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ORIGINAL STUDY

The value of delayed MRI scans in the assessment of acute wrist injuries

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The aim of this study was to better quantify the role of delayed MRI scans in acute wrist injuries, and to assess the prevalence and distribution of multiple occult injuries of the wrist.

A retrospective study was made of all patients who had been referred to the orthopaedic trauma clinic for a possible scaphoid fracture and with normal radiographs over a two year period. There were 110 patients. Patients were initially treated conservatively with a scaphoid cast or a futura splint for two weeks. This was then removed and the wrist examined and further radiographs taken. The patients with normal radiographs who had positive clinical findings for a scaphoid fracture at two weeks or persisting pain at six weeks had an MRI scan. MRI was performed with and without fat saturation sequences.

A total of 110 wrists were analysed. Twenty-eight (25.4%) were reported as normal ; 24 patients (21.8%) had occult bone fractures. Three (2.7%) had scaphoid fractures diagnosed by MRI scans. There were nine (8.1%) distal radius, two trapezium and five hook of hamate fractures. Bone bruising was seen in 12 (10.9%). Carpal degeneration was seen in ten and a TFC tear was noted in five (4.5%). Other findings were a ganglion in 14 (12.7%) and three (2.7%) had Kienbock's disease.

The MRI scan is a useful tool in obtaining a definite diagnosis in acute wrist injuries. Among other findings, an occult scaphoid fracture was diagnosed on MRI in 2.7% of cases in this study. To conclude, in the majority of patients with persisting symptoms after two weeks following a wrist trauma, the cause of symptoms was pathology in other tissues in the wrist including soft tissues, other carpal bones and distal forearm.

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Keywords : MRI ; delayed ; wrist injuries ; scaphoid fractures.

INTRODUCTION

Nonunion and secondary osteoarthritis are well documented sequelae of a 'missed' scaphoid fracture (*1,14,15,20,26*). Various studies suggest that patients with a history of acute wrist trauma, clinical signs of a scaphoid fracture but no evidence of fracture on plain radiographs, may have a fracture in up to 25% of cases (*4,5,10*).

Up to 25% of scaphoid fractures can be missed on initial radiographic evaluation. Some studies have suggested that repeat radiographs at two weeks are unlikely to demonstrate a fracture : fractures can

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take up to six weeks to become evident on plain films (*22*). It is therefore common practice to immobilize the wrist for six weeks when there is clinical suspicion of a scaphoid fracture with normal radiographs. This is the so-called ''clinical'' scaphoid fracture (*7,27*). These patients have further clinical and radiological review at intervals until definitive diagnosis or resolution of symptoms. This may result in overtreatment of patients without fracture and many additional and unnecessary outpatient visits. Moreover, the frequency of false-positive clinical diagnoses (25-100%), promotes therapeutic uncertainty.

The MRI appearance of proven scaphoid fractures was described in the early 1990s (*22*). Subsequently several small series of early MRI in cases of clinical scaphoid fracture have shown promising results (*2,3,9,10,12,13,22,23*).

MR imaging is both sensitive and specific to other occult osseous injuries (*11,22*). We conducted a retrospective study of the usefulness to detect and exclude occult scaphoid fractures in patients with normal or equivocal findings on radiographs. Our study also assessed the prevalence and distribution of occult injuries of the carpal bones, distal forearm bone & soft tissue injuries. Obtaining a definitive diagnosis in the patients with ongoing wrist symptoms following acute trauma is also taken in to consideration.

MATERIALS AND METHODS

A retrospective analysis of 110 patients over a period of two years was carried out. All patients referred to trauma clinic with a suspected scaphoid fracture but normal radiographs were included.

All had an initial period of conservative treatment either with a scaphoid cast or a futura splint for two to six weeks before they were referred for a MRI scan. The inclusion criteria were :

1. The patients who had persisting symptoms in the nature of pain and tenderness despite immobilisation.
2. Patients with normal radiographs (scaphoid views)

There were 72 males and 38 females. The age range was 13 to 71 years (average 35.14 years).

The right side was involved in 56 cases (50%) and two cases were bilateral. The dominant side was affected in 61 (55%) cases ; in 16 patients (15 %) the dominant side was not documented.

Conventional radiographs were taken in the posterior-anterior (PA), lateral views & additional scaphoid bone series were performed. All images were interpreted by a senior musculoskeletal radiologist.

MRI was performed with and without fat saturation sequences. The MR images were analyzed for detection of occult trabecular contusions and cortical discontinuity in the carpus, the distal forearm, intercarpal ligaments and metacarpal bases.

MRI

All MRI examinations were performed on a 1.5-T magnet (Intera, Philips) with a dedicated small extremity flex coil. A limited protocol examination was performed to include :

Coronal STIR (2.5 mm thick images TE 60 TR2500)
Coronal T1 SE (2.5 mm thick images TE16 TR490)
Axial T2TSE (2.5 mm thick images TE 100 TR 4043).

The combination of sequences chosen was considered appropriate not only for demonstration of scaphoid fractures, but also for demonstration of other pathologies which might be considered relevant to symptoms. Overall scanning time was approximately 15 minutes.

The following criteria were used for the evaluation of MR images :

A trabecular/cortical fracture line was considered diagnostic for fracture. Diffuse or patchy marrow oedema was considered to be bone contusion (bone bruise) and was not classified as a fracture. The MR images were evaluated by a musculoskeletal radiologist.

RESULTS

A total of 110 wrist MRI scans were analysed. Twenty-four scans demonstrated (21.8%) occult bone fractures. Among these 24, only three patients (2.7%) had scaphoid fractures diagnosed by MRI scans. Seventy-two patients (65%) had incidental findings in the MRI scan. More than one finding was made in 12 patients (11%). A detailed breakdown of results is given in table I.

Table I. — Findings of MRI scans

MRI Result	No.	MRI Result	No.
Normal	28	Scaphoid fracture	3
Ganglion	14	Ulna & ulna styloid	1
Bone bruising	12	Kienbock`s disease	3
Tenosynovitis	11	Trapezium fracture	2
Distal radius fracture	9	Capitate fracture	2
Carpal degeneration	10	Triquetrum fracture	1
TFC tear	9	DRUJ dissociation	1
Hamate fracture	5	Metacarpal fracture	2

DISCUSSION

It is known that failure to diagnose and treat scaphoid fractures increases the non-union rate. Alternatively exclusion of a scaphoid fracture may allow earlier rehabilitation and return to function.

There are three important statistical considerations in determining the accuracy of an investigation : sensitivity (the true negative test ratio) ; specificity (the true positive test ratio) ; and reliability (the inverse relation of interobserver variation).

Studies have shown plain radiographs to have a low accuracy in the diagnosis of clinical scaphoid fracture. Tiel-van Buul *et al* (*22*) assessed reliability of reporting of scaphoid radiographs. Four observers of varying experience reported 134 radiographs taken at one day, two weeks and six weeks post trauma. In all combinations of observers at each time interval, reliability was poor with a kappa value of less than 0.4. The authors concluded that, as a kappa value in excess of 0.6 is required for an investigation to be deemed reliable, plain radiograph should not be used as the gold standard investigation of clinical scaphoid fracture.

Isotope bone scanning in clinical scaphoid fracture has been shown to be highly reliable and to have sensitivity approaching 100% ; however specificity is less good with two large series (*1,26*), both finding a false positive rate of 25% when compared with delayed radiographs.

CT for clinical scaphoid fracture has a low sensitivity. Tiel-van Buul *et al* (*24*) found that CT missed 21% of occult scaphoid fractures on a single read and 16.7% on a double read.

Studies have suggested MRI to be the most accurate investigation for the detection of occult scaphoid fractures (*11,12,18*). Statistical assessment of MRI of the wrist in clinical scaphoid fracture has been performed. Those studies that have assessed sensitivity and specificity of MRI against delayed radiographs have revealed excellent results. Gaebler (*10*) reported sensitivity and specificity for scaphoid fractures of 100%, Hunter *et al* (*12*) reported 100% sensitivity and Breitenseher *et al* (*2*) reported 100% specificity, 100% sensitivity for one reader and 100% specificity, 95% sensitivity for a second reader.

Reliability of MRI has also been addressed. Breitenseher *et al* (*2*) reported a kappa value of 0.953, Bretlau *et al* (*3*) reported a kappa value of 0.8 and Hunter *et al* (*12*) reported kappa values for each imaging sequence used of 0.87 (STIR), 0.96 (proton density weighted) and 0.96 (T1 weighted). These figures are well in excess of the 0.6 kappa value regarded as satisfactory for an investigation to be deemed valid (*23*). All but one of the small published studies (*3*) used a 1.0 T or 1.5 T body scanner with a surface coil and three imaging sequences. We used a dedicated extremity low field MRI scanner with a two sequence imaging protocol (coronal STIR and T1 SE).

Breitenseher *et al* have also analysed the sensitivity of three imaging sequences (T1 SE, STIR and T2* gradient echo (GE) (*2*). The T2* GE sequence was the least sensitive for trabecular fracture lines (47%), cortical fracture lines (14%) and bone marrow oedema changes (59%). The STIR sequence had a sensitivity of 88%, 100% and 100%, respec-

Table II. — Previous studies of MRI scans following acute wrist injuries

Study	Subject number	Scaphoid	Distal Radius	Hamate	Capitate	Triquetrum	Trapezium
Breitenseher *et al*, 1997 (*2*)	41	14 (34.1%)	2 (4.9%)	0	4	1	1
Hunter *et al*, 1997 (*12*)	36	13 (36.1%)	9 (25%)	0	0	0	0
Kukla *et al,* 1997 (*13*)	25	8 (32%)	2 (8%)	1	1	0	0
Bretlau *et al,* 1999 (*3*)	47	9 (19.9%)	6 (12.8%)	0	1	2	0
Gaebler *et al,* 1996 (*10*)	32	6 (18.8%)	3 (9.4%)	0	2	0	0
Teil-van Buul, 1996 (*23*)	16	5 (31.2%)	0	0	0	0	0
Gaebler *et al,* 1998 (*9*)	60	8 (13.3%)	*	*	*	*	*
Brydie *et al*, 2003 (*4*)	195	37 (19%)	28 (14.4%)	1	2	2	1
Cumulative totals	452	100 (22.1%)	51 (11.2%)				
Our study, 2010	*110*	*3 (2.7%)*	*9 (8.1%)*	*5*	*2*	*1*	*2*

*- unspecified 23.

tively, for the above abnormalities, the corresponding T1 SE sensitivities were 88%, 21% and 100%. The authors concluded that the combination of T1 SE and STIR sequences, as used in the current study, had the highest sensitivity for demonstration of fracture.

Beer *et al* in 2006 concluded that bone scintigraphy in combination with physical examination is the gold standard for patients with signs of a scaphoid fracture that cannot be proven on scaphoid radiographs (*6*).

Beer *et al* in a later study (*5*) stated that early MRI vs Bone scan on suspected scaphoid fractures did not confirm that early, short-sequence MRI was superior to bone scintigraphy for the detection of suspected scaphoid fractures. They concluded that, despite the radiation dose, bone scintigraphy remains the investigation of choice in the diagnosis of clinically suspected scaphoid fractures where plain radiographs have been unhelpful.

A study done by Brydie *et al* (*4*) was the first study reported on the findings obtained in a working clinical setting rather than in a research setting. In their group of patients with a "clinical scaphoid fracture", MRI of the wrist performed within 14 days of injury demonstrated a radiographically occult scaphoid fracture incidence of 19% with an overall fracture detection incidence of 38%. There were seven other smaller published studies of MRI within two weeks of scaphoid injury as the first subsequent investigation following negative initial radiographs (*3,4,9,10,12,13,23*) (Table II).

The published data shows a wide range of scaphoid fracture incidence from 13.3% (*9*) to 36.1% (*12*) with cumulative average incidence of 22.1% among 8 studies. Overall fracture detection incidence was 42%. Similar to our study five of these studied used delayed radiographs as the gold standard with which to compare the MRI findings (*3,4,9,10,12*).

In our study there were only three patients (2.7%) who showed occult scaphoid fracture.

Twenty-four MRI scans (21.8%) demonstrated occult bony injuries, a low incidence compared to the existing literature and cumulative figures from the above eight studies.

Injuries in the wrist may be complicated by delay in diagnosis and inadequate treatment. Clinical signs, such as localised tenderness and limited movement, do not correlate with the existence of a fracture in all cases. Commonly the initial radiographs of acute wrist injury are often negative. Studies have shown that a follow-up radiograph 10-14 days after injury does not improve diagnostic management. Fractures of the carpal bones are often not isolated, but accompanied by additional fractures and ligamentous injuries. Occult fractures of bones other than the scaphoid were present almost as frequently as occult scaphoid fractures (17% *vs* 19%). This is best disclosed by further MRI scans which will enable for early definitive treatment and

prevent prolonged immobilisation leading to loss of earnings. In a normal clinical setting MRI allows approximately three-fifths of patients with query scaphoid fracture to be discharged without further review. The remaining two-fifths will have occult fractures demonstrated, of which only half will be scaphoid fracture.

To conclude, the MRI scan is a useful tool to obtain a definite diagnosis in acute wrist injuries. If, however, the MRI scans are done after two weeks from the wrist injury, the probability of finding a definitive diagnosis of occult scaphoid fracture was only 2.7% in our study. We conclude that in the majority of patients with persisting symptoms four to six weeks following a wrist trauma, the pathology will most often affect other carpal bones or in other structures including soft tissues.

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