The imaging assessment of suspected scaphoid fracture

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Learning objectives

To raise awareness of the range of, and indications for, different imaging modalities in the assessment of suspected scaphoid fractures, their imaging appearances and the common diagnoses encountered.
Background

Injuries to the wrist and carpus are common presenting complaints to the Emergency Department. Scaphoid fractures are more common in younger males\(^1\) and often result from a fall onto an outstretched hand. Clinical examination can be unreliable and it is often difficult to ascertain the exact site of injury in these circumstances. Tenderness within the anatomical snuff box (ASB), over the scaphoid tubercle and male gender have all been proposed as independent predictors of fracture.\(^2\)

Scaphoid fractures most commonly involve the waist (70%), proximal (20%) or distal pole (10%).\(^3\) Although the majority of suspected scaphoid injuries turn out not to be fractured, as many as a third of scaphoid fractures are initially occult. Scaphoid fractures are also prone to complications such as non-union, avascular necrosis, development of carpal instability and osteoarthritis. In addition, those patients who do not suffer a fracture face potential morbidity related to prolonged unnecessary immobilisation.\(^4\) Therefore the importance of early and accurate diagnosis of scaphoid fractures cannot be overstated.
Findings and procedure details

Clinical findings and investigation with plain radiographs

Initial imaging assessment of suspected scaphoid fracture is with plain film radiography. Four views of the scaphoid are obtained, (posteroanterior (PA), lateral, PA with ulnar deviation and oblique) (Figs 1 & 2). If these images show a definite fracture (Fig 3) the patient is usually immobilised in a scaphoid-type cast for a period of six weeks with subsequent orthopaedic clinical and radiographic review. However, scaphoid fractures can be particularly difficult to identify on initial plain radiographs and therefore repeat plain radiograph 10-14 days post injury is frequently advised.

In a recent audit of practice in the UK almost a fifth of patients with suspected scaphoid fracture required further clinical follow up due to ongoing symptoms. Patients were followed up with repeat plain radiographs in 68% of hospitals in this survey, with second line imaging variably utilising MRI (63.9%), CT (27%) or isotope bone scan (9%) mostly between 10 days and 4 weeks of injury.5

MRI

MRI has emerged as the gold standard in the investigation of occult scaphoid fracture, having excellent sensitivity (97.7%) and specificity (99.8%). It outperforms both bone scan and CT in the diagnosis of radiographically occult scaphoid fractures.

In addition to detecting radiographically occult scaphoid fractures (Fig 4), MRI can detect other pathologies such as bone bruising (Fig 5), tenosynovitis (Fig 6), and fractures of surrounding carpal or wrist bones (Figs 7 & 8). Carpal instability resulting from scaphoid fracture and injury to the scapholunate ligament complex can also be determined (Fig 9) and injuries to other soft tissues such as the triangular fibrocartilage can also be inferred (Fig 10).

Unfortunately the benefits of MRI must be weighed against the limited availability and increased cost of the modality compared to other techniques. In our institution we strive to offer MRI for patients with suspected scaphoid fracture using a limited trauma protocol. This offers the current gold standard for the detection of scaphoid fracture with the potential disadvantage that other pathologies such as ligamentous injuries may not be adequately visualised, a phenomenon that has been observed in other previously published work.6
CT

CT is not as sensitive or specific as MRI in the detection of radiographically occult scaphoid fractures, however it is superior to plain radiography and may be useful in areas where MRI is not easily accessible. In these situations confirmation of scaphoid fracture and/or other pathologies initially missed by plain radiograph may become apparent (Figs 11-13).

Union can also be assessed with CT, where bony trabeculae can be seen crossing the fracture site as a sign of healing. In our institution we advise CT to assess union in this particular group of patients. However MRI has also gained popularity in this area recently.

The benefit of CT lies in its ability to provide exquisite images for the purposes of operative planning in complex/intra-articular fractures or where there is non-union (Fig 14). We are able to provide multiplanar reformats to our orthopaedic hand surgery colleagues such that they can optimally visualise fracture anatomy prior to surgical intervention (Fig 14).

NM

Technetium bone scans of scaphoid fractures demonstrate increased tracer uptake at the fracture site, best detected on scans performed more than 72 hours following injury.\(^7\) The technique can also be used to demonstrate avascular necrosis where there is lack of tracer uptake, usually seen in the proximal scaphoid due to its retrograde blood supply. Whilst bone scintigraphy is highly sensitive for occult fracture, poor specificity (false positives secondary to marrow oedema without fracture), radiation burden and lack of anatomical information hamper the techniques widespread acceptance.\(^7\) Regarding the investigation of scaphoid fractures, for these reasons, we do not use nuclear medicine bone scintigraphy in our institution.

Complications of scaphoid fracture

Mal-union & Non-union

The incidence of scaphoid fracture nonunion is 5-15%. Many injuries may take as long as 12 weeks to heal, non-union is diagnosed if the fracture does not unite within 6 months (Fig 14). Non-union is most commonly associated with fractures of the proximal pole and displaced fractures. Non-united fractures demonstrate a rim of increased sclerosis with cyst formation at the fracture line (Fig 14).
Non-union in the setting of an unstable fracture may predispose to dorsal (DISI) (Fig 13) or volar (VISI) intercalated segment instability, scaphoid non-union advanced collapse (SNAC wrist), scapholunate advanced collapse (SLAC wrist) (Fig 9) and resultant osteoarthritis. Mal-union usually results in a flexion deformity with secondary development of pain, osteoarthritis and reduced range of movement.

Avascular necrosis

Avascular necrosis (AVN) occurs in 10-15% of scaphoid fractures and is substantially higher in the presence of scaphoid non-union. Due to the anatomically distal origin of the blood supply of the scaphoid, the proximal pole is most frequently affected. CT and MRI are both useful in the assessment of early AVN, although late changes can be diagnosed on plain films as well. CT shows sclerotic changes in the affected bone (Fig 15). MRI with and without intravenous contrast is preferred over CT for occult AVN of the scaphoid, although this examination is not routinely performed in our institution. Low signal within the marrow on all phases is indicative of established AVN in this setting, although imaging appearances in partially viable and/or ischaemic marrow can be confusing. Dynamic contrast enhanced imaging of the scaphoid has been trialled with varied success, however overall gadolinium enhanced MRI is superior to unenhanced MRI regarding the detection of AVN.  

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Fig. 1: PA and PA oblique views of the scaphoid bone

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Fig. 2: Lateral and PA with ulnar deviation views of the scaphoid bone

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Fig. 3: Scaphoid fracture on plain radiograph

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Fig. 4: Scaphoid fracture on STIR MRI

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**Fig. 5:** An example of bone bruising (high signal) at the proximal pole of the scaphoid bone - no fracture demonstrated.

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Fig. 6: High signal on STIR MRI images of the abductor tendons around the wrist in an example of De Quervain's tenosynovitis clinically mimicking scaphoid fracture following a fall onto outstretched hand.

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Fig. 7: High signal on STIR MRI in the distal radius in suspected Salter Harris type V fracture which clinically mimicked a scaphoid injury.

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Fig. 8: Fracture of the radial styloid on MRI performed for suspected scaphoid fracture.

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Fig. 9: Widening of the scapholunate interval indicating scapholunate ligament injury and early scapholunate advanced collapse (SLAC wrist).

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**Fig. 10:** High signal in the region of the TFCC suggesting injury to this structure. A modified trauma MRI protocol as performed in our institution is only able to provide limited information regarding this and other alternative soft tissue injuries in suspected scaphoid fracture.

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**Fig. 11:** Scaphoid fracture as demonstrated by CT

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**Fig. 12:** Scaphoid fracture with scapholunate dissociation and distal radioulnar joint disruption on CT

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Fig. 13: Dorsal tilt of the lunate in keeping with a DISI deformity on CT imaging (sagittal images). Note the associated fracture of the dorsal aspect of the lunate bone.

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Fig. 14: Scaphoid non-union on CT - note the sclerosis surrounding the fracture line and associated cystic change. Sagittal oblique reformat enabling optimal imaging of the scaphoid to allow surgical planning.

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Fig. 15: Sclerosis of the proximal pole of the scaphoid in keeping with AVN on CT imaging
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Conclusion

Suspected scaphoid injuries are a common finding in any radiologists reporting pile. It is important that all radiologists are aware of the imaging appearances on plain radiography and that scaphoid fractures may initially be radiographically occult. An understanding of the correct subsequent imaging investigations where scaphoid fracture is suspected despite normal appearing radiographs is also paramount in order to manage patients effectively and reduce the incidence of complications arising from inappropriate management of these injuries.
References