almost 50% of cases. Scapholunate ligament disruption commonly accompanies intra-articular fracture through the lunate facet of the distal radius. Fracture of the ulnar styloid is infrequently associated with tear of the triangular fibrocartilage.

Key words Fracture · Distal radius · Radiograph · MRI

Introduction

Fractures of the distal radius account for one sixth of all fractures seen in the emergency room. They are a significant cause of patient morbidity, and result in a significant loss of industrial manpower hours [1, 2].

In most cases, fractures heal following simple cast fixation. Surgical fixation is undertaken when external manipulation fails to restore alignment or when extension of fracture to an articular surface is associated with significant step off, greater than 2 mm [3]. Postero-anterior (PA), lateral and oblique conventional radiographs allow accurate evaluation of bony alignment and angulation in most cases. However, being a composite representation, conventional radiographs often fail to detect subtle articular margin step off and hence limit detailed surgical planning. When diagnostic uncertainty persists or operative fixation is planned, computed tomography in direct

sagittal and coronal 2 mm planes provides optimum evaluation of articular margins and of both fracture fragment position and number [4, 5]. Although favored by orthopedic colleagues, neither modality facilitates evaluation of concomitant soft tissue injury and hence when undertaken following such imaging, the aim of surgical intervention is to restore osseous integrity alone.

Following an awareness that many patients have continuing morbidity following fracture of the distal radius, despite restoration of osseous alignment, the impact of accompanying soft tissue injury is now under scrutiny [6, 7]. In a recent prospective study, Geissler et al. [8] arthroscopically examined 60 patients with displaced intra-articular distal radial fractures and found that 41 patients (68%) had associated soft tissue injuries. Triggered by arthroscopic findings [8], this study was undertaken to compare evaluation of distal radial fractures with conventional radiographs and MRI on the premise that MRI might not only improve evaluation of osseous injury but also allow simultaneous preoperative detection of accompanying soft tissue injury.

Patients and methods

Patient inclusion

Twenty-one consecutive inpatients admitted for surgical fixation following fracture of the distal radius over a 12-month period were included for study (one patient was actually admitted for fixation of a concomitant tibial plateau fracture).

Conventional radiographs

Conventional radiographs were taken in each patient in the PA, lateral and oblique projections with standard exposure factors.

MRI

MRI was performed on a 1.5-T Philips Gyroscan NT (powertrack 1000; Philips Medical Systems, Shelton, Conn.) following placement of a plaster splint. Imaging was performed with a dedicated extremity coil, 8–10 cm field of view and 3 mm slice thickness in coronal (SE T1, STIR, FFE T2 with off-resonance magnetization transfer), sagittal (SE T1) and axial planes (SE T2) [Spin Echo (SE) T1: TE 15 ms, TR 500 ms; Spin Echo T2: TE 80 ms, TR 2000 ms; T2* Fast Field Echo (FFE): flip angle 25°, TE 15 ms, TR 500 ms; Short Tau Inversion Recovery (STIR): TI 160 ms, TE 20 ms, TR 2000 ms].

Image interpretation

Acquired images were subsequently interpreted by two musculoskeletal radiologists and a single orthopedic hand surgeon. Images from each modality were read at two sessions, the readers being unaware of findings of the complementary modality. In each case documentation was made of the extent of the fracture, extension to radiocarpal and radioulnar joints, articular margin step off, and presence or absence of ulnar styloid fracture. Note was also made of soft tissue injury at MRI, specifically the presence or absence of scapholunate ligament or lunatotriquetral ligament disruption, and of the presence or absence of triangular fibrocartilage tear. Discrepancy in interpretation was resolved by consensus.

Gold standard

Correlation was made with CT scans (7 cases) and findings at surgical intervention.

Results

There were seven women and 14 men, of mean age 38 years (range 23–59 years).

Osseous injury: conventional radiography versus MRI

Of 21 patients with distal radial fractures, 18 presented with displaced fractures (dorsal tilt and displacement) and three presented with undisplaced fractures. Conventional radiographs revealed extension to the radiocarpal articulation in 17 cases: extension to the radiocarpal articulation was identified in 20 patients at MRI. Extension to the distal radioulnar joint was identified in 11 cases on conventional radiographs and in 14 cases at MRI (Fig. 1). Five patients had ulnar styloid fractures (identified on both conventional radiographs and at MRI), one patient had a concomitant fracture of the scaphoid waist (identified by both modalities), and two patients had undisplaced occult fractures (not detected on conventional radiographs) of the capitate and of the base of the second metacarpal. Direct sagittal MR images allowed clear visualization of the relative volar or dorsal angulation of the distal radial articular surface in each case, however, recorded angulation correlated with recorded angulation on conventional radiographs in each case.

In seven patients, no discrepancy was observed between osseous evaluation (fragment number and position, angulation and articular margin step off) at MRI and additional CT.

Soft tissue injury: conventional radiography versus MRI

MRI demonstrated soft tissue injury in ten patients (48%), including six with scapholunate ligament rupture (Fig. 2), two with acute tears of the triangular fibrocartilage complex (TFCC) (Fig. 3), one with extensor carpi ulnaris tenosynovitis and one with a tear of a dorsal radiocarpal ligament.

Widening of the scapholunate interspace was identified in five of the six patients with scapholunate ligament disruption on conventional radiographs suggesting the diagnosis prior to MRI; however, in one patient the diagnosis was unsuspected and in one other the scapholunate ligament was noted to be intact despite radiographic widening. In each of the affected patients, the scapholunate lig-

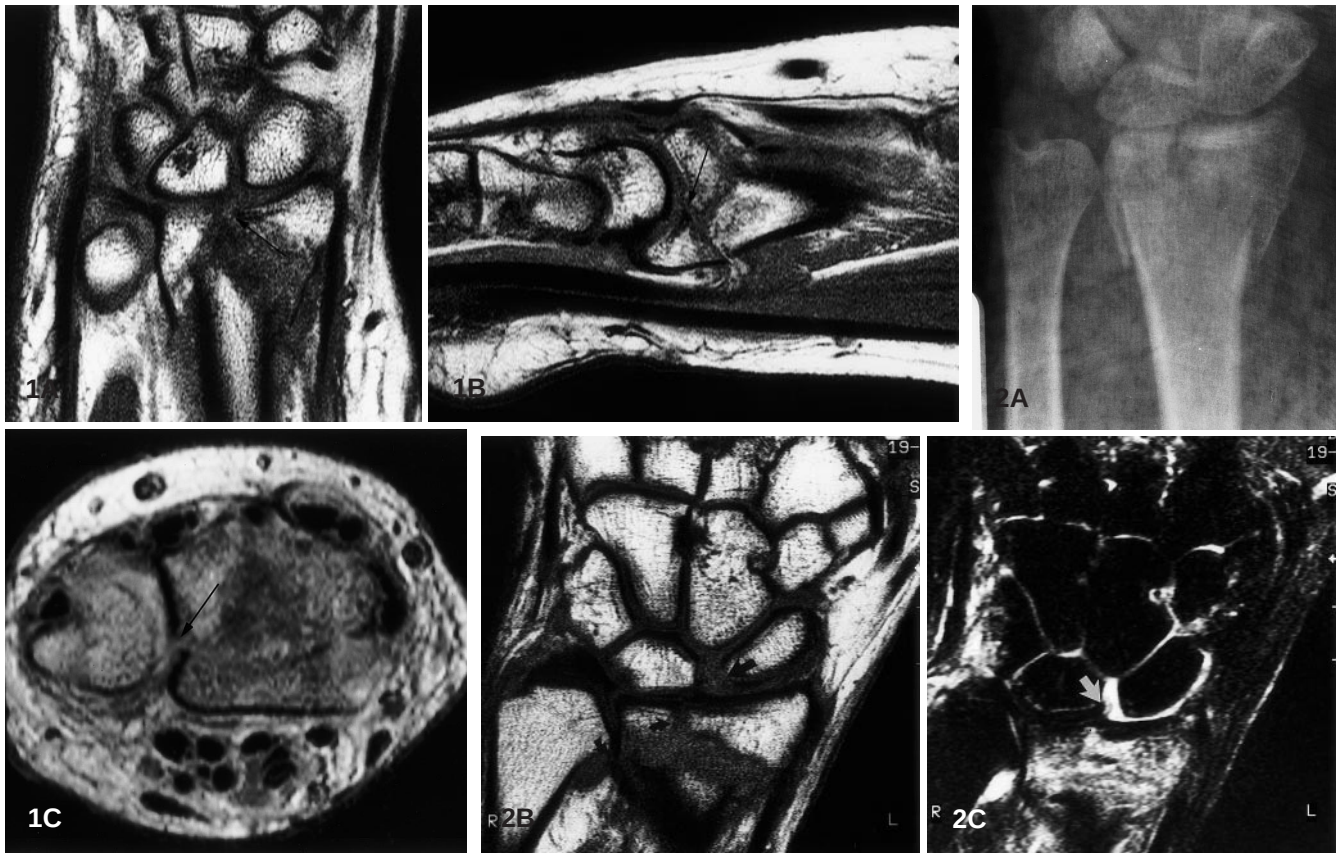

Fig. 1 **A** Coronal T1-weighted SE image (TE 15, TR 500) shows a comminuted impaction fracture of the distal radius, with intra-articular extension to the junction of the scaphoid and lunate facets (*arrow*). **B** Sagittal image shows impaction, and intra-articular extension (*arrow*) with neutral angulation. **C** Axial image shows undisplaced intra-articular fracture to the distal radioulnar joint (*arrow*)

Fig. 2 **A** PA radiograph (through plaster cast) shows comminuted intra-articular fracture of the distal radius with radiocarpal extension to the lunate facet. **B** Coronal T1-weighted SE image (TE 15, TR 500) shows radiocarpal extension without significant step off (*small arrow*). Note is made of unsuspected scapholunate ligament disruption (*arrow*). **C** Coronal STIR image (TI 160, TE 20, TR 1800) confirms radiocarpal joint extension to the lunate facet. Note is made of scapholunate ligament billowing within radiocarpal joint fluid (*arrow*). The lunate attachment is intact; the ligament is avulsed from its scaphoid insertion

Fig. 3 Coronal spin echo T1-weighted image (TE 15, TR 500) shows impaction fracture of the distal radius with associated complex tear of the triangular fibrocartilage (TFCC; *arrow*)

ament was avulsed from its scaphoid insertion. None of the five patients with ulnar styloid avulsions had evidence of TFCC tears (Fig. 4). All six patients with scapholunate tears had fractures extending through the lunate facet of the distal radius.

Surgical findings

Closed reduction, which included joint distraction by an external fixation device prior to restoration of articular congruity and K wire fragment fixation, was undertaken

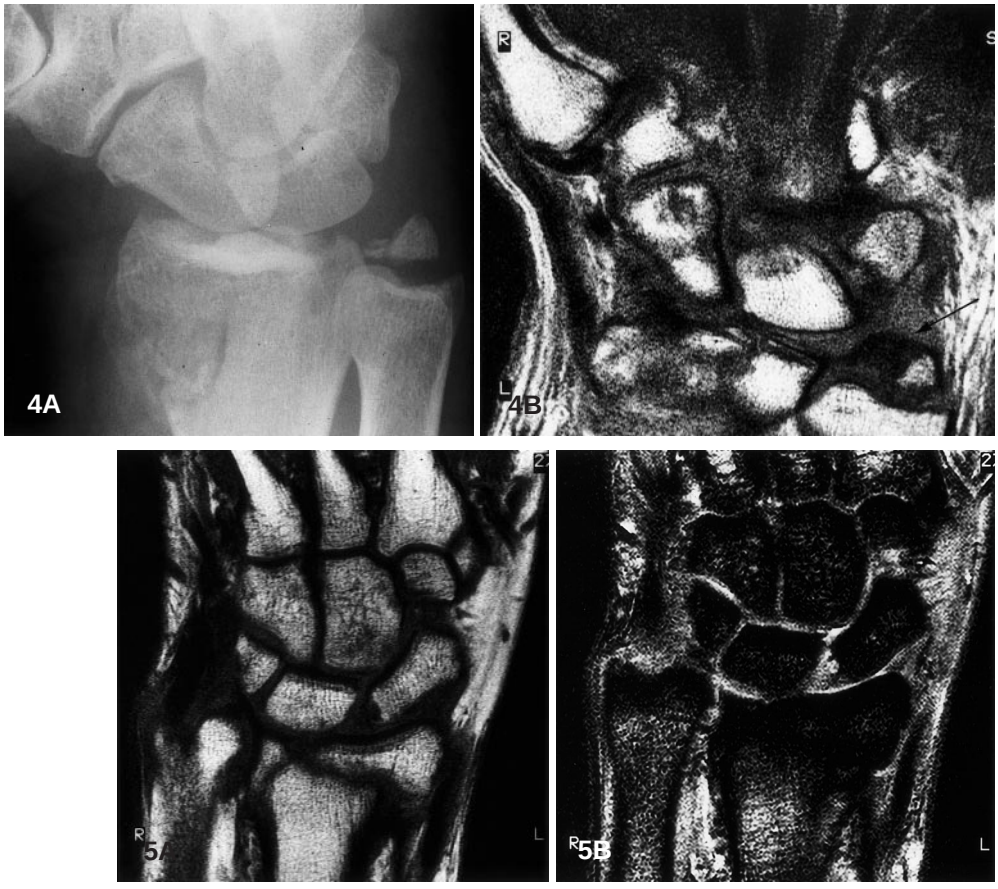

Fig. 4 **A** PA radiograph shows a comminuted intra-articular fracture with associated displaced fracture of the ulnar styloid. **B** Coronal T1-weighted spin echo image (TE 15, TR 500) shows buckling of an intact TFCC attached to the ulnar styloid and distal radius (*arrow*)

Fig. 5 **A** T1-weighted spin echo coronal image (TE 15, TR 500) shows a healing impaction fracture with three well-defined fragments. **B** Coronal T2-weighted gradient echo (fast field echo) image (TE 30, TR 500) of same patient shows impaction and foreshortening of the distal radius. Fracture margins are obscured by susceptibility effects at trabeculae, fatty marrow and air interfaces

in all but three patients. Surgical intervention was undertaken in five of the 21 patients in whom conservative management had been planned following review of conventional radiographs (3 intra-articular fractures, 1 scapholunate ligament disruption, 1 tear of TFCC). Joint arthroscopy confirmed tear of the TFCC in one patient.

Open exploration and primary repair of the disrupted scapholunate was performed in one patient. Dorsal capsulodesis (Blatt procedure) was performed in one patient with scapholunate ligament disruption. Expectant management of scapholunate ligament disruption was undertaken in four cases. Arthroscopy confirmed TFCC complex disruption in one patient (Fig. 3).

Discussion

The surgical treatment of distal radial fractures has altered considerably since the earliest descriptions of these fractures, based on clinical examination, by Colles and Smith in the early 1800s. Although intervention is dictated by the severity of the fracture and by the functional requirements of the affected patient, operative reduction is usually undertaken if a fracture has resulted in significant displacement of bone fragment or greater than 2 mm articular margin step off. Despite surgical intervention, complications and morbidity following this common injury remain significant.

Cooney et al. [9] reported complications in 31% of a large retrospective series of 565 patients with fractures of the distal radius, including median nerve dysfunction, tendon and ligament rupture, carpal instability, avascular necrosis, and radiocarpal and distal radioulnar joint arthritis [10]. Trumble et al. [11] analyzed functional outcome in patients following displaced intra-articular distal radial fractures and found that, despite restoration of anatomic alignment and articular congruity, grip strength averaged only 69% and range of movement only 75% that of the opposite side following fracture of the distal radius. While recognizing that restoration of skeletal integrity is crucial, several authors believe that associated soft tissue injuries may explain why such patients continue to have reduced grip strength, reduced range of movement and pain despite anatomically healed fractures [6, 7].

Traditionally radiologists have advocated the use of CT to supplement conventional radiographic evaluation of fractures on the premise that 2 mm slices afford improved spatial resolution and hence evaluation of both fragment position and articular margin integrity. The multiplanar thin slice imaging afforded by MRI represents

an alternative to CT, in this study affording equivalent evaluation of bone to CT scan in seven patients in whom both techniques were performed. When undertaken for this purpose, FFE (Philips Medical Systems) sequences should be interpreted with caution (Fig. 5). Lack of a refocusing pulse, in effect the creation of an echo by gradient reversal, allows signal distortion by magnetic susceptibility differences between osseous and marrow components. These susceptibility effects are particularly marked on long TE (or T2-weighted) FFE or GE sequences, as are often used to evaluate soft tissue structures within the radiocarpal joint space. Although such differences may rarely enhance fracture conspicuity, equally frequently the resulting susceptibility effects lead to obscuration of fractures (Fig. 1).

Previous studies have emphasized the limitations of conventional radiographs in evaluating osseous injury, emphasizing the need for additional imaging. Doczi and Renner [12] found that conventional radiographs failed to detect 39 of 626 fractures of the distal radius at the first examination. In this study, MRI afforded either equivalent or improved osseous evaluation in each of the 21 patients, imaging in contiguous 3 mm thin slices allowing detection of radiocarpal extension in three patients at MRI alone, in each case leading to surgical intervention and fixation. In a further three patients distal radioulnar joint extension was identified that had not been recognized despite retrospective review of conventional radiographs. Although existing imaging costs and availability of scanners mitigate against routine use, surgical intervention was undertaken in five of the 21 patients following MRI in whom conservative management had been planned following review of conventional radiographs (3 intra-articular fractures, 1 scapholunate ligament disruption, 1 tear of TFCC). Although it would be inappropriate to define indications for MRI of distal radial fractures on the basis of this experience in a small group of patients, it is clear that, when employed, MRI frequently improves interpretation of the extent of the underlying injury. Deployment of emergency room scanners (including low field extremity units) paralleled by dramatic reductions in acquisition times may lead to routine use of MRI in this setting in the future.

This study, similar to that of Geissler et al. [8], confirms that soft tissue injury frequently accompanies distal radial fractures. It is recognized that conventional radiographs allow the detection of scapholunate ligament disruption in most cases on the basis of well-described radiographic signs (widening of the scapholunate interspace greater than 4 mm, volar tilt of the scaphoid, dorsal tilt of the lunate). Nevertheless, it is only using MRI that direct visualization of the soft tissue injury may be achieved. Scapholunate ligament rupture was identified in 28% (6/21) of our patients, and although the diagnosis was suspected in five of six patients prior to MRI, the diagnosis was only confirmed at MRI (Fig. 2). Equally relevant, one patient with a widened scapholunate interspace greater than 4 mm was noted to have an intact ligament at MRI.

Conforming to the mechanism of injury postulated by Mudgal and Jones [13] (as the lunate is driven proximally, a shearing stress is imposed on the scapholunate ligament), each case in our study was associated with fracture through the junction of the lunate and scaphoid articular facets of the distal radius. In each case, the scapholunate ligament was avulsed from its scaphoid rather than its lunate insertion. In effect, even if MRI is not to be undertaken, identification of radiocarpal joint extension through the lunate facet on conventional radiographs should trigger some concern for scapholunate ligament integrity.

Although no lunatotriquetral tears were identified in our patients at MRI, it is conceivable that this injury may have been missed, as it is recognized that these tears are difficult to appreciate at MRI [14].

Injuries to the TFCC are relatively common in patients with distal radial fractures, with reported rates of 45–66% [6, 7]. Unlike ligamentous disruption, conventional radiographic evaluation of the TFCC is unhelpful unless there is either wide diastasis or dislocation at the distal radioulnar joint, and its evaluation can therefore only be achieved by either arthrography, arthroscopy or MRI. MRI has a reported diagnostic accuracy in this role of 95% [14, 15].

In contrast to published results, TFCC tear was identified in only two of our 21 patients, in both cases accompanying impaction fractures (Fig. 3). Although Mohanti et al. [7] reviewing soft tissue injury accompanying distal radial fractures concluded that a tear of the TFCC occurred more commonly in association with a fracture of the ulnar styloid process, no tear was identified in five patients in our study with fracture at this site (Fig. 4).Since most distal radial fractures occur in the elderly, it is important to differentiate age-related degenerative changes from acute tears when this diagnosis is being made [16].

In summary, this preliminary experience suggests that MRI affords better evaluation of osseous injury accompanying distal radial fractures than conventional radiographs and that in almost 50% of cases identifies concomitant soft tissue injury. Scapholunate ligament disruption appears commonly to accompany intra-articular fracture through the lunate facet of the distal radius; unlike previously published data, in our series fracture of the ulnar styloid was infrequently associated with tear of the TFCC.

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