



The anatomy, diagnosis and management of acute scaphoid fractures: An Overview

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Abstract

Scaphoid fractures are the most common carpal bone injury in young adults and remain a frequent cause of diagnostic uncertainty and delayed treatment. Missed fractures risk progression to nonunion and scaphoid nonunion advanced collapse (SNAC wrist), with long-term functional and economic consequences. This educational review outlines key anatomical considerations, clinical assessment, and the role of imaging in early diagnosis. We review contemporary evidence guiding the management of scaphoid fractures by anatomical location and displacement, including insights from the SWIFFT trial and current British Society for Surgery of the Hand (BSSH) guidance. Surgical and non-operative approaches are discussed, alongside evolving techniques such as arthroscopic-assisted fixation. Emphasis is placed on appropriate imaging, timely intervention, and shared decision-making to optimise outcomes and minimise complications.

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Introduction

The scaphoid is the most commonly fractured carpal bone¹, accounting for 90% of acute carpal bone fractures in young individuals². Middle third fractures account for 60-66% of scaphoid fractures¹. When managed in a timely manner, clinical outcomes are good, with a union rate of 88-95% in nondisplaced waist fractures managed in plaster³. However, it is not unusual for these fractures to be missed or misdiagnosed. Patients with undiagnosed scaphoid fractures can go on to develop degeneration of the carpus and eventually scaphoid nonunion advanced collapse (SNAC wrist). This results in significant impairment of hand and wrist function, with substantial individual and economic burden. It is therefore imperative that these injuries be identified and treated as soon as possible after injury to ensure the best possible outcome. There are a variety of treatment strategies, each with their own set of benefits and complications.

Anatomy of the Scaphoid

The word “scaphoid” derives from the Greek *skaphē* meaning skiff or boat because of the elongated shape of the bone. It is almost completely covered in articular cartilage⁴, creating precise surface loading demands and an intolerance to malunion. The scaphoid flexes during wrist flexion and radial deviation, and extends in extension and ulnar deviation. On longitudinal loading of the scaphoid, there is a tendency towards flexion, whilst in extension, the palmar cortex is under tension. For this reason, excessive loading with wrist extension and ulnar deviation puts the scaphoid at high risk of fracture⁵.

Ligamentous attachments account for roughly 9% of the surface area including both intrinsic and extrinsic wrist ligaments⁵. In a non-injured scaphoid, these ligaments ensure that all movements are closely related to the rest of the carpal bones. The ligamentous attachments of the scaphoid are concentrated within the proximal portion, so following a fracture the forces no longer act across the whole bone. The unstable distal fragment can rotate and displace, whilst the proximal portion continues to move in conjunction with the surrounding carpus due to the strong intercarpal ligaments⁵.

Scaphoid blood supply is complex and not entirely understood (figure 1). Although there is significant anatomical variation, the blood supply is mainly via the radial artery. A dorsal carpal branch from the radial artery enters at the dorsal ridge of the scaphoid and accounts for around 80% of the total supply⁴. The only supply to the proximal pole is via retrograde interosseous flow

from this dorsal branch, hence fractures disrupting this flow increase the risk of nonunion and proximal fragment avascular necrosis. The more proximal the fracture, the higher the risk of nonunion⁴. The remaining 20% of the total blood supply is via the superficial palmar branch, entering at the scaphoid tubercle but this only supplies the distal pole⁴. Understanding the blood supply is important when planning surgical management of fractures, as causing damage to the dorsal vessels will risk the entire supply to the proximal pole.

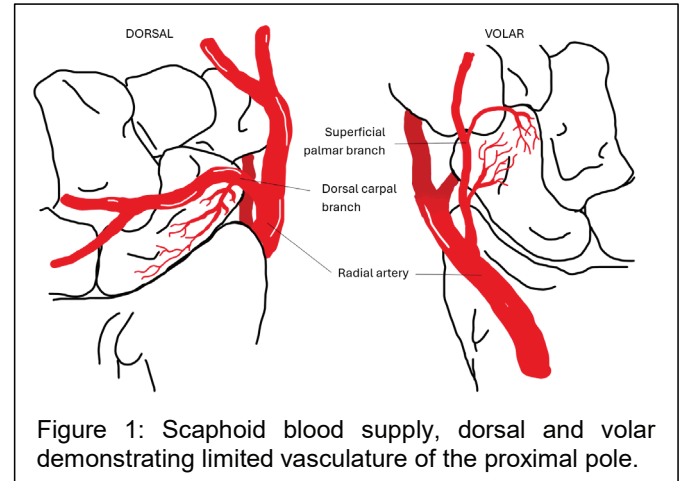


Figure 1: Scaphoid blood supply, dorsal and volar demonstrating limited vasculature of the proximal pole.

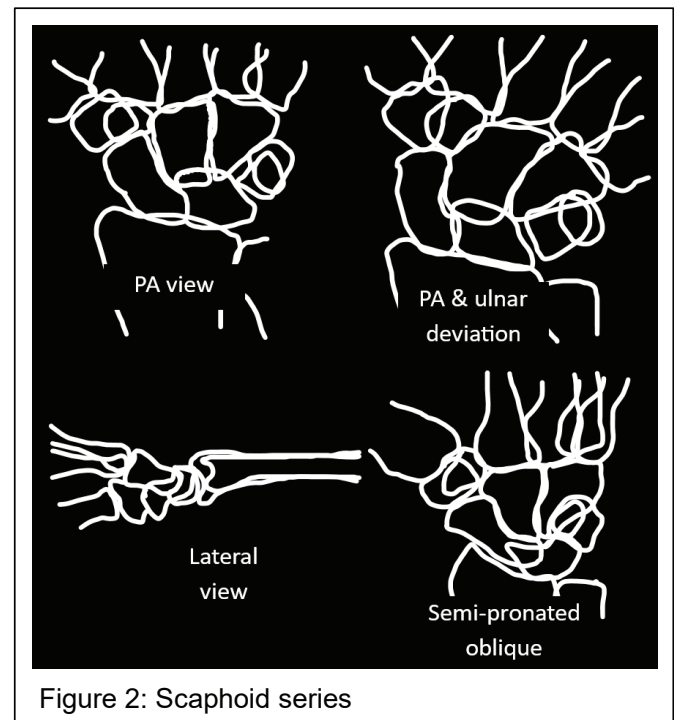


Figure 2: Scaphoid series



Classification

Classification of scaphoid fractures can be based on fracture stability, pattern, and location. However, these systems have poor inter and intra-observer reliability⁶ so for simplicity, scaphoid fractures can broadly be categorised into anatomical subgroups by dividing the scaphoid into thirds.

Middle third 'waist' fractures are the most common (60-85%), whilst 25% are in the distal third (including tuberosity fractures), and the remaining 5-10% in the proximal third⁴. Fractures in the proximal third are at highest risk of nonunion whilst the separate blood supply to the distal pole (via the superficial palmar branch, figure 1), means that these fractures are most likely to heal without surgical intervention.

Presentation and Clinical Assessment

Evaluation of these injuries relies on a thorough history, physical examination and radiographic evaluation of the patient. Clinicians should maintain a high index of suspicion as fracture is commonly missed. Scaphoid fractures are most common following a fall on outstretched hand with the wrist in extension and ulnar deviation as the scaphoid is extended and under most stress in this position. They can however occur after any forced hyperextension injury. Scaphoid fractures are uncommon in children under the age of 9, with a peak between 20 and 29 years of age in men, and between 10 and 19 years of age in women¹ There is a male predominance

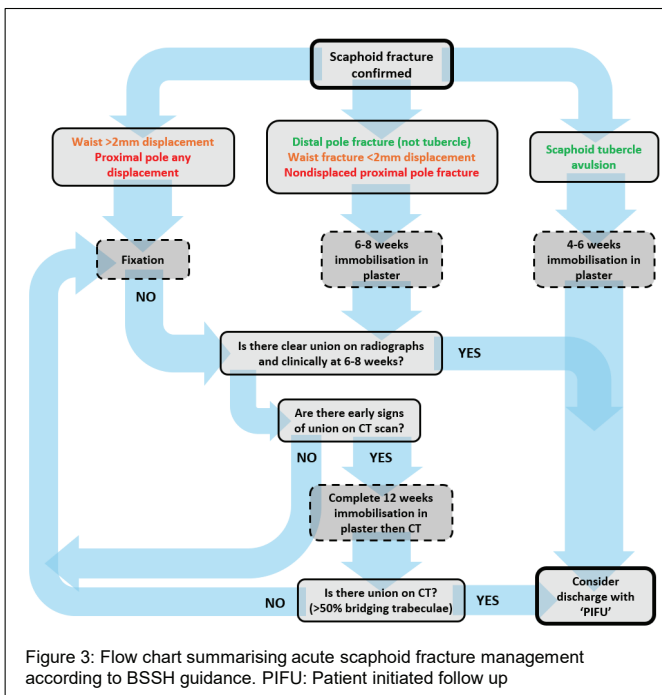
with an incidence of 107-151 compared to 14-46 per 100,000 in women¹.

A thorough history of the mechanism can indicate the likelihood of other injuries. A high energy mechanism could point to significant carpal injury which must be considered in the differential, even with a clear scaphoid fracture, as missing concurrent injuries may mean underestimating a much more significant problem. Particularly in patients with a high energy injury, other injuries must be ruled out (table 1). An analysis of scaphoid injuries presenting to US trauma centres found that the most common associated injuries were fractures of the distal radius, distal ulna and fracture of other carpal bones⁸. It is important to ascertain the patient's handedness, their activity level, smoking status and past medical history including any immunosuppressive medication.

On examination following forced hyperextension injury, any one of anatomic snuffbox (ASB) tenderness, scaphoid tubercle tenderness, pain on ulnar deviation or pain on axial loading of the thumb, indicates a high probability of scaphoid injury⁷, though when used in combination the positive predictive value is improved. The sensitivity of these tests is high (0.87 for ASB tenderness and 0.82 for tubercle tenderness), but they have low specificity risking overtreatment and unnecessary immobilisation (table 2). The remainder of the hand and fingers should be assessed for any other injuries, and the distal radius and ulna for deformity and tenderness that might indicate fracture.

Imaging

If a scaphoid fracture is suspected following clinical examination, then plain radiograph scaphoid series should be performed including at least 4 views: posteroanterior, lateral, semi-pronated oblique, and elongated scaphoid view (PA in ulnar deviation, figure 2)⁷. In as many as 21.8% of cases, fractures are missed on initial radiographs^[J]. If initial radiographs show no clear fracture but clinical suspicion remains high, then further imaging is required. This will also help to identify any additional injuries that may be suspected based on initial evaluation. Traditionally, patients were placed into a cast and repeat radiographs were taken at two weeks, as by this time the fracture would be easier to delineate due to resorption of bone from the margins. Unfortunately, this means patients may be subject to unnecessary immobilisation if subsequently they are found not to have a fracture.





MRI is the modality of choice for occult fractures with a high sensitivity and specificity (table 3). It also has the additional advantage of being able to pick up alternate pathologies such as soft tissue injuries and bone contusions which may explain the patient's symptoms in the absence of a fracture. In addition to detecting scaphoid injuries in the acute setting, MRI can be helpful in evaluating delayed presentations for signs of avascular necrosis of the proximal pole in the setting of nonunion. This is helpful in determining management of these patients, though is beyond the scope of this article.

Studies have demonstrated that MRI is cost-effective, may save lost workdays, and prevent stiffness resulting from unnecessary prolonged cast immobilisation¹². It has been reported that as many as 80% of patients treated with plaster for suspected scaphoid fracture, but normal initial radiographs, may have been immobilised unnecessarily¹³, and that early MRI could have prevented this. Current 'National Institute of Health and Care Excellence' (NICE) guidance therefore recommends early magnetic resonance imaging (MRI) to establish a diagnosis and initiate a management plan within 2 weeks of injury^{7,11}. Unfortunately, studies have shown that many UK trusts have only limited access to MRI and only very few are in a position to offer this directly from first encounter in the emergency department¹⁴. Computed tomography (CT) scanning of the scaphoid is also a helpful tool, despite having a lower sensitivity than MRI for detection of occult fractures, it has a high specificity (table 3). The scanning plane should be in line with the 1st metacarpal with the wrist in radial deviation to elicit views in the longitudinal axis of the scaphoid and allow better appreciation the anatomy¹³. Where a fracture has been diagnosed, CT provides better visualisation and characterisation of the displacement and angulation of fracture fragments⁷. In particular, CT is helpful in assessing for a humpback deformity in scaphoid waist fractures and can evaluate fracture position, comminution, and the degree of displacement, which might indicate the probability of nonunion. It is also important for assessing union following management, whether non-operative or surgical. If patients have bridging trabeculae over more than 50% of the cross-sectional area of the fracture on CT, in the majority of cases this will progress to complete union without further immobilisation¹⁵.

Management

Treatment of the acute scaphoid fracture depends on the location of the fracture and the degree of displacement. Broadly speaking, for fractures with a high risk of nonunion, operative management is usually recommended, whilst

in cases with a low risk of nonunion, non-operative immobilisation is suitable (figure 3).

Distal pole fractures are most likely to unite due to their generous blood supply, and therefore the British Society for Surgery of the hand (BSSH) recommend immobilisation of the wrist in a below elbow plaster excluding the thumb for 6 weeks⁷. If there is significant displacement or signs of delayed healing after 12 weeks, surgical management can be considered. For extra-articular tuberosity avulsion fractures, immobilisation is only required for 4-6 weeks⁷ as stability is not compromised.

For scaphoid waist fractures, the SWIFFT study compared surgical fixation with immobilisation. They found no significant difference in long term functional outcomes between the operative and non-operative groups but noted that surgical complications were higher in the group that initially underwent surgery². They also found there was no significant difference in union rates between the two at 52 weeks². This was in contrast with previous work that reported a more favourable outcome with surgery in terms of functional outcome, grip strength, return to work and time to union¹⁶.

The study authors concluded that in patients with <2mm displacement, cast immobilisation should be the initial management strategy (as for distal pole fractures), with operative management only in the case of subsequent delayed union². This finding was incorporated into the guidance subsequently published by BSSH⁷. In patients treated with plaster promptly within 3 weeks of injury, outcomes are usually favourable with union rates of 88-95%³.

For all patients managed non-operatively, BSSH recommend radiographs out of cast at 6-8 weeks after immobilisation. If there is snuffbox or tubercle tenderness and no radiological evidence of union, the plaster should be replaced and a CT performed. Where there is no evidence of union on CT, fixation should be considered within 2 weeks. However, where there are signs of early union then immobilisation can be continued with a further review and imaging at 12 weeks. It should be noted that prolonged cast immobilisation is associated with stiffness and patient dissatisfaction¹⁶ so if at this point the fracture is still not uniting, surgery should be offered⁷.

Waist fractures with displacement of greater than 2mm, carry an increased risk of nonunion (50%) and AVN (50%)³ and therefore BSSH recommend acute surgical fixation within 2 weeks of injury⁷. As we have established, proximal pole fractures have a high nonunion risk, hence



early fixation of these injuries is also recommended⁷. In the case of entirely non-displaced fractures, cast immobilisation can be considered following careful discussion with the patient, if this is their preference^{3,4,7}.

Patients who have undergone fixation, require close follow up to ensure they go on to unite. BSSH advises patients should not be discharged until union is confirmed radiographically, either on CT, or delayed radiographs at 6 months⁷. In addition to radiological confirmation of union, clinical parameters should also be assessed, including ASB and tubercle tenderness, and pain on ulnar deviation of the wrist. If the pain has settled and radiologically they have united, the patient can be discharged via a patient initiated follow up (PIFU) pathway, facilitating re-review if their symptoms return⁷.

In the paediatric population, management of scaphoid fractures is aimed towards cast immobilisation in the first instance, even if the fracture remains non-displaced a period of nonoperative management can be trialed prior to surgical management. However, that in the case of displaced nonunion ORIF +/- bone grafting is the preferred option¹⁷. Paediatric scaphoid fracture nonunion is incredibly rare, tending to result from delayed or missed diagnosis that was not immobilised in time^{1,17}. A delay of >21 days associated with lower union rates when managed nonoperatively, resulting in 75% union in delayed management vs 97% in acute fractures¹⁸. Unfortunately, the rate of delayed presentation and treatment can be as high as 29% in paediatric scaphoid fractures¹⁸.

Surgical technique

Surgical fixation can be performed using either a percutaneous or open reduction, and internal fixation with either a compression screw or Kirschner wires. This can be achieved via either a volar or dorsal approach.

In open reduction, the dorsal approach allows a more central screw placement, but can compromise the dorsal blood supply risking proximal pole AVN. If the screw head is proud, it can cause articular damage to the scaphoid fossa¹⁹, accelerating arthritic degeneration. Hyperflexion of the wrist is required to place the screw, increasing angulation of any humpback deformity. The dorsal approach is best employed in the fixation of proximal pole fractures as it allows superior engagement of the proximal fragment with the screw³.

The volar approach on the other hand, preserves the dorsal blood supply and allows for visualisation and

correction of any humpback deformity. In cases with significant deformity or bone loss, it facilitates placement of bone graft. It is used in fixation of waist and displaced distal pole fractures⁴, as well as in the context of nonunion. However central screw placement is not possible without disruption of the scapho-trapezial joint causing articular damage¹⁹.

Open reduction and internal fixation requires significant dissection, which can disrupt the soft tissues and further compromise an already tenuous blood supply. For this reason, percutaneous methods are preferred by some surgeons. This requires use of image intensifier to ensure reduction and screw placement is correct. In terms of approach, a 2016 meta-analysis found no significant difference in rate of nonunion, complications, grip strength, or in functional outcomes between the volar and dorsal approaches¹⁹.

Use of arthroscopy to assist in percutaneous fixation can be a powerful adjunct which allows visualisation of fracture reduction and can aid screw positioning²⁰. It offers a clear view of the fracture and can enable a skilled operator to assess blood supply and deformity that may need addressing prior to fixation. Furthermore, it can assist in detecting other pathology within the carpal joints such as ligamentous disruption that may lead to carpal instability.

Complications

Complications can be divided into those seen in patients managed with plaster immobilisation, and those managed with surgical fixation. The SWIFFT study² found that in patients managed in plaster, complications associated with the cast itself were predominant. Within the first 6 weeks of treatment this included broken plaster (3.2%), cast being too tight (3.6%), or cast being too soft (4.1%). The main complication associated with plaster was discomfort and soreness (10.5% at 6 or 12 weeks), this was compared with only 1.4% for patients who underwent surgery. Whilst discomfort during a prolonged period of immobilisation is unlikely to cause significant long-term complications, it is likely to reduce compliance. Overall, 20.5% of patients in the plaster group had at least 1 plaster-related complication, compared with 2.7% of those managed operatively².

For patients managed with surgery, only 2.7% had a plaster related complication at any time point. However, the rate of surgery related complications was unsurprisingly, higher. The study looked at a variety of complications including surgical site infection, delayed



wound healing and regional pain syndrome, all of which had very low rates. There were also very low rates of nerve related complications, with 1.4% experiencing damage to the superficial median nerve and numbness. The most common complications were screw related, with screw protrusion seen in 4.6% of patients in the surgery group. Overall, 14.2% of patients managed operatively had at least 1 surgical complication, compared with 1.4% in the cast immobilisation group².

Dias et al. reported that though the overall risk of a complication between the two groups was similar, the plaster group were much more likely to have plaster related complications, and the surgical group, screw related complications. They note that the plaster complications overall were relatively trivial without long lasting consequences, whereas the complications relating to screw fixation could have significant implications such as need for further operations and resultant poorer outcomes².

Table 1: Incidence of injuries associated with scaphoid fractures (Wells et al.)

Associated Injury	Distal Pole	Waist	Proximal Pole	Total
Distal radius fracture	28.0%	24.2%	42.8%	28.0%
Non-scaphoid carpal bone fracture	14.0%	21.4%	25.4%	19.4%
Distal ulnar fracture	16.4%	13.4%	21.0%	15.4%

Clinical Test	Sensitivity	Specificity
ASB tenderness	0.87–1.00	0.03–0.98
Scaphoid tubercle tenderness	0.82–1.00	0.17–0.57
Painful ulnar deviation	0.67–1.00	0.17–0.60
Axial loading	0.48–1.00	0.22–0.97

Table 3: Comparison of CT and MRI in the diagnosis of occult scaphoid fractures (Bäcker et al.)

Imaging Type	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value
Computed Tomography	81.5	96	83.9	94.4
Magnetic Resonance Imaging	94.2	97.9	95.3	98

Discussion

Scaphoid fractures are a common injury that can be isolated or associated with other significant injuries to the wrist. It is imperative that they are accurately diagnosed, and promptly treated to avoid complications such as nonunion and subsequent SNAC wrist, with substantial resultant disability.

In order to diagnose and treat these injuries an appreciation of the usual history and mechanism, the examination findings, and the appropriate imaging is required. Patients should be involved in decision making regarding their management and should be made aware of the increased risk of nonunion due to inadequate immobilisation. A joint decision as to the best ultimate course of treatment tailored to patient physical demands, should be made in line with best practice^{2,7}.

GAIT statement for Generative AI use²¹: Generative AI was not used in this article. The authors take full responsibility for the accuracy and integrity of the work.

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