



■ WRIST & HAND

Suspected scaphoid injuries managed by MRI direct from the emergency department

A SINGLE-CENTRE PROSPECTIVE COHORT STUDY

**B. J. F. Dean,
C. Little,
N. D. Riley,
E. Sellon,
W. Sheehan,
J. Burford,
P. Hornbrey,
M. L. Costa**

From Oxford University
Hospitals NHS Trust,
Oxford, UK

Aims

To determine the role of early MRI in the management of suspected scaphoid fractures.

Methods

A total of 337 consecutive patients presenting to an emergency department (ED) following wrist trauma over a 12-month period were prospectively included in this service evaluation project. MRI was not required in 62 patients with clear diagnoses, and 17 patients were not managed as per pathway, leaving a total of 258 patients with normal scaphoid series radiographs who were then referred directly from ED for an acute wrist MRI scan. Patient demographics, clinical details, outcomes, and complications were recorded at a minimum of a year following injury.

Results

The median time from injury to ED presentation was one day and the median number of positive clinical signs was two out of three (snuffbox tenderness, tubercle tenderness, pain on telescoping). Of 258 patients referred for acute MRI, 208 scans were performed as 50 patients either did not tolerate (five patients) or did not attend their scan (45 patients). MRI scans demonstrated scaphoid fracture (13%), fracture of another bone (22%), scaphoid contusion (6%), other contusion/ligamentous injury (20%), or solely degenerative pathology (10%). Only 29% of scans showed no abnormality. Almost 50% of those undergoing MRI (100 patients) were discharged by ED with advice, with only one re-presentation. Of the 27 undisplaced occult scaphoid fractures, despite prompt cast immobilization, two experienced delayed union which was successfully treated with surgery.

Conclusion

The use of MRI direct from ED enables prompt diagnosis and the early discharge of a large proportion of patients with normal radiographs following wrist trauma.

Cite this article: *Bone Jt Open* 2021;2-6:447–453.

Keywords: MRI, Fracture, Wrist, Scaphoid, Outcome, Trauma

Introduction

Wrist trauma represents a huge clinical and economic burden for both patients and healthcare providers.¹ A substantial proportion of patients with wrist trauma have clinical signs consistent with a scaphoid fracture but normal radiographs,² the so-called 'suspected scaphoid fracture'. The majority of these patients will not have a scaphoid injury that requires immobilization but, given the inherent high likelihood of post-traumatic

arthritis of an untreated acute scaphoid fracture³ and the considerable difficulty and expense of treating a scaphoid nonunion and any associated arthritis, accurate identification of fractures at the time of acute presentation is imperative.

There is a considerable volume of evidence relating to the diagnostic sensitivity of different imaging methods, and attempts have been made to model the cost-effectiveness of different imaging

Correspondence should be sent to Benjamin J. F. Dean; email: benjamin.dean@ndorms.ox.ac.uk

doi: 10.1302/2633-1462.26.BJO-2021-0054.R1

Bone Jt Open 2021;2-6:447–453.

pathways.^{4,8} In the UK, guidance from The National Institute for Health and Care Excellence (NICE) currently advises the consideration of MRI as first-line imaging for people with suspected scaphoid fractures following a thorough clinical examination.⁴ The guidance is based upon some detailed health economic modelling which compared three clinical pathways (radiograph alone versus radiograph + CT versus radiograph + MRI). One difficulty in interpreting much of this evidence relates to how contextual factors may influence cost-effectiveness, and the lack of evidence relating to real-world clinical pathways, many of which have evolved considerably over recent years. As a result, the majority of centres in the UK do not offer MRI direct from the emergency department (ED), despite the supporting evidence, the reasons for which are likely highly complex.⁹

There is a paucity of published evidence relating to real-world MRI-based suspected scaphoid fracture pathways which draw together the clinical features, imaging findings, and clinical outcomes. There is only one other published study with a similar number of patients in this area which focused on diagnostics and did not describe the management and clinical outcomes.⁸ The only recent randomized controlled trial (RCT) is the Scaphoid Magnetic Resonance Imaging in Trauma (SMaRT) trial which used a rather different MRI-based pathway, with 67 patients randomized to MRI and a focus on cost-effectiveness.¹⁰ We therefore carried out this study with the aim of assessing the number of patients with scaphoid fractures detected on plain radiographs, and the number of patients with normal radiographs whose scaphoid fracture was detected on MRI.

Methods

This prospective service evaluation project was carried out after a new MRI-based imaging pathway was initiated. From the end of September 2018 until the end of September 2019, we collected routine, anonymized data with no change to clinical care pathways. The study was registered locally as a service evaluation project and, as such, no ethical approval was required, as stated by the Health Research Authority (HRA).

Process/pathway. All patients who attend ED following wrist trauma with a radiograph-confirmed scaphoid fracture, or who were at clinical suspicion of a scaphoid fracture following normal radiographs, were included. Patients were first assessed by an ED clinician and plain radiographs (posteroanterior (PA) and lateral views of wrist) were obtained after clinical examination. After discussion with a senior ED clinician who had been scaphoid pathway-trained (consultant, ED registrar, or emergency nurse practitioner (ENP)), scaphoid series radiographs were then obtained for all patients with a suspicious history and at least one positive clinical sign (snuffbox tenderness or scaphoid tubercle tenderness). The determination

of what constituted a 'suspicious history' was subjective and made by the pathway-trained clinician. Those aged 12 years and over with normal reported radiographs were then immobilized in a wrist splint without thumb extension and referred for a wrist MRI scan. The radiology department has a dedicated daily appointment for a scaphoid MRI involving four sequences (coronal T1 and short tau inversion recovery (STIR), axial proton density fat saturation and a gradient echo 3D isotropic sequence). The MRI scans were all reported by a consultant musculoskeletal radiologist. A team of extended scope physiotherapists (ESPs) who work within both the ED and orthopaedic trauma service manage the pathway beyond this point. The MRI scan result was then relayed to the patient by an ESP both by a telephone consultation and a personalized letter to document the diagnosis and management plan, including safety-net advice regarding re-referral for worrying or persistent symptoms. The management plan was determined for each patient by the MRI scan findings. Those with normal scans or minor abnormalities were discharged with verbal and written advice by the ESP without further clinical assessment. All MRI-detected scaphoid fractures were followed up in a specialist hand trauma clinic and immobilized in a cast. Cases which had demonstrated other abnormalities were discussed with the specialist hand surgical team to determine the optimal management plan in terms of immobilization (none, removable splint, cast) and clinical follow-up (none, general trauma clinic, hand trauma clinic, or hand therapy), actioned by the ESP. Details of further treatment, including surgical intervention, were recorded. Electronic patient records were searched in January 2021 to ensure that all re-presentations were captured.

Statistical analysis. The study is reported according to the guidelines from Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) and a STROBE checklist has been included as Supplementary Material.⁵ Statistical analysis was carried out using SPSS Statistics for Windows v. 27.0 (IBM, USA). Unless otherwise stated in the characteristics description, numbers represent median (interquartile range (IQR)) for continuous variables and n (percentage) for categorical variables. Histograms for all data sets were analyzed to assess for normality. The Fisher's exact test was used to compare variables between multiple groups for categorical data, while differences between multiple groups of unpaired non-parametric continuous data were assessed using the Kruskal-Wallis test. Statistical significance was set at a level of $p < 0.05$. No correction was made for multiple testing as this study was descriptive in nature and not testing specific hypotheses.

Results

Pathway. Figure 1 summarizes the patient pathway. In all, 337 patients were assessed for a suspected scaphoid

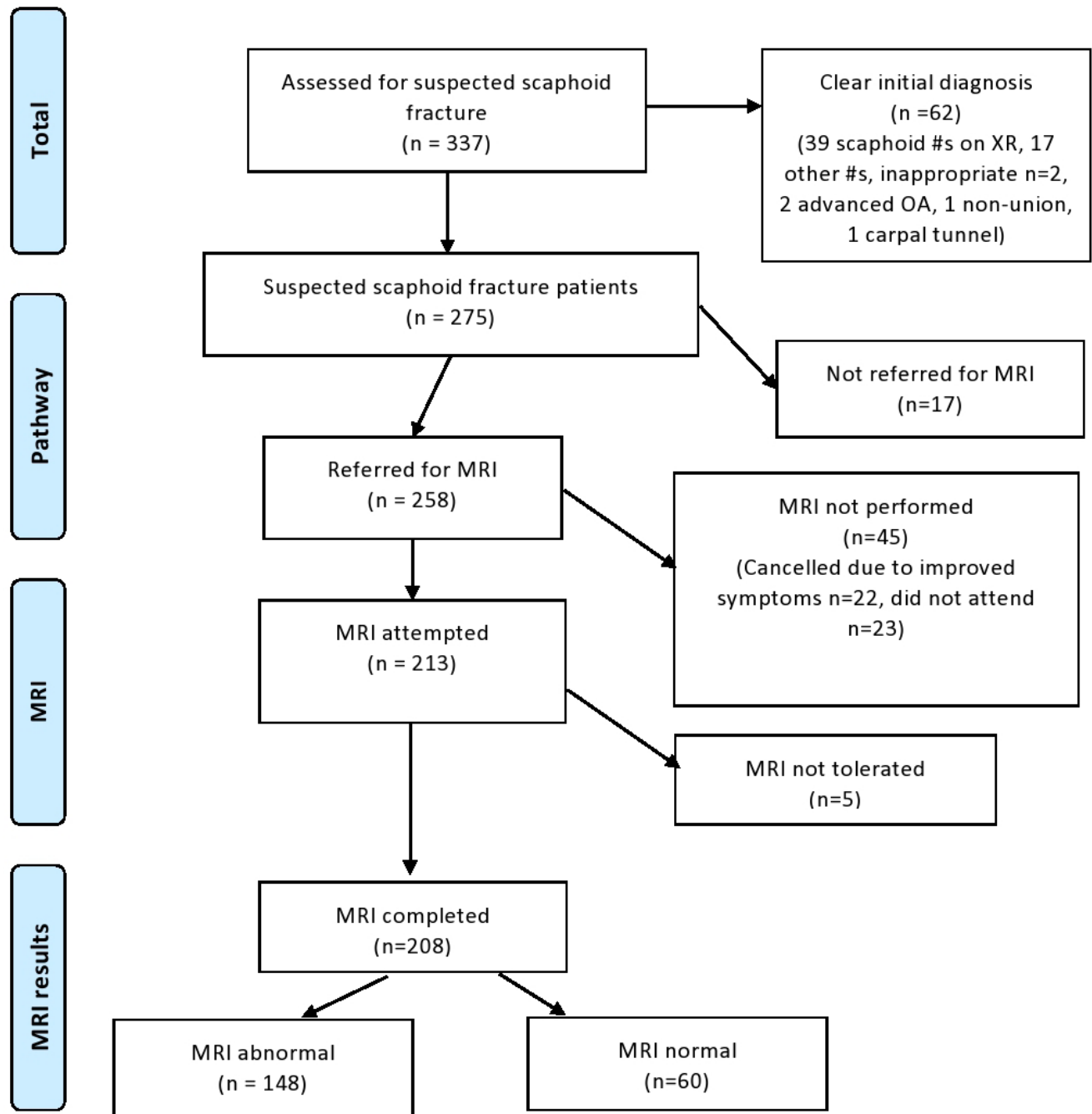


Fig. 1

Flow diagram of included patients.

fracture, of whom 258 were referred on for scaphoid MRI on the basis of their clinical examination findings and review of plain radiographs. A total of 17 patients with a suspected scaphoid fracture following normal radiographs were not referred for MRI as per pathway. Of these 17 patients, seven were followed up in specialist clinic and subsequently discharged (four based on clinical assessment and three based on further imaging also), six were discharged directly from ED, and four did not attend clinical follow-up. Of the 258 patients referred for

MRI, a scan was not performed in 45 (22 cancelled due to improved symptoms, while 23 did not attend and were not contactable) and the scan was not tolerated in five, leaving 208 patients who had an MRI scan.

Patient characteristics and clinical follow-up. Table I shows the demographic data, clinical features, time from injury to ED presentation, details relating to clinical follow-up, and outcomes for all patients. Table II shows the demographic data, clinical features, time from injury to ED presentation, time to MRI from ED attendance,

Table I. The patient characteristics, clinical findings, and outcomes in the entire cohort.

Factor	Overall	Not referred for MRI		Referred for MRI		p-value
		Clear initial diagnosis	Non-MRI suspected scaphoids	MRI not completed	MRI completed	
Total, n (%)	337	62 (18)	17 (5)	50 (15)	208 (62)	-
Median age, yrs (IQR)	28 (21 to 51)	28 (21 to 50)	38 (15 to 66)	27 (20 to 43)	30 (21 to 51)	0.877*
Sex, M:F	183:154	39:23	9:8	29:22	106:101	0.381†
Median time from injury to ED, days (IQR)	1 (0 to 2)	0 (0 to 1.5)	0 (0 to 1)	1 (0 to 1)	1 (0 to 2)	0.086*
FOOSH, n (%)	265 (79)	52 (84)	15 (88)	36 (72)	162 (78)	0.370†
Sport-related, n (%)	73 (22)	12 (19)	1 (6)	10 (20)	50 (24)	0.522†
Alcohol-related, n (%)	25 (7)	7 (11)	1 (6)	6 (12)	11 (5)	0.351†
Median number of positive clinical signs out of 3 (IQR)	2 (2 to 3)	2 (1 to 3)	1 (1 to 3)	2 (2 to 3)	2 (2 to 3)	0.036*
Median time to MRI, days (IQR)	4 (2 to 7)	-	-	-	4 (2 to 7)	-
Discharged direct from ED, n (%)	120 (36)	4 (6)	6 (4)	10 (20)	100 (48)	< 0.001†
Clinic review, n (%)	167 (50)	52 (84)	7 (4)	4 (8)	104 (50)	< 0.001†
DNA follow-up, n (%)	48 (14)	6 (10)	4 (24)	36 (72)	3 (1)	-
Immobilized, n (%)	121 (36)	45 (73)	4 (24)	0 (0)	62 (30)	< 0.001†
Cast, n (%)	91 (27)	43 (69)	3 (18)	0 (0)	45 (22)	< 0.001†
Median period of immobilization, wks (IQR)	6 (4 to 6)	6 (4 to 6)	1.5 (1 to 3.5)	-	4 (4 to 6)	< 0.001*
Therapy, n (%)	26 (8)	4 (6)	0 (0)	1 (2)	21 (10)	0.138†
Median total clinic appointments (IQR)	2 (1 to 3)	3 (2 to 4)	1 (1 to 2)	2 (1 to 2)	2 (1 to 3)	< 0.001*
Imaging follow-up, n (%)	77 (30)	41 (66)	3 (18)	0 (0)	33 (16)	< 0.001†
CT follow-up, n (%)	53 (16)	29 (47)	1 (6)	0 (0)	23 (11)	< 0.001†
Surgery, n (%)	7 (2)	5 (8)	0 (0)	0 (0)	2 (1)	0.094†
Re-presentation, n (%)	3 (1)	0 (0)	1 (6)	1 (2)	1 (0.5)	-
Complications, n (%)	6 (2)	3 (5)	0 (0)	0 (0)	3 (1.5)	-

"-" refers to testing for differences between the four groups.

*Kruskal-Wallis test.

†Fisher's exact test.

ED, emergency department; FOOSH, fall on the outstretched hand (injury type); IQR, interquartile range.

details relating to clinical follow-up, and outcomes for all patients who completed an MRI scan. Of the 208 patients who had MRI scans, 27 had a scaphoid fracture (13%), 45 'other fracture' (22%), 13 a scaphoid contusion (6%), 42 'other contusion'/ligamentous injury (20%), 21 solely degenerative pathology (10%), and 60 scans returned entirely normal findings (29%). This means that 41% of all fractured scaphoids are not apparent on radiograph (27 MRI-detected 'occults' of the total 66 scaphoid fractures).

Surgery, outcomes, and complications overall. In total, seven patients underwent surgery. Two patients with radiograph-detected scaphoid fractures were treated with acute surgical fixation (one minimally displaced treated with percutaneous fixation, and one displaced treated with open reduction, bone grafting, and internal fixation). Three patients with radiograph-detected scaphoid fractures progressed to delayed union (accounting for the three complications in this group) and were treated by open reduction, bone grafting, and internal fixation. Two patients with undisplaced MRI-detected scaphoid fractures (one proximal one-third and one middle one-third) progressed to delayed union and were treated with

surgical fixation (one with bone graft and one without), which accounted for two of the three complications in the MRI-completed group. The other complication was a patient with an MRI-detected undisplaced distal radial fracture who was treated in a cast and subsequently developed chronic regional pain syndrome. Only three patients re-presented following discharge: one in the non-pathway scaphoid suspected group re-presented to ED at one month with persistent pain and was discharged with advice following further reassuring imaging; one patient who had cancelled their initial MRI re-presented five months later and was discharged following a normal MRI scan; and one patient within the MRI-completed group re-presented with pain one month following discharge after a normal MRI scan and was discharged following a short course of physiotherapy.

Imaging findings and associations. Table III details the associated findings with distal radial fractures, scaphoid fractures, scaphoid contusions, triquetral avulsion fractures, and scapholunate ligament (SLL) injuries. Lunate and/or capitate contusions were seen in almost a quarter of scaphoid fractures. A majority of scaphoid fractures (18

Table II. The patient characteristics, clinical findings, and outcomes in all those with a completed MRI scan. p-values refer to testing for differences between the six groups.

Factor	Overall	Abnormal MRI					Normal MRI	p-value
		Scaphoid #	Other #	Scaphoid contusion	Other contusion or ligamentous	Degenerative pathology		
Total, n (%)	208	27 (13%)	45 (22%)	13 (6%)	42 (20%)	21 (10%)	60 (29%)	
Median age, yrs (IQR)	30 (21 to 51)	27 (17 to 24)	41 (23 to 61)	26 (14 to 38)	32 (21 to 51)	53 (32 to 65)	27 (20 to 41)	< 0.001*
Sex, M:F	106:101	22:5	22:23	9:4	20:22	7:14	26:34	0.005†
Median time from injury to ED, days (IQR)	1 (0 to 2)	1 (0 to 1)	1 (0 to 2)	1 (0.5 to 3.5)	1 (0 to 2)	1 (0 to 4.5)	1 (0 to 3.75)	0.619*
FOOSH, n (%)	162 (78)	23 (85)	38 (84)	11 (85)	33 (79)	17 (81)	40 (67)	0.357†
Sport-related, n (%)	50 (24)	10 (37)	11 (24)	10 (77)	6 (14)	1 (5)	12 (20)	< 0.001†
Alcohol-related, n (%)	11 (5)	1 (4)	2 (4)	0 (0)	3 (7)	1 (5)	4 (7)	0.858†
Number of positive clinical signs out of 3, n (%)	2 (2 to 3)	2 (2 to 3)	2 (1 to 3)	3 (1 to 3)	2 (1.75 to 3)	3 (2 to 3)	3 (2 to 3)	0.098*
Median time to MRI, days (IQR)	4 (2 to 7)	5 (2 to 8)	5 (1 to 8)	6 (2.5 to 11)	4 (2 to 7)	3 (1 to 6)	4 (2 to 8)	0.702*
Discharged direct from ED, n (%)	100 (48)	0 (0)	4 (9)	4 (31)	28 (67)	14 (67)	50 (83)	< 0.001†
Clinic review, n (%)	104 (50)	27 (100)	40 (89)	9 (69)	12 (29)	6 (29)	10 (17)	< 0.001†
DNA follow-up, n (%)	3 (1)	0 (0)	1 (2)	0 (0)	2 (5)	0 (0)	0 (0)	
Immobilized, n (%)	62 (30)	27 (100)	26 (58)	4 (31)	4 (10)	1 (5)	0 (0)	< 0.001†
Cast, n (%)	45 (22)	27 (100)	13 (29)	3 (23)	2 (5)	0 (0)	0 (0)	< 0.001†
Median period immobilized, wks (IQR)	4 (4 to 6)	6 (6 to 6)	4 (4 to 4)	5 (2.5 to 6)	4 (3.25 to 5.5)	4 (4 to 4)	0 (0%)	< 0.001*
Therapy, n (%)	21 (10)	3 (11)	8 (18)	2 (15)	5 (12)	2 (10)	1 (2)	0.059†
Median total clinic appointments (IQR)	2 (1 to 3)	3 (2 to 4)	1 (1 to 2)	2 (1 to 2.5)	1 (1 to 2)	1 (1 to 2.5)	1 (1 to 2)	< 0.001*
Imaging follow-up, n (%)	33 (16)	26 (97)	4 (9)	2 (15)	1 (2)	0 (0)	0 (0)	< 0.001†
CT follow-up, n (%)	23 (11)	21 (78)	2 (4)	0 (0)	0 (0)	0 (0)	0 (0)	< 0.001†
Surgery, n (%)	2 (1)	2 (7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
Re-presentation, n (%)	1 (0.5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (2)	
Complications, n (%)	3 (1.5)	2 (7)	0 (0)	0 (0)	0 (0)	1 (5)	0 (0)	

*Kruskal-Wallis test.

†Fisher's exact test.

ED, emergency department; FOOSH, fall on the outstretched hand (injury type).

Table III. The associated findings on MRI.

Injury group	Associated fractures	Associated contusions	Associated effusions/ligaments
Distal radial fracture (23)	Distal ulna (1), capitate (1), scaphoid (1), base of metacarpal (1)	Base of metacarpal (2), lunate (1), capitate (2), trapezium (1), scaphoid (1)	SL partial (1), TFC (1), distal radioulnar effusion (2), radiocarpal effusion (4)
Scaphoid fracture (27)	Capitate (1), distal radius (1), metacarpal base (1)	Lunate (5), capitate (6), triquetrum (1), hamate (1), trapezium (1), trapezoid (1)	TFC (2), midcarpal effusion (3), radiocarpal effusion (6), SL complete (1), SL partial (2), STT effusion (3), dorsal intercarpal (1)
Scaphoid contusion (13)	Capitate (1), distal radius (1), triquetrum (1)	Lunate (2), capitate (1), trapezoid (1), trapezium (2)	SL partial (3), STT effusion (2), dorsal intercarpal (2), radiocarpal effusion (3), TFC (1), midcarpal effusion (1)
SL partial tears (9)	Distal radius and ulna (1), triquetrum (1), scaphoid (2)	Scaphoid (2), lunate (3), capitate (1), trapezoid (2), triquetrum (1)	LT (1), dorsal intercarpal (1), STT effusion (1)
Triquetral avulsion fractures (6)	None	Trapezium (1), hamate (1), scaphoid (1)	SL partial (1), LT (1), dorsal intercarpal, thumb CMCJ effusion (1), radioulnar (1), radiocarpal (1)
SL complete (2)	Scaphoid (1)	Lunate (1), capitate (1)	Radiocarpal effusion (2)

CMCJ, carpometacarpal joint; LT, lunotriquetral; SL, scapholunate; STT, scaphotrapeziotrapezoid; TFC, triangular fibrocartilage complex.

of 27) have another area of fracture or contusion visible on MRI. Scapholunate ligament injuries were commonly associated with either a scaphoid fracture or a scaphoid contusion. Distal radial fractures and triquetral avulsion

fractures were not frequently associated with other specific fractures or contusions.

Discussion

The study shows that an MRI-based pathway for suspected scaphoid fractures enables prompt diagnosis and the early discharge of a high proportion of patients with normal radiographs following wrist trauma. There is a high rate of abnormal findings on MRI, including a 13% rate of scaphoid fracture, demonstrating that 41% of all acute scaphoid fractures remain undetected following clinical examination and initial scaphoid series radiographs. Despite prompt early cast immobilization, the occult undisplaced scaphoid fracture is not necessarily benign in outcome and, in some instances, may progress to delayed union, as seen in two cases in this series.

Many potential pathways exist for the management of suspected scaphoid injuries and these were broadly summarized by the work of NICE in 2016, which concluded that “Immediate MRI is likely to be the most cost effective imaging strategy for patients with a suspected scaphoid fracture”.¹¹ The NICE model used MRI as a diagnostic reference standard with an assumed sensitivity and specificity of 100%, which has been supported by a recent systematic review by Bäcker et al¹² which demonstrated that MRI had a superior sensitivity and specificity to CT in the detection of scaphoid fractures. The recent SMaRT trial has demonstrated benefits to the use of immediate MRI which include cost savings, as well as improved diagnostic accuracy, and patient satisfaction.⁵

Guidance from the Royal College of Emergency Medicine (RCEM) concisely summarizes the best evidence relating to clinical signs in suspected scaphoid injuries.⁷ The sensitivity of tubercle and snuffbox tenderness has been reported as 100% by several studies, although the specificity of these tests is significantly lower. Our results are consistent with the demonstrable lack of specificity of clinical signs, in that there was no significant difference in the number of positive clinical signs between different diagnostic groups. Therefore, we feel that the conclusion of the RCEM that “There is no one examination or combination of examinations that can reliably exclude a scaphoid fracture” is correct.⁷

Although CT will detect the majority of fractures, it will not detect bony contusions or most ligamentous injuries which are detected by MRI.⁸ It therefore means that pathways solely using radiograph, or radiograph and CT, leave both patients and clinicians with the difficult dilemma of whether or not to mobilize early. Of note, 23% of patients with a scaphoid contusion on MRI were immobilized with a cast following review of the imaging by the specialist hand surgeon. Although little has been published in this area, in our experience there is a definite grey area in between a scaphoid contusion and a scaphoid waist fracture. Generally, we have erred on

the side of caution in treating scaphoid contusions with cast immobilization when the oedema is not confined to just the tubercle region, and this explains the rate of cast immobilization in this group.

Without MRI, either one has to over-treat by cast immobilization to prevent the inevitable litigation that comes with the occasional delayed or nonunion, or one has to gamble with early mobilization and pay the price when a group of patients develops a symptomatic nonunion or post-traumatic arthritis, with the potential for litigation for inadequate treatment of the occult scaphoid fracture. Additionally, over-treatment with cast immobilization is not without morbidity for patients but is also costly for providers in terms of multiple clinic and plaster room appointments. In this study, almost half of all patients who underwent an MRI scan (48%) were discharged with advice and no further clinical follow-up. Without the MRI direct from ED, all of these patients would need to be seen in clinic and imaged further, and this is at least as expensive as the cost of the MRI itself.⁶ The rate of re-presentation was also extremely low (0.5%). In recent months, our practice has continued to evolve, with our threshold for clinical follow-up increasing, which will likely result in further cost savings for the hospital.

The litigation costs associated with scaphoid fractures represent a significant burden in the UK, with the majority related to delayed or missed diagnoses, alleged mismanagement, or poor care.^{13,14} The current litigation costs per case are around £50,000. This is equivalent to the cost of 500 MRI scans, thus demonstrating that MRI can more than pay for itself purely in terms of reducing litigation costs.

There are limitations to this study which include the absence of patient-reported outcomes and it being from a single centre. In order to provide context, we have included the whole cohort which includes the small number of patients who were not managed per pathway and those with scaphoid fractures reported on radiograph. Another limitation to this study is the uncertainty relating to the diagnoses of those patients who did not undergo an MRI for a variety of different reasons (did not attend scan due to improved symptoms, did not attend and did not tolerate scan). This study showed how, in the real world, full compliance with a pathway is highly unlikely to occur. It would be advantageous to have routinely collected patient-reported outcomes, but unfortunately this has not yet been possible to embed within the electronic patient record. The strength of this study is that it is the first time that an entire cohort of this type has been described in terms of clinical presentation, imaging findings, and outcomes.

In summary, the use of MRI direct from ED enables prompt diagnosis and the early discharge of a large proportion of patients with normal radiographs following wrist trauma.



Take home message

- The use of early MRI direct from emergency department (ED) enables prompt diagnosis and treatment.
- A large proportion of patients can be immediately discharged to mobilize early without the need for further clinical assessment or clinic attendance.
- A total of 41% of all scaphoid fractures presented to the ED are not detected on initial radiographs. Occult scaphoid fracture was present in 13% of MRI scans.

Twitter

Follow B. J. F. Dean @bendean1979

Follow C. Little @oxford_hand

Follow N. D. Riley @hand_specialist

Supplementary material



Strengthening the Reporting of Observational Studies in Epidemiology checklist.

References

1. **de Putter CE, Selles RW, Polinder S, Panneman MJ, Hovius SE, van Beeck EF.** Economic impact of hand and wrist injuries: health-care costs and productivity costs in a population-based study. *J Bone Joint Surg Am.* 2012;94-A(9):e56.
2. **Patel NK, Davies N, Mirza Z, Watson M.** Cost and clinical effectiveness of MRI in occult scaphoid fractures: a randomised controlled trial. *Emerg Med J.* 2013;30(3):202–207.
3. **Clementson M, Thomsen N, Besjakov J, Jørgsholm P, Björkman A.** Long-term outcomes after distal scaphoid fractures: a 10-year follow-up. *J Hand Surg Am.* 2017;42(11):927.e1–927.e7.
4. **No authors listed.** Fractures (non-complex): assessment and management. NICE guideline [NG38]. National Institute for Health and Care Excellence (NICE). 2016. <https://www.nice.org.uk/guidance/ng38> (date last accessed 14 June 2021).
5. **Rua T, Malhotra B, Vijayanathan S, et al.** Clinical and cost implications of using immediate MRI in the management of patients with a suspected scaphoid fracture and negative radiographs results from the SMaRT trial. *Bone Joint J.* 2019;101-B(8):984–994.
6. **Rua T, Gidwani S, Malhotra B, et al.** Cost-effectiveness of immediate magnetic resonance imaging in the management of patients with suspected scaphoid fracture: results from a randomized clinical trial. *Value Health.* 2020;23(11):1444–1452.
7. **Machin E, Blackham J, Bengler J.** Guidelines in Emergency Medicine Network - GEMNet. Guideline for the Management of Suspected Scaphoid Fractures in the Emergency Department. College of Emergency Medicine, 2013. [https://www.rcem.ac.uk/docs/College%20Guidelines/5z25.%20Suspected%20Scaphoid%20Fractures-%20\(Flowchart\)%20\(Sept%202013\).pdf](https://www.rcem.ac.uk/docs/College%20Guidelines/5z25.%20Suspected%20Scaphoid%20Fractures-%20(Flowchart)%20(Sept%202013).pdf) (date last accessed 14 June 2021).
8. **Jørgsholm P, Thomsen NOB, Besjakov J, Abrahamsson S-O, Björkman A.** The benefit of magnetic resonance imaging for patients with posttraumatic radial wrist tenderness. *J Hand Surg Am.* 2013;38(1):29–33.
9. **Snaith B, Walker A, Robertshaw S, Spencer NJB, Smith A, Harris MA.** Has NICE guidance changed the management of the suspected scaphoid fracture: a survey of UK practice. *Radiography.* 2021;27(2):377–380.
10. **Jørgsholm P, Thomsen NO, Besjakov J, Abrahamsson SO, Björkman A.** The benefit of magnetic resonance imaging for patients with posttraumatic radial wrist tenderness. *J Hand Surg Am.* 2013;38(1):29–33.
11. **NICE.** Appendix M. Cost-effectiveness analysis: Imaging of suspected scaphoid fractures. 2016. <https://www.ncbi.nlm.nih.gov/books/NBK368138/>
12. **Bäcker HC, Wu CH, Strauch RJ.** Systematic review of diagnosis of clinically suspected scaphoid fractures. *J Wrist Surg.* 2020;9(1):81–89.
13. **Ring J, Talbot C, Price J, Dunkow P.** Wrist and scaphoid fractures: a 17-year review of NHSLA litigation data. *Injury.* 2015;46(4):682–686.
14. **Harrison W, Newton AW, Cheung G.** The litigation cost of negligent scaphoid fracture management. *Eur J Emerg Med.* 2015;22(2):142–143.

Author information:

- B. J. F. Dean, DPhil FRCS, Consultant Hand Surgeon, Senior Research Fellow
- M. L. Costa, PhD, Professor of Orthopaedic Trauma Surgery Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, Oxford, UK; Department of Orthopaedics, Oxford University Hospitals NHS Foundation Trust Nuffield Orthopaedic Centre, Oxford, UK.
- C. Little, FRCS, Consultant Surgeon
- N. D. Riley, FRCS, Consultant Hand Surgeon
- E. Sellon, FRCR, Consultant Musculoskeletal Radiologist
- W. Sheehan, MCSP, Senior Physiotherapist
- J. Burford, RN, Emergency Nurse Practitioner
- P. Hornbrey, MB ChB, Consultant in Emergency Medicine Department of Orthopaedics, Oxford University Hospitals NHS Foundation Trust Nuffield Orthopaedic Centre, Oxford, UK.

Author contributions:

- B. J. F. Dean: Led the study design, Analyzed and interpreted the data, Drafted the work.
- C. Little: Contributed to the design of the work, Interpreted the data, Drafted the manuscript.
- N. D. Riley: Contributed to the design of the work, Analyzed and interpreted the data, Drafted the manuscript.
- E. Sellon: Contributed to the design of the study, Analyzed and interpreted the data, Drafted the manuscript.
- W. Sheehan: Contributed to the design of the work, Collected, analyzed, and interpreted the data collection, Drafted the manuscript.
- J. Burford: Contributed to the design of the work, Interpreted the data, Drafted the manuscript.
- P. Hornbrey: Contributed to the design of the work, Analyzed and interpreted the data, Drafted the manuscript.
- M. L. Costa: Study group have been involved in the design of the work, data analysis, data interpretation, drafting of the work and final approval, writing group have contributed in terms of data interpretation, drafting of the work and final approval.

Funding statement:

- Although none of the authors has received or will receive benefits for personal or professional use from a commercial party related directly or indirectly to the subject of this article, benefits have been or will be received but will be directed solely to a research fund, foundation, educational institution, or other non-profit organization with which one or more of the authors are associated.

ICMJE COI statement:

- N. D. Riley reports the receipt of consultancy fees from Acumed unrelated to the submitted work. M. L. Costa reports the receipt of institutional research grant funding from the National Institute for Health Research, EU, the Royal College of Surgeons of England, and Industry, all unrelated to the submitted work. B. J. F. Dean is part funded by the BMA's Doris Hillier grant, which does not relate to this work.

Data availability statement:

- Data are available from the lead author upon reasonable request.

© 2021 Author(s) et al. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial No Derivatives (CC BY-NC-ND 4.0) licence, which permits the copying and redistribution of the work only, and provided the original author and source are credited. See <https://creativecommons.org/licenses/by-nc-nd/4.0/>