The College of Emergency Medicine

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Guidelines in Emergency Medicine Network - GEMNet

Guideline for the Management of Suspected Scaphoid Fractures in the Emergency Department

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About this guideline

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Contents

1. Executive summary

- The Guidelines in Emergency Medicine Network (GEMNet) exists to promote best medical practice in a range of conditions presenting to Emergency Departments (EDs) in the UK.
- This guideline presents a summary of the best available evidence to guide the management of adult patients who present to the ED with a suspected scaphoid fracture.
- The guideline has been developed following discussion amongst Emergency Physicians to decide which topics would benefit from the development of clinical guidelines.
- The guideline is intended for use in the ED by Emergency Physicians and is based on a review of the best available evidence at the time of writing.
- There is no one examination finding or combination of examination findings that can reliably exclude a scaphoid fracture. However it would be reasonable to consider this possibility if the patient has sustained trauma compatible with scaphoid fracture and has anatomical snuffbox or scaphoid tubercle tenderness. Such patients should usually undergo imaging.
- Plain radiographs remain a useful first line imaging test for scaphoid fracture, however they are insufficiently sensitive to exclude a fracture. Repeat imaging between 2 and 6 weeks increases the sensitivity, but is still not high enough to exclude a fracture.
- On the basis of currently available evidence, dual energy X-Ray absorptiometry, macroradiography, ultrasound and intrasound vibration cannot be recommended as useful imaging tests for a suspected scaphoid fracture.
- Bone scanning has a very high sensitivity; however it also produces a number of false positives when compared with delayed plain radiographs. There have been few studies of CT, but those performed demonstrate a high sensitivity for scaphoid fracture.
- MRI for patients with ongoing clinical suspicion of scaphoid fracture despite normal initial radiographs has a very high sensitivity for detecting scaphoid fracture and other injuries to the wrist, and is the second-line investigation of choice.
- There are no studies comparing wrist splints with or without thumb extensions to a plaster cast for the definitive management of scaphoid fractures. Based on the available evidence there is no benefit of a scaphoid cast over a standard "Colles" cast.
- There is no guidance in the published literature on follow up per se. The period of follow up is dependent on the chosen imaging modality, since once a fracture has been excluded further follow up is not required.
- These recommendations are summarised in a clinical decision support guideline that has been presented as a simple algorithm.
- The intention is for every GEMNet guideline to be updated and reviewed as further evidence becomes available. The formal revision date has been set at 5 years from publication, though the guideline is subject to continuous informal review.

2. Introduction

2.1 Responsibility for development

This document has been developed in response to a perceived need to improve and standardise clinical care in patients with a suspected fracture of the scaphoid bone. The intention is to distil the best available evidence into practical advice for clinicians working in the Emergency Department. The information is presented in the form of clinical decision support guidelines, readily available for use in the ED.

Abbreviations used in this guideline:

ASB - Anatomic snuff box

CT – Computed tomography

ED – Emergency Department

LC – Longitudinal compression

MRI – Magnetic resonance imaging

SC – Scaphoid compression

ST - Scaphoid tubercle

3. Topic background

Scaphoid fractures are the commonest fracture of the carpal bones, comprising almost 90% of carpal fractures. They are most common in men aged between 15 and 30 years.

Middle third Scaphoid fractures usually result from extreme dorsiflexion of the wrist with pressure over the radial side of the palm – most commonly due to a fall on an outstretched hand. Scaphoid fractures can also be caused by a direct blow to the palm of the hand; historically this was a "crank handle" injury, but it can also be caused by holding a car steering wheel during a motor vehicle collision.

Generations of medical students have been told that tenderness in the anatomical snuff box is the cardinal sign of a scaphoid fracture, and that missed scaphoid fractures are common. The cutaneous branch of the radial nerve runs directly over the anatomical snuff box, which means that discomfort on firm palpation of this area is common even in the absence of injury.[1]

The published incidence of false negative initial radiographs is between 5 and 48%.[2] Early diagnosis is commonly held to be necessary in order to avoid complications such as non-union, pseudoarthrosis and avascular necrosis. That said, as long ago as 1969 McLaughlin and colleagues noted that fractures of the scaphoid that were not visible on the initial radiographs were ‘class A fractures’: undisplaced fractures that are little more than a split in the articular cartilage.[3] They stated that ‘it was abundantly clear that, barring a reinjury, the fractures in this group would heal under almost any circumstance’.

The incidence of delayed union increases from 9% in patients where treatment is instituted within days of fracture to 36% if treatment is delayed beyond 4 weeks. Similarly, the non-union rate rises from 5% to 45%.[4]

A number of authors have questioned the diagnosis of ‘clinically fractured’ scaphoid. Duncan et al. undertook a study of patients with suspected or proven scaphoid fractures over one year in a single hospital.[5] Of the 156 patients, 42 were initially felt to have scaphoid fractures, and 108 to have a clinical scaphoid fracture by the “casualty officer”. They were unable to demonstrate a case of a scaphoid fracture becoming visible radiologically after a period of observation. Leslie noted that of 222 fresh scaphoid fractures, 98% were visible on initial radiographs, but 3% of these were missed by “casualty officers”.[6] The remaining 2% were not visible until 2 weeks, however these were incomplete fractures. As noted above, McLaughlin felt that incomplete fractures of this type were stable fractures that required no immobilization.

There is great variation between hospitals in the initial management of suspected scaphoid fractures, even amongst neighbouring hospitals.[7] In an international study of hospital management of suspected scaphoid fractures, there was no agreement on initial imaging, follow up period or the type of repeat imaging for ongoing clinical suspicion. The most common second line investigation was MRI (31/105).[8]

The immobilisation of a suspected scaphoid fracture entails significant inconvenience for patents; in many cases leaving them unable to work for prolonged periods of time (an average of 21 days in one study).[5]

Recent Royal College of Radiology guidelines recommend plain radiology followed by CT, MRI or nuclear medicine, but with MRI as the recommended form of secondary imaging.[9] The current American College of Radiology guidance recommends repeat plain radiographs at 14 days or MRI if the original radiographs are normal, with CT as a an alternative option if MRI contra-indicated.[10]

Dorsay and colleagues reviewed the published literature as part of a cost effectiveness study to find the positive predictive value of clinical examination.[11] They found it ranged from 13-69%, with a weighted average of 21%. This means that four out of five patients with a clinically suspected Scaphoid fracture turn out not to have one. They went on to look at the negative predictive value of normal initial radiographs and noted that the range was 50-80%, with a weighted average of 74%.

4. Scope

This guideline is intended for the management of patients aged over 8 years presenting to the Emergency Department with suspected scaphoid fracture. Scaphoid fractures are very rare in children under 8 years of age; alternative diagnoses should therefore be considered in this patient group.

5. Methodology

MEDLINE 1966-05/11, EMBASE 1980-05/11, CINHAL 1981-05/11 and the Cochrane Library were searched using the strategies described below to answer a number of "three part" questions:

5.1 Clinical examination

In a [patient with suspected scaphoid fracture] which [clinical test] is most effective in [diagnosing a scaphoid fracture] [12]

[(SCAPHOID BONE OR scaphoid.ti.ab) AND (FRACTURES, BONE/di) AND (PHYSICAL EXAMINATION OR (clinical ADJ test).ti.ab) OR examin$.ti)]

5.2 Imaging

In a [patient with suspected scaphoid fracture] which [imaging strategy] is most effective in [achieving the correct diagnosis]

[(SCAPHOID BONE OR scaphoid.ti.ab) AND (FRACTURES, BONE/di) AND (DIAGNOSTIC IMAGING/ OR MAGNETIC RESONANCE IMAGING/ OR RADIONUCLIDE IMAGING/ OR TECHNETIUM TC 99M MEDRONATE/ OR TECHNETIUM/ OR X-RAYS/ OR ultrasound.ti,ab OR mri.ti,ab OR (magnet$ ADJ resonan$).ti,ab OR x-ray$.ti,ab OR (bone AND scan).ti,ab OR scint$.ti,ab)]

5.3 Immobilisation

In a [patient with a clinically suspected scaphoid fracture] is [wrist immobilisation in a splint] better than [wrist immobilisation in a cast] for [reducing complications from occult fractures]

[(SCAPHOID BONE OR scaphoid.ti.ab)] AND [(CASTS, SURGICAL/ OR CALCIUM SULFATE/ OR SPLINTS/) OR (plaster AND of AND paris).ti,ab OR splint$.ti,ab OR IMMOBILIZATION/ OR immobilisation.ti,ab OR immobilization.ti,ab OR cast$.ti,ab] AND [FRACTURES, BONE/]

5.3 Follow up

In a [patient with a clinically suspected scaphoid fracture] is [clinical follow up] or [further imaging] best for [excluding occult fractures]

The duration of follow up was considered in the imaging section. It was noted that the sensitivity and timing of clinical and radiological examination determines the duration of follow up required.

Cochrane reviews

There was one relevant Cochrane review: "Diagnosing suspected scaphoid fractures: a systematic review and meta-analysis".[2]

Levels of evidence and grading of recommendations

Studies included in this guideline were graded for their level of evidence according to accepted definitions.[13]

In summary:

Level 1 evidence is derived from well-designed randomised controlled trials (RCTs),

Level 2 evidence is derived from large cohort studies or poorly designed RCTs,

Level 3 evidence is derived from small cohort studies or case-control studies, and

Level 4 evidence is derived from experimental studies, case series or case studies.

The suffix 'a' implies that evidence at this level is from a systematic review or meta-analysis, whereas the suffix 'b' implies that the evidence is from original research.

The recommendations made have been graded according to the level of evidence upon which they are based:

Grade A: Based upon multiple level 1a or 1b papers.

Grade B: Based upon individual level 1a or 1b papers, or multiple level 2a or 2b papers.

Grade C: Based upon individual level 2a or 2b papers, or multiple level 3a or 3b papers.

Grade D: Based upon individual level 3a or 3b papers, or level 4 papers.

Grade E: Based upon consensus guidelines or studies of expert opinion.

6. Summary of recommendations

6.1 Clinical examination

There is no one examination or combination of examinations that can reliably exclude a scaphoid fracture. This is based on a number of small level 3 studies which limits the reliability of the conclusions that can be drawn. The highest probability of fracture is in patients with ASB and ST tenderness combined with pain on LC of the thumb (sensitivity 100%; specificity 74%). ASB or ST tenderness also has a reasonable specificity and sensitivity.

It would be reasonable to consider the possibility of a scaphoid fracture if the patient has ASB or ST tenderness as this will pick up patients in both the above groups. These patients should undergo imaging. **[Grade C]**

6.2 Imaging

A problem with all published studies is the lack of a "gold standard" imaging modality against which reliable comparisons can be made. Plain radiographs are a useful first line imaging technique for scaphoid fracture; however they are insufficiently sensitive to exclude a fracture. Repeat imaging at between 2 and 6 weeks increases the sensitivity, but is still not high enough to exclude fracture.

Dual energy X-Ray absorptiometry and macroradiography are not sensitive or specific enough to have a role in excluding scaphoid fractures. There have been a number of small studies looking at the role of ultrasound and intrasound vibration in the diagnosis of scaphoid fractures. There is great variation in the sensitivity and specificity of ultrasound, and this modality cannot be recommended on the basis of currently available evidence. **[Grade C]**

Bone scanning has a very high sensitivity (100% in most studies), however it produces a number of false positives when compared with delayed plain radiographs. It also requires intravenous radioisotope and multiple images over a 3 hour period which is inconvenient for patients and represents a significant workload for radiology departments. **[Grade C]**

There have been few studies of CT, but those performed demonstrate a high sensitivity for scaphoid fracture. **[Grade C]**

In comparison studies MRI performs similarly to CT and bone scan. MRI for patients with an ongoing clinical suspicion of scaphoid fracture despite normal initial radiographs has a very high sensitivity for detecting scaphoid fracture and other injuries to the wrist, and is the second-line imaging investigation of choice. **[Grade C]**

6.3 Immobilisation

There are no studies comparing wrist splints with or without thumb extensions to a plaster cast for the definitive management of scaphoid fractures. Based on the available evidence:

- There is no benefit of a scaphoid cast over a standard "Colles" cast. **[Grade C]**
- Immobilising the wrist in up to 20 degrees extension is better than having the wrist immobilised in flexion **[Grade D]**
- There may be some benefit to immobilising a scaphoid fracture in an above elbow cast, but the two studies in this area do not agree.

6.4 Follow up

There is no useful guidance in the literature regarding the duration of patient follow up. The period of follow up is dependent on the chosen imaging modality, since once a fracture has been excluded (normal MRI, CT or bone scan) further follow up is not required.

7. Detailed findings

1. **Clinical Examination**

   The search strategy produced 21 unique results

2. **Imaging**

   The search strategy produced 147 unique results

3. **Immobilisation**

   The search strategy produced 173 unique results

4. **Follow up**

   The search strategy produced no useful results

5. **Scaphoid Fractures in Children**

7.1 Clinical examination

Clinical suspicion of a fractured scaphoid leads to many patients being immobilised unnecessarily,[14] with the incidence of occult fracture being reported as low as 1.3% and a final diagnosis of soft tissue injury being made in 88.8% of patients. Knowledge of surface anatomy of the carpal bones is often poor.[15]

Clinical examination can be useful, but any proposed clinical test should be easy to teach and apply. Table 1, below, summarises 9 studies looking at commonly used clinical examination findings. The sensitivity of clinical examination tests are usually high, but the corresponding specificity poor, limiting their use in clinical practice.

Table 1: Clinical examination findings

Study	Patient group	Incidence (and Gold standard used)	ASB tenderness	ST tenderness	Axial loading of thumb*	Other examination findings and combinations
Freeland [16]	246 patients presenting over a 10 month period with possible scaphoid fracture	30 patients eventually shown to have a fracture	Sensitivity = 90% Specificity = 40%	Sensitivity = 87% Specificity = 57%	-	-
Parvizi et al [17]	215 patients presenting within 24 hours of injury with a suspected scaphoid fracture.	56 patients had proven scaphoid fractures on initial or repeat plain radiographs or radioisotope bone scan	Sensitivity =100% Specificity = 19%	Sensitivity =100% Specificity = 30%	Sensitivity =100% Specificity = 48%	ASB, ST *and* LC Sensitivity =100% Specificity = 74%
Esberger [18]	99 patients with suspected Scaphoid fracture,	Initial x-rays positive = 34 patients. 10 further fractures found on repeat x-ray or bone scan at 2 weeks	-	-	Sensitivity = 70% Specificity = 22%	-

Waizenegger et al [19]	64 patients with suspected scaphoid fracture presenting within 3 days of injury	52 included patients of whom 23 had confirmed scaphoid fractures and 29 in whom scintigraphy excluded a scaphoid fracture	Day 1/Day 14 Sensitivity = 87%/65% Specificity = 38%/41%	-	Day 1/Day 14 Sensitivity = 48%/9% Specificity = 52%/76%	Pronation/ulnar deviation – Day1/Day14 Sensitivity = 82%/57% Specificity = 17%/45%
Grover [20]	221 patients with suspected scaphoid fracture presenting over a 6 month period	29 patients had proven fractures, plain X-rays repeated 10 days if initial films were normal	Sensitivity = 100% Specificity = 29%	Sensitivity = 83% Specificity = 51%	Sensitivity = 100% Specificity = 80%	Wrist diameter - significantly higher in patients with a fracture ($p<0.05$) but no cut-off value given
Rhemrev et al [21]	78 patients with suspected clinically scaphoid fracture presenting within 48 hours of injury and normal initial plain radiography	13 patients had definite scaphoid fractures following MRI and bone scintigraphy assessment	-	-	-	Supination strength <10% of contralateral side Sensitivity = 85% Specificity = 59% Extension <50% of contralateral side Sensitivity = 85% Specificity = 59%
Unay et al [22]	187 patients with a suspected scaphoid fracture presenting to a single hospital over a 1-year period.	Initial x-rays positive = 89. Of remaining 98 patients, 67 had MRI, which showed 12 additional scaphoid fractures.	-	-	Sensitivity = 71% Specificity = 35%	Pain on thumb/index pinch Sensitivity = 73% Specificity = 75% Pain during pronation Sensitivity = 79% Specificity = 58%
Wilson et al [23]	111 patients with clinical scaphoid injury but normal initial radiographs	29 patients had scaphoid fractures confirmed on bone scintigraphy	-	-	Sensitivity = 70% Specificity = 22%	-
Evenski et al [24]	104 children referred to orthopedics with high clinical suspicion of scaphoid fracture but normal initial X-ray	31children had radiographically evident scaphoid fracture on follow up x-ray	Sensitivity = 100% Specificity = 9%	-	-	Volar scaphoid tenderness OR 5.50 Pain with radial deviation OR 9.75 Pain with wrist active range of movement OR 5.51

* Axial loading of thumb includes tests described as Scaphoid compression or longitudinal thumb compression or thumb telescoping or thumb compression.

7.2 Imaging

Macroradiography

Only 2 studies on macroradiography were identified, these are summarised in table 2. On the basis of the available evidence macroradiography cannot be recommended as a useful diagnostic test in clinically suspected scaphoid fracture.

Table 2: Macroradiography

Study	Patient group	Key Results
Gaebler et al [25]	60 patients with suspected scaphoid fractures and normal initial radiography underwent macroradiography and MRI (8 confirmed scaphoid fractures)	Sensitivity = 50%, Specificity = 100%, Positive Predictive Value = 100%, Negative Predictive Value = 92.8%
Kukla et al [26]	25 patients with suspected scaphoid fractures and normal initial radiography underwent macroradiolgraphy and MRI (4 confirmed scaphoid fractures)	Correctly identified 2 of 4 scaphoid fractures and 4 of 8 bony lesions of the scaphoid.

Dual Energy X-Ray Absorptiometry (DXA) scanning

1 study, summarised in table 3, suggested that DXA scanning is insufficiently sensitive and specific to be clinically useful.

Table 3: Dual Energy X-Ray Absorptiometry (DXA) scanning

Study	Patient group	Key Results
Stephen et al [27]	10 patients with known scaphoid fractures were compared to 10 controls with DXA scans at day 3 post injury	Sensitivity = 50%, Specificity = 60%, Positive Predictive Value = 55.5%, Negative Predictive Value = 54.5%

Sonography and Intrasound Vibration

There is great variation in the sensitivity and specificity of ultrasound, with sensitivity ranging from 33.3% to 100% in the 5 studies shown in table 4.

Shenouda and England [30] also found timing to be important. In patients with definite fractures where the ultrasound test was initially positive it became negative after the second or third visits.

Ultrasound cannot be recommended on the basis of currently available evidence. At present there is insufficient evidence to support the use of intrasound vibration in the diagnosis of scaphoid fracture.

Table 4: Sonography and Intrasound Vibration

Study	Patient Group	Key Results
Hauger et al [28]	54 patients with clinical scaphoid fracture and normal radiographs underwent ultrasound examination within 7 days of injury, followed up at 2 weeks with conventional radiography and MRI, CT or bone scanning	Sensitivity = 100%, Specificity = 98%, Positive Predictive Value = 83%, Negative Predictive Value = 100% (Accuracy = 98%)
Senall et al [29]	18 patients with clinical scaphoid fracture but normal initial radiographs who underwent ultrasound of the scaphoid were then followed up with plain radiographs (9 confirmed fractures)	Sensitivity = 78%, Specificity = 89%, Positive Predictive Value = 88%, Negative Predictive Value = 80%
Shenouda and England [30]	74 patients with suspected scaphoid fractures – ultrasound assessment considered positive if pain, tingling or burning on affected side (43 confirmed fractures)	Sensitivity = 90.7%, Specificity = 96.7%, Positive Predictive Value = 97.5%, Negative Predictive Value = 88.2% (Accuracy = 93%)
DaCruz et al [31]	111 patients with clinical scaphoid fracture and negative initial radiology – ultrasound within a week of injury and re-x-rayed at 2-3 weeks (6 confirmed fractures)	Sensitivity = 33.3%, Specificity = 62.8%, Positive Predictive Value = 4.88%, Negative Predictive Value = 94.2%
Finkenberg et al [32]	50 patients with clinical scaphoid fracture and negative initial imaging underwent intrasound vibratory testing prior to bone scan/delayed X-ray examination (6 confirmed fractures)	Sensitivity = 100%, Specificity = 95%, Positive Predictive Value = 75%, Negative Predictive Value = 100% A further 36 patients (excluded from study as confirmed fracture on initial radiography) all had positive vibratory tests.

Scintigraphy (Bone Scan)

Bone scintigraphy has excellent sensitivity for the detection of scaphoid fracture, but generates a number of false positive results (Table 5). Technical difficulties and the duration and cost of the test limit its usefulness in clinical practice.

Table 5 Scintigraphy/Bone scanning

Study	Patient group	Key Results
Stordahl et al [33]	28 patients with clinically suspected scaphoid fracture and normal initial radiography who underwent bone scanning at 2 weeks post injury and repeat x-rays at 2 and 6 weeks.	Sensitivity = 100%, Specificity = 57.89%, Positive Predictive Value = 52.9%, Negative Predictive Value = 100% N.B.: 2 patients who were excluded as had confirmed scaphoid fractures on initial imaging both had positive bone scans.
Waizenegger et al [34]	84 patients with clinically suspected scaphoid fracture and normal initial radiology who underwent bone scanning and repeat radiography +/- CT scanning (7 confirmed scaphoid fractures)	Sensitivity = 100%, Specificity = 85%, Positive Predictive Value = 50%, Negative Predictive Value = 100% N.B.: 25 patients had increased uptake in areas of the wrist other than the scaphoid
Akdemir et al [35]	32 patients with suspected carpel injury and normal radiology underwent bone scintigraphy at 2 weeks post injury. (8 confirmed scaphoid fractures)	Sensitivity = 100%, Specificity = 85%, Positive Predictive Value = 50%, Negative Predictive Value = 100% N.B.: 12 patients had fractures of bones other than the scaphoid, and all had positive bone scans
Young et al [36]	23 patients with suspected scaphoid fracture and normal initial radiology who had bone scanning at 10-14 days post injury and repeat radiology at 3 weeks (3 confirmed fractures)	Sensitivity = 100%, Specificity = 85%, Positive Predictive Value = 50%, Negative Predictive Value = 100% N.B.: 2 patients had 'mildly positive' bone scans which were treated as 'normal' with under 3 weeks immobilization – neither patient had a confirmed fracture.
Jorgensen et al [37]	50 patients with suspected scaphoid fracture who had plain radiographs on the day of presentation, x-ray and bone scan on day 10 and x-ray on day 20 (22 confirmed fractures)	Sensitivity = 100%, Specificity = 37.04%, Positive Predictive Value = 52.78%, Negative Predictive Value = 100% N.B.: 4 patients had uninterpretable bone scans due to wet plasters and 10 of the positive bone scan patients had fractures of bones other than the scaphoid.
Wilson et al [23]	111 patients with suspected scaphoid injury but normal initial radiology underwent bone scanning. The first 42 patients were re-x-rayed at 10 days.	Bone scanning used as rule out test – those with negative bone scans had immobilization removed and no missed fractures were reported. 29 patients had bone scans consistent with scaphoid fracture – 2 of whom had positive x-rays at day 10 – however only 42 of the 111 patients underwent x-rays at day 10.
Bayer et al [38]	40 patients with suspected scaphoid fracture and initially normal radiographs had bone scanning at 14 days post injury (8 confirmed scaphoid fractures)	Sensitivity = 100%, Specificity = 85%, Positive Predictive Value = 50%, Negative Predictive Value = 100% N.B.: 10 patients with positive bone scans had wrist fractures affecting bones other than the scaphoid

CT Scanning

2 studies, summarised in table 6, looked specifically at the use of CT scanning. Further papers considered CT scanning in comparison to other modalities and these are discussed later.

Table 6: CT scanning

Study	Patient group	Key Results
Temple et al [39]	CT and plain film images were compared in 11 cadaver specimens with iatrogenic fractures.	CT: Sensitivity for detecting fracture =100%, sensitivity for detecting if fracture displaced >1mm =50%, specificity for detecting if fracture displaced >1mm =89% Plain film: Sensitivity for detecting fracture =99%, Specificity for detecting if fracture displaced >1mm =84%
Nguyen et al [40]	118 patients with clinical scaphoid fractures and normal or non-conclusive initial x-rays underwent CT scanning (26 fractures were identified)	3 scaphoid fractures identified by CT in the 16 patients with suspicious initial radiography 23 scaphoid fractures identified by CT in the 102 patients with normal films

MRI

Table 7 summarises the studies looking at MRI. The sensitivity for detecting scaphoid fractures was excellent (typically 100%) while also being able to give diagnostic information on non-scaphoid injuries both bony and ligamentous.

Table 7: MRI scanning

Study	Patient group	Key Results
Brydie & Raby [41]	195 patients with clinically suspected scaphoid fractures and normal initial x-rays underwent MRI. 2 patients were excluded due to movement artifact. (37 scaphoid fractures were identified)	37 scaphoid fractures demonstrated 37 non-scaphoid fractures (28 distal radial) 20 bone bruises 99 normal examinations 180 (92%) of patients had management altered as a result of MRI findings.
Bretlau et al [42]	47 patients with clinically suspected scaphoid fractures and normal initial x-rays underwent MRI between 4 and 11 days post presentation and at 8 weeks if positive for fracture. 5 patients were excluded. (9 scaphoid fractures were identified)	All 9 scaphoid fractures detected on initial MRI (sensitivity =100%) plus 9 other carpal/distal radial fractures
Lepisto et al [43]	18 patients with clinically suspected scaphoid fractures underwent MRI. (11 acute fractures were identified)	11 acute fractures demonstrated and also identified ligamentous injuries 2 fractures detected on plain film were not apparent on MRI but proved to be old
Kukla et al [26]	25 patients with clinically suspected scaphoid fracture and normal initial plain films underwent MRI within 7 days of injury with treating clinicians blinded to MRI results (9 fractures identified)	4 scaphoid body fractures and 5 other bony lesions (e.g. avulsion fractures) of scaphoid identified. Sensitivity =100%
Kumar et al [44]	22 patients with clinical scaphoid fractures and normal initial plain films had MRI imaging within 24 hours of presentation with review and repeat plain films or MRI at 10-14 days. (6 scaphoid fractures were identified on initial MRI)	Sensitivity = 100%, Specificity = 100%
Hunter et al [45]	36 patients with clinically suspected scaphoid fracture and normal initial plain films underwent MRI and repeat plain films at 2 weeks (13 scaphoid fractures identified)	10 of the 13 scaphoid fractures became visible on plain film. Sensitivity =100%
Khalid et al [46]	611 patients with clinically suspected scaphoid fractures and normal initial x-rays underwent MRI within 2 weeks of injury	269 patients had normal scans 272 patients had acute bony injuries (including scaphoid fractures) 23 patients had acute soft tissue injuries 47 scans demonstrated incidental pathology

Comparing Bone Scan with MRI

Two studies compared scintigraphy (bone scanning) with MRI and are described in table 8.

Table 8: Bone scanning versus MRI scanning

Study	Patient group	Key Results
Thorpe et al [47]	Prospective study comparing bone scan and MRI in 62 patients (3 of whom were excluded due to inability to tolerate MRI/degraded images) with suspected scaphoid fracture and normal initial radiographs. 4 scaphoid fractures were identified.	Bone Scan Sensitivity = 100%, Specificity = 94.5%, Positive Predictive Value = 57.1%, Negative Predictive Value = 100% MRI Sensitivity = 100%, Specificity = 98.18%, Positive Predictive Value = 80%, Negative Predictive Value = 100%
Beeres et al [48]	Study comparing bone scan and MRI in 100 patients with suspected scaphoid fracture and normal initial radiographs with plain radiographs and examination at 6 weeks used as gold standard where there was disagreement between MRI and bone scan. 20 scaphoid fractures were identified.	Bone Scan Sensitivity = 100%, Specificity = 90%, Positive Predictive Value = 71%, Negative Predictive Value = 100% MRI Sensitivity = 80%, Specificity = 100%, Positive Predictive Value = 100%, Negative Predictive Value = 95%

Comparing CT and Bone Scan

Only 1 study compared CT against bone scanning, the details of which are given in table 9.

Table 9: CT versus Bone Scan

Study	Patient group	Key Results
Breederveld et al [49]	Prospective study comparing CT and bone scan with follow up CT at 6 weeks and clinical follow up at 8-14 months in 29 patients with suspected scaphoid fracture and normal initial radiographs. 9 scaphoid fractures identified.	Bone Scan Sensitivity = 78 %, Specificity = 90%, Positive Predictive Value = 78%, Negative Predictive Value = 90% CT Sensitivity = 100%, Specificity = 100%, Positive Predictive Value = 100%, Negative Predictive Value = 100%

Comparing MRI and CT

Table 10 summarises the 2 studies comparing MRI and CT.

Table 10: CT versus MRI

Study	Patient group	Key Results
Memarsadeghi et al [50]	Prospective study comparing CT and MRI against gold standard of plain radiographs at 6 weeks in 29 patients with suspected scaphoid fracture and normal initial radiography – differentiated between cortical fractures (8 fractures) and trabecular fractures (3 fractures)	MRI – All scaphoid fractures Sensitivity = 100%, Specificity = 100%, Accuracy = 100%, MRI – Cortical scaphoid fractures Sensitivity = 38%, Specificity = 100%, Accuracy = 55%, CT – All scaphoid fractures Sensitivity = 73%, Specificity = 100%, Accuracy = 89%, CT – Cortical scaphoid fractures Sensitivity = 100%, Specificity = 100 %, Accuracy = 100%,
Mallee, W., et al. 2011	Prospective study comparing CT and MRI against gold standard of plain radiographs at 6 weeks in 40 patients with suspected scaphoid fracture and normal initial radiography. 6 scaphoid fractures identified (5 on plain films, 1 not visible on x-ray but seen on CT and MRI) with 5 patients lost to follow up and 1 excluded due to inadequate imaging.	MRI – scaphoid fractures only Sensitivity = 67 %, Specificity = 89%, Accuracy = 85%, CT – scaphoid fractures only Sensitivity = 67%, Specificity = 96%, Accuracy = 91%,

The results of the Mallee study are significantly worse than all others looking at CT and MRI. The authors excluded all fractures visible on initial imaging, and considered a focal area of bone oedema on MRI as diagnostic of a fracture. If the MRI criteria had been changed to require a cortical abnormality to be visible, then it would have found 4 fractures (instead of 7), with one false positive result (instead of 3) and three false-negative results (instead of 2). This would have given a sensitivity of 50%, specificity of 96% and accuracy of 88%.

One difficulty is the lack of a definition as to what constitutes a scaphoid fracture. MRI findings may be a bone bruise, CT findings may be a vascular channel, and 6 week plain radiography may not be a definitive gold standard.

Cost effectiveness studies

There have been a number of cost effectiveness studies that demonstrate that one mode of imaging is more cost effective than another. These are shown in Table 11. However there is great variation in the calculated costs of different types of imaging and follow up, which makes interpretation of these data difficult. Furthermore the loss of income and personal inconvenience associated with being unnecessarily immobilized in a cast or splint is difficult to quantify, and will vary greatly between individuals.

Table 11: Cost effectiveness studies comparing different management strategies in suspected Scaphoid fracture.

Study	MRI Cost	X-ray cost	Clinic cost	Bone scan cost	Plaster cast cost
Gooding et al [65]	NZ$300	NZ$60	NZ$77	Not stated	NZ$125
Brooks et al [64]	AU$475	AU$28	1st AU$119 (subsequent AU$60)	AU$295	Not stated
Saxena et al [63]	£120	£22	£40	£70	£25
Hansen et al [62]	€330	€88	€170	Not stated	Not stated
Buul et al [61]	Not stated	€28	Not stated	€164	€50

Published Reviews

Yin and colleagues used a meta-analysis to compare bone scintigraphy, MRI and CT in the detection of clinically suspected scaphoid fractures.[2] This is also the current Cochrane review. The main results are shown in table 12.

Table 12: Results of a meta-analysis of the diagnostic properties of commonly used tests in suspected scaphoid fracture.[2] (Ln DOR = Natural logarithm of Diagnostic Odds Ratio)

Imaging modality	Number of Studies	Number of patients	Sensitivity [95% CI]	Specificity [95% CI]	Ln DOR [95%CI]
Bone Scintigraphy	15	1,102	97% [93-995]	89% [83-94%]	4.78 [4.02-5.54]
MRI	10	513	96% [91-99%]	99% [96-100%]	6.60 [5.43-7.76]
CT	6	211	93% [83-98%]	99% [96-100%]	6.11 [4.56-7.66]

The studies included in the meta-analysis were generally small, with the largest recruiting just over 200 patients. None of the studies were randomised. Bone scintigraphy demonstrated a statistically worse specificity than MRI ($p<0.001$) and CT ($p=0.001$), however there was no statistically significant difference between CT and MRI. The diagnostic odds ratio (DOR) for MRI was greater than bone scintigraphy ($p=0.009$), but no other significant differences were identified in DOR.

Ring and colleagues [60] also undertook a review of the literature and calculated the diagnostic properties of bone scintigraphy, MRI, CT and ultrasound (Table 13). The high negative predictive value is attributable to the low prevalence of scaphoid fractures.

Table 13: Diagnostic properties of commonly used imaging tests in suspected scaphoid fracture.[60]

Imaging modality	Number of patients	Sensitivity [95% CI]	Specificity [95% CI]	Accuracy	Prevalence adjusted positive predictive value	Prevalence adjusted negative predictive value
Bone Scintigraphy	9	96%	89%	93%	0.39	0.99
MRI	22	98%	99%	96%	0.88	1.00
CT	8	94%	96%	98%	0.75	0.99
Ultrasound	4	93%	89%	92%	0.38	0.99

Overall, MRI appears to have the best diagnostic performance of the available second-line imaging modalities, and has the additional advantage of detecting other wrist pathology such as ligamentous injury. However, access to MRI is limited in many UK hospitals and the test is contraindicated or poorly tolerated in some individuals. Given the problems noted above in relation to bone scintigraphy, CT scanning is a reasonable alternative if MRI is not possible or contraindicated.

7.3 Immobilisation

Published research in this area is very limited (see table 14), but the available evidence suggests that a Scaphoid cast offers no benefit over a standard "Colles" cast, and is more disabling for the patient. There may be some benefit to immobilising a Scaphoid fracture in an above elbow cast, but the two studies in this area do not agree.

Table 14: Immobilisation

Study	Patient Group	Key Results
Kaneshiro et al [52]	Cadaveric study of 4 iatrogenic scaphoid fractures immobilised with a below elbow cast	Significant movement of scaphoid (>1mm) with pronation/suppination
Clay et al [53]	Prospective randomized trial comparing rate of non-union between patients randomly allocated to either a "Colles" or scaphoid cast. 292 patients were reviewed at 2, 4 and 8 weeks when the cast was removed. If healing was in doubt at this point, the plaster was replaced for a further 4 weeks.	No difference in non-union rate between the two groups, but patients felt the scaphoid cast was more disabling.
Hambidge et al[56]	Compared rate of non-union after immobilising the wrist in flexion or extension in fractures of the waist or distal pole of the scaphoid treated in a "Colles" cast	No difference in non-union rate, flexion or grip strength at 6 months, but significantly reduced extension in patients who were immobilized in 20 degrees of flexion rather that 20 degrees of extension
Karantana et al [55]	Compared hand function with the wrist immobilized in a "Colles" or scaphoid cast	Scaphoid cast caused significantly more disability than the "Colles" cast, or no cast at all
Gellman et al [57]	Compared a long thumb spica, which included elbow immobilization (28 fractures), with a short thumb spica that did not immobilise the elbow (23 fractures)	Fractures of the proximal or middle third of the scaphoid healed quicker if immobilised for 6 weeks in a long thumb spica followed by a short thumb spica, rather than spending the entire period of immobilisation in a short thumb spica. Fractures of the distal third healed independently of splint length
Terkelsen et al [58]	48 patients in the long cast group and 44 in the short cast group, all of whom were followed up for at least 12 months.	Non-union occurred in 2 of 5 fractures in the proximal part of the scaphoid, and 8 of 77 fractures in the waist or distal part. There were 7 non-unions in the long cast group and 3 in the short cast group, but this difference was not significant (p=0.25).

7.4 Follow up

There is no useful evidence on the duration or timing of clinical follow-up in suspected scaphoid fracture. Once a fracture has been confirmed or excluded further management can proceed accordingly, and therefore clinical follow-up is only required until a firm diagnosis has been made, either on clinical grounds or through the use of additional imaging.

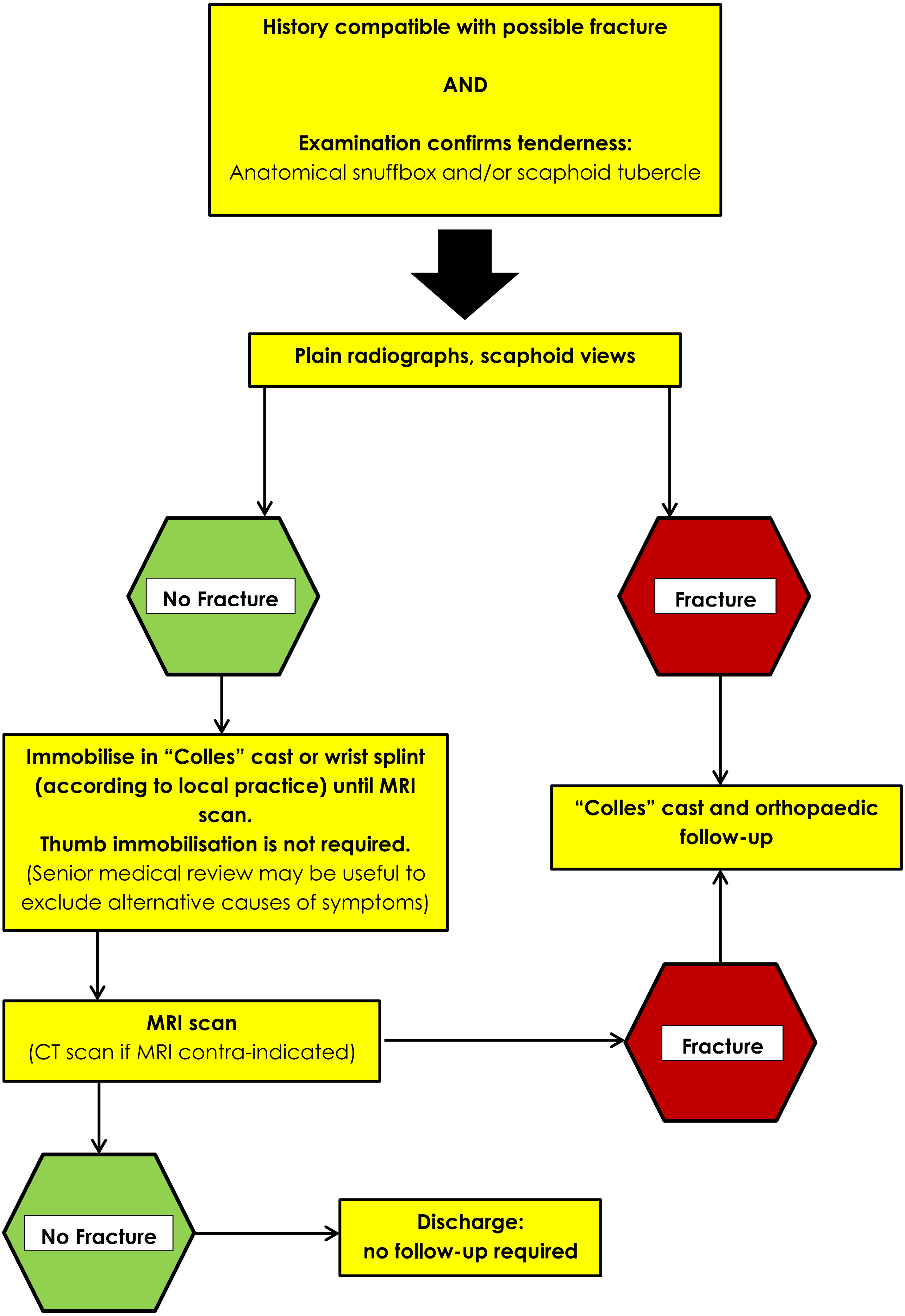
Outpatient review at two weeks is a popular option, based on the assumption that an initially occult fracture will be more readily visualized on plain X-rays taken at this stage. However, whilst it is true that scaphoid fractures that cannot be detected on initial X-rays may become apparent on an X-ray taken after two weeks, the published evidence indicates that scaphoid fractures may still be diagnosed for the first time when a patient is X-rayed at 8 weeks,[29] though the clinical significance of such injuries is unclear.

7.5 Scaphoid fractures in children

These are rare fractures; accounting for 0.34% of all children's fractures. However scaphoid fractures become more common as the child grows older. [59]

Evenski and colleagues performed a retrospective review of children with suspected scaphoid fracture who presented to a single children's emergency department over a 7 year period.[24] Of 165 wrists, 104 were included in the study (there were 103 patients, since in one child both wrists were included). 21 had scaphoid fractures on presentation, 11 had an ipsilateral upper limb fracture and there were incomplete data for 29. Those included were 57 boys and 46 girls with an average age of 13 years (range 5-15 years). 31(30%) children were found to have a scaphoid fracture during follow up: 14 at two weeks, 12 at five weeks and 5 at seven weeks.

8. Evidence-based flowchart



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