Review Article

# Evaluation and Management of Carpal Fractures Other Than the Scaphoid

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## Abstract

Fractures of the carpus can be debilitating injuries and often lead to chronic pain and dysfunction when not properly treated. Although scaphoid fractures are more common, fractures of the other carpal bones account for nearly half of all injuries of the carpus. Often missed on initial presentation, a focused physical examination with imaging tailored to the suspected injury is needed to identify these fractures. In addition to plain radiographs, advanced imaging such as CT and MRI are helpful in diagnosis and management. Treatment of carpal fractures is based on the degree of displacement, stability of the fracture, and associated injuries. Those that require surgical fixation often affect the congruency of the articular surfaces, are unstable, are at risk for symptomatic nonunion, are associated with notable ligamentous injury, or are causing nerve or tendon entrapment. Surgical strategies involve percutaneous Kirschner wires, external fixation, screws and/or plates, excision, or fusion for salvage. Owing to the intimate articulations in the hand, small size of the carpal bones, and complex vascular supply, carpal fracture complications include symptomatic nonunion, osteonecrosis, and posttraumatic arthritis.

The carpus is a complicated mosaic of polyarticular bones that allows for the impressive range of motion of the human wrist. Scaphoid fractures are the most common, representing 60% of carpal fractures, and deservedly receive the most attention. However, the neglected neighbors of the scaphoid still represent 40% of carpal fractures, which accounts for 1.1% of all fractures. Carpal fractures from most to least common are scaphoid (68%), triquetrum (18%), trapezium (4%), lunate (4%), capitate (2%), hamate (2%), pisiform (1%), and trapezoid (0.5%)[1-3] (Figure 1). These injuries most often occur in young adults after a fall on to an outstretched hand and are frequently missed on initial presentation.[4,5] This is partly because of their small and densely packed arrangement that makes imaging difficult and limits physical examination specificity. Trained orthopaedic surgeons have a 30% to 88% precision in palpating the various bony landmarks of the carpal bones, with emergency medicine-trained physicians having a third to a fifth of this precision.[6] This underscores the difficulty of diagnosing carpal fractures on initial presentation and the high index of suspicion that must be maintained during this evaluation. All suspected fractures should be evaluated with a general hand and wrist examination as well as basic PA and lateral hand and wrist radiographs. Additional examination maneuvers and imaging

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**Figure 1**

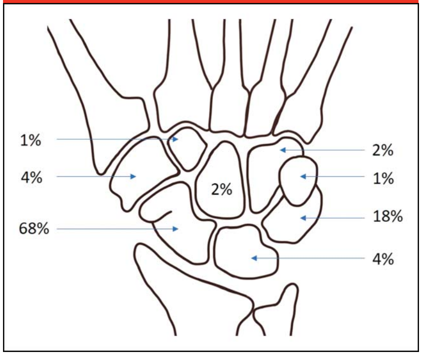
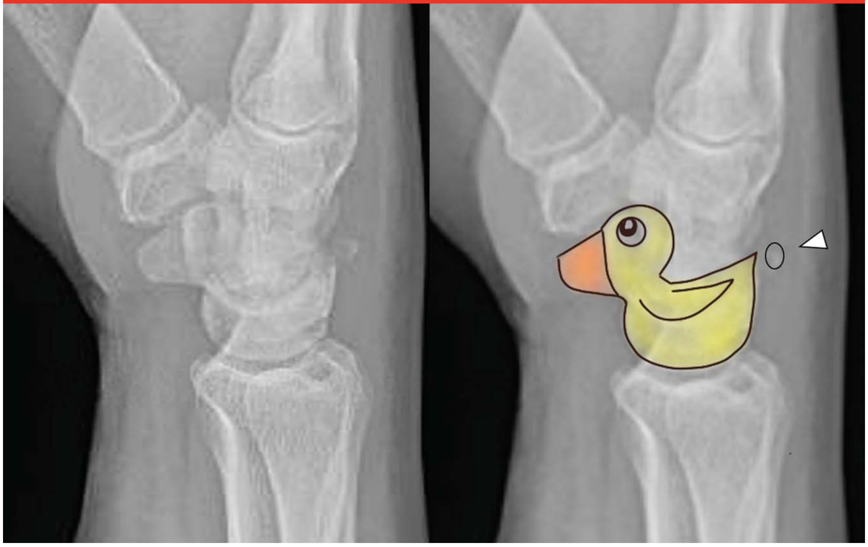



Illustration showing carpal bone fracture prevalence.

**Figure 2**



Lateral wrist radiograph demonstrating the "pooping duck" sign, indicative of a dorsal cortical triquetrum fracture (arrow).

can then be tailored to the suspected injury.

## Triquetrum

The triquetrum has three facets for articulation with the lunate, hamate, and pisiform bones on the radial, distal, and volar borders, respectively. The proximal-ulnar edge of the triquetrum articulates with the triangular fibrocartilage complex near the ulnar styloid. Its articulation with the lunate is stabilized by the lunotriquetral (LT) interosseous ligament, which has three components (volar, intercalated, and dorsal). The volar LT ligament is the most important for stability, and fractures to the volar-radial triquetrum put the wrist at risk for volar intercalated segmental instability (VISI).

On examination, the ulnar and dorsal aspects of the hand may demonstrate swelling and ecchymosis. Radial deviation and flexion of the wrist aids in palpation, with the triquetrum found just distal to the ulnar styloid.[7] Pain with flexion/extension is common with triquetral fractures. Additional imaging should include the 45° pronated oblique radiograph which silhouettes the dorsal-ulnar border of the triquetrum. Dorsal cortical comminution is evident on this view and on the lateral radiograph with a classic finding termed the "pooping duck sign" (Figure 2). Fractures of the volar aspect of the triquetrum are difficult to evaluate with radiographs, therefore CT may be necessary. When ligamentous stability is a concern, such as with volar-radial fragments, MRI can evaluate for peritriquetral soft-tissue injury.

The most common fracture pattern is a dorsal cortical fracture, which in isolation can be treated as a wrist sprain.[8,9] Notably, although the dorsal intercarpal ligament and the dorsal radiocarpal ligament insert on the dorsal triquetrum, the location of the dorsal fragments is typically proximal and ulnar to the insertions of the dorsal intercarpal/dorsal radiocarpal, and therefore, the body of the triquetrum and the wrist maintains stability. The second most common are triquetral body fractures (Figure 3), which are more ominous and require careful clinical consideration[10] (Table 1). Important patterns to recognize are transverse fractures, which are associated with perilunate fracture-dislocations[11] (Figure 4), and palmar cortical fractures, which can be a sign of avulsion of the LT ligament, putting the wrist at risk for VISI deformity.[12]

Stable small dorsal fragment fractures can be treated with a splint or cast immobilization for 3 to 4 weeks, followed by removable wrist brace support and progressive wrist motion. These injuries have a notable chance of progressing to painless fibrous nonunion, which will likely remain asymptomatic and not require further treatment. Stable nondisplaced body fractures and volar cortex fractures can be treated with cast immobilization for 4 to 6 weeks with good outcomes.[9] Displaced triquetral body fractures should undergo closed reduction with pinning versus open reduction and internal fixation. All cases that demonstrate ligamentous instability should be treated with open reduction and internal fixation. If the integrity of the LT ligament is disrupted, the lunotriquetral joint should be pinned in a reduced position and ligamentous repair should be attempted.

Early intervention for triquetrum fractures may mitigate its complications. The position in the ulnar column highlights the triquetrum's role in carpal stability. Therefore, missed body fractures that cause instability lead to functional impairment and have an increased risk for nonunion.[13] Malunions are also a concern and predispose patients to developing posttraumatic arthritis.[14] Both complications can be avoided with surgical fixation that maintains appropriate reduction. Pisotriquetral arthritis with volar cortex fractures may develop, which can be managed with pisiform excision.

Figure 3

Lateral hand radiograph and CT imaging of a triquetrum body fracture with mid carpal joint subluxation (white arrows).

## Trapezium

The trapezium has a key role in the function of the thumb with the carpometacarpal saddle joint accounting for 60° of flexion/extension, 60° radial abduction, and 10° adduction available to the thumb.[15] The volar ridge serves as an attachment for the radial aspect of the transverse carpal ligament and provides a groove for the path of the flexor carpi radialis tendon (Figure 5). The flexor carpi radialis tendon and flexor pollicis long tendons pass just ulnar to the ridge, whereas the superficial palmar branch of the radial artery passes just radial.

On examination, swelling and ecchymosis about the thenar eminence may be present. Pain will be present with metacarpophalangeal joint range of motion and wrist dorsiflexion and radial deviation. In addition to the standard radiographs, the Bett view isolates the articular surfaces. For this view, the hand is semipronated, the elbow is elevated relative to the wrist, and the thumb is abducted and extended. The carpal tunnel view is useful for evaluating the trapezium ridge. Noncontrast CT is advisable if no fracture is seen on the radiographs but index of suspicion is high or if needed for further fracture classification such as with severe comminution.

There are several patterns of injury to the trapezium that can be grouped grossly into trapezial body fractures and ridge fractures. These have been previously classified as types 1 through 5 by Walker et al[16] (Table 1). Nondisplaced fractures of the body are treated with short arm-thumb spica casting for 4 to 6 weeks. Trapezium body fracture displacement is associated with carpometacarpal dislocation and should be managed aggressively.[17] Displaced body fractures with minimal comminution should undergo closed versus open reduction and internal fixation. The volar-radial approach, as originally described by Wagner,[18] is useful for fracture reduction and fixation. Bone loss from impaction should be restored with bone graft (cancellous allograft versus distal radius autograft). For proximal migration of the radial fragment and attached metacarpal, the thumb can be distracted to maintain length and a Kirschner wire can be placed through the first and second metacarpals or from the first metacarpal into the carpal bones[19] (Figure 6). Fractures of the ridge can be treated with a removable wrist splint for comfort. Patients should be educated that during the healing process there can be notable tenderness over the ridge, which lasts for several months.

High-energy trapezium fractures can lead to carpometacarpal (CMC) joint instability and result in notable functional impairment. However, studies have found that appropriately treated fractures have reasonably good outcomes. McGuigan and Culp reviewed 11 patients with high-energy intra-articular trapezium fractures and found that at an average 4-year follow-up, grip strength, and pinch strength were equivalent to the uninjured side, and all patients continued working at their chosen occupation. Notably, five patients had radiographic evidence of trapeziometacarpal arthritis.[19] This demonstrates the high prevalence of posttraumatic arthritis in even appropriately managed trapezium fractures.

## Lunate

Lunate fractures most commonly occur secondary to a fall on an outstretched hand and have a notable risk of associated carpal instability. The lunate is situated in the proximal carpal row and has ligamentous attachments essential in carpal stability. The LT ligament maintains the lunotriquetral joint, with disruption resulting in volar intercalated

**Table 1**

**Carpal Fractures Mechanism and Treatment**

| |
|---|
| Triquetrum |
| Dorsal cortical fracture (most common) |
| Mechanism: Avulsion of the dorsal radiotriquetral and triquetroscaphoid ligaments during hyperflexion and radial deviation; impaction by the ulnar styloid and hamate during hyperextension and ulnar deviation |
| Treatment: short arm cast/splint for 3-4 weeks followed by wrist brace for comfort with progressive ROM |
| Ulnar tuberosity fracture |
| Mechanism: direct blow to ulnar wrist |
| Treatment: nondisplaced—short arm cast for 4-6 weeks; displaced—CRIF versus ORIF |
| Sagittal body fracture |
| Mechanism: AP directed force; crush injury |
| Treatment: no instability and nondisplaced—short arm cast for 4-6 weeks; displaced or unstable—CRIF versus ORIF |
| Transverse body fracture |
| Mechanism: greater arc perilunate fracture-dislocation injury |
| Treatment: nondisplaced—short arm cast for 4-6 weeks; displaced—ORIF (most common) versus CRIF |
| Palmar cortical fracture |
| Mechanism: avulsion of the volar lunotriquetral ligament; shear impaction from the pisiform |
| Treatment: short arm cast/splint for 2-3 weeks followed by wrist brace for comfort with progressive ROM |
| Trapezium |
| Sagittal body fracture |
| Mechanism: axial load through the thumb (associated with thumb metacarpal base fracture-dislocation) |
| Treatment: nondisplaced—short arm-thumb spica cast for 4-6 weeks; displaced or CMC joint subluxation—CRPP versus ORIF versus external fixator |
| Transverse body fracture |
| Mechanism: shear force |
| Treatment: nondisplaced—short arm-thumb spica cast for 4-6 weeks; displaced—CRPP versus ORIF versus external fixator |
| Dorsal-radial ridge fracture |
| Mechanism: shearing by the radial styloid during hyperextension |
| Treatment: nondisplaced—short arm-thumb spica cast for 4-6 weeks; displaced—CRPP versus ORIF |
| Volar ridge fracture |
| Mechanism: direct blow to palm or avulsion of the transverse carpal ligament |
| Treatment: short arm-thumb spica casting for 4-6 weeks; painful fracture nonunions can undergo excision |
| Lunate |
| Volar lip fracture |
| Mechanism: wrist hyperextension with tension and subsequent avulsion by the radiolunate ligaments |
| Treatment: small fragment with no carpal instability—short arm cast immobilization for 4-6 weeks with close follow-up; large fragment (with or without displacement) or carpal instability—ORIF |
| Dorsal lip fracture |
| Mechanism: wrist hyperextension with impaction on the dorsal distal radius ridge |
| Treatment: nondisplaced or small fragment and stable—short arm cast for 4-6 weeks; large fragment with displacement or unstable—ORIF |
| Coronal body fracture |
| Mechanism: axial load or dorsal extension force with palmar flexion force distraction injury |
| Treatment: nondisplaced—short arm cast for 4-6 weeks; displaced—ORIF |
| Transverse body fracture |
| Mechanism: shear force during a radiocarpal fracture-dislocation |

(*continued*)

CRIF = Closed reduction and internal fixation, CRPP = Closed reduction and percutaneous pinning, FCU = Flexor carpi ulnaris, ORIF = Open reduction and internal fixation, ROM = Range of motion

**Table 1 (*continued*)**

| Carpal Fractures Mechanism and Treatment |
| --- |
| Treatment: nondisplaced—short arm cast for 4-6 weeks; displaced—ORIF |
| Capitate |
| Transverse/oblique waist/neck fracture |
| Mechanism: hyperextension of the wrist with abutment on the dorsal ridge of the distal radius, leading to distractive forces on the volar capitate |
| Treatment: nondisplaced—short arm cast for 6-8 weeks; displaced—ORIF with headless compression screws through the third and fourth extensor compartments |
| Volar/dorsal avulsion fracture |
| Mechanism: axial load through the third metacarpal |
| Treatment: nondisplaced or fleck avulsion—short arm cast for 4-6 weeks; displaced fragment large enough to fix—ORIF between the third and fourth extensor compartments |
| Hamate |
| Hook of hamate fracture (type 1): |
| Mechanism: direct external blow or ligamentous avulsion |
| Treatment: nondisplaced and minimally displaced—ulnar gutter cast for 3 weeks followed by short arm cast for 3 weeks; evidence of carpal tunnel syndrome, ulnar neuropathy, chronic symptomatic nonunions, or acute displaced fractures—fragment excision |
| Transverse fracture (type 2b) |
| Mechanism: shear force during greater arc perilunate fracture-dislocation |
| Treatment: nondisplaced with no evidence of CMC instability—ulnar gutter cast for 3 weeks followed by short arm cast for 3 weeks; displacement or CMC instability—ORIF with injury-specific treatment of perilunate dislocation |
| Coronal body fractures (type 2a) |
| Mechanism: axial load through the fourth and fifth metacarpals |
| Treatment: nondisplaced and extra-articular—ulnar gutter cast for 3 weeks followed by short arm cast for 3 weeks; displaced or intra-articular extension into the CMC joint—ORIF |
| Pisiform |
| Transverse and sagittal/comminuted body fractures |
| Mechanism: crush injury of the pisiform between a hard surface and the triquetrum (sagittal/comminuted) or a similar position with the additional strong pull of the FCU tendon insertion (transverse) |
| Treatment: nondisplaced and minimally displaced—short arm cast in slight ulnar deviation and 30° of flexion for 4-6 weeks; displaced—pisiformectomy |
| Trapezoid |
| Volar rim or coronal fracture |
| Mechanism: axial load through second metacarpal base |
| Treatment: nondisplaced—short arm-thumb spica cast immobilization for 4-6 weeks; displaced or CMC subluxation—ORIF (fragment excision is contraindicated) |

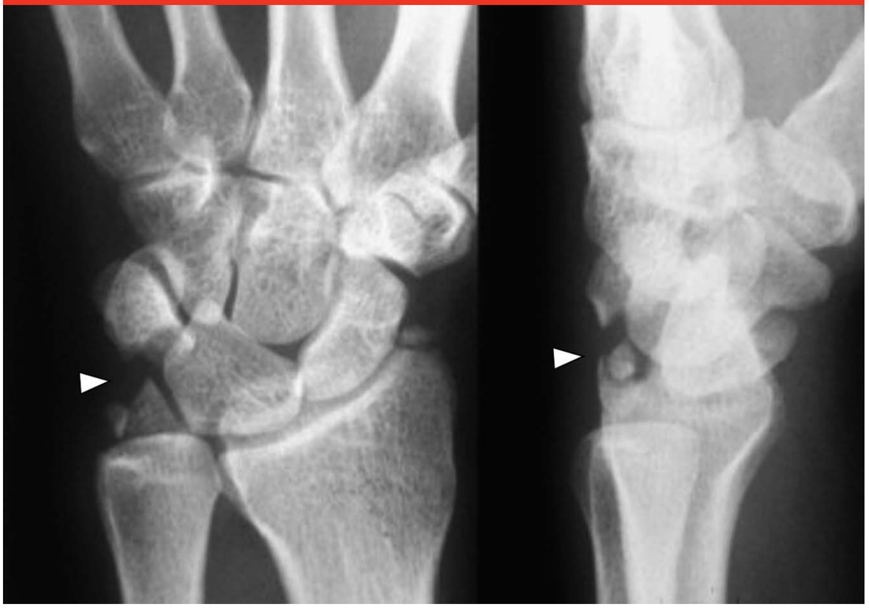
CRIF = Closed reduction and internal fixation, CRPP = Closed reduction and percutaneous pinning, FCU = Flexor carpi ulnaris, ORIF = Open reduction and internal fixation, ROM = Range of motion

segmental instability (VISI). The scapholunate ligament mirrors this attachment on the radial side, and injury to this ligament can cause dorsal intercalated segmental instability The vascular supply of the lunate is also important in fracture treatment because up to 20% of lunates have a volar-dominant blood supply, putting the lunate at risk for osteonecrosis with volar lip injuries.[20] In addition, given the similar radiographic presentation, Kienbock disease must be ruled out when evaluating for lunate fractures. Kienbock disease typically presents with lunate collapse and sclerosis, as defined by the Lichtman classification.[21]

A thorough evaluation of the hand is essential, given the high incidence of associated injuries in these cases. In addition, these fractures are difficult to note on standard radiographs and CT scans are often necessary to reveal the full fracture pattern. MRIs can be used to evaluate for ligamentous injuries.

Fractures of the lunate can be divided into volar lip, dorsal lip, and body fractures. The widely accepted mechanism of injury for most fractures of the lunate is an axial load through the capitate with the wrist in hyperextension and ulnar deviation

**Figure 4**



Posteroanterior and lateral hand radiographs demonstrating a transtriquetral transstyloid dorsal perilunate fracture-dislocation. (Reproduced with permission from Leung YF, IP SPS, Wong A et al: Trans-triquetral dorsal perilunate fracture dislocation. *J Hand Surg Eur* 2007;32:647-648.)

**Figure 5**

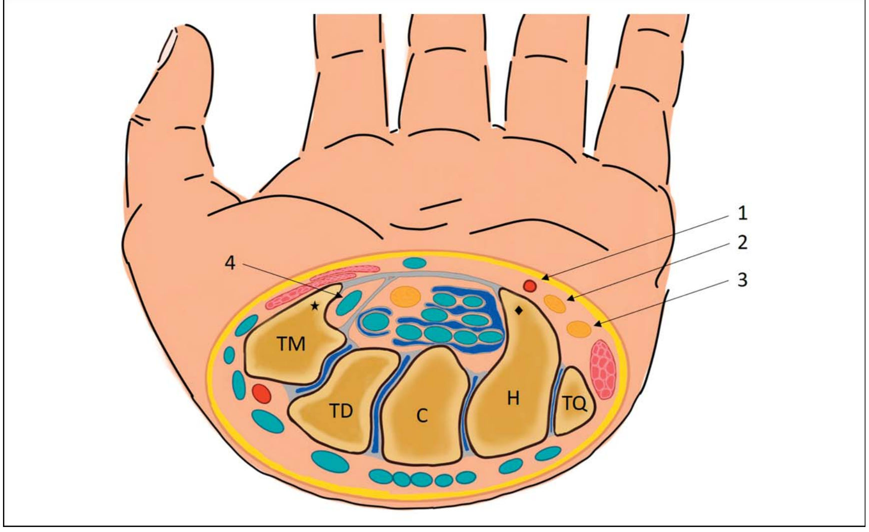



Illustration depicting the transverse cross section through the distal carpal row (TM = triquetrum, TD = trapezoid, C = capitate, H = hamate, TQ = triquetrum) highlighting the relationship of the hook of the hamate (black diamond) and the ridge of the trapezium (black star) to the surrounding tissue (1 = ulnar artery, 2 = motor branch of ulnar nerve, 3 = sensory branch of ulnar nerve, 4 = flexor carpi radialis tendon).

resulting in a coronal body fracture (Figure 7, A). Nondisplaced fractures without evidence of carpal instability can be managed with short arm cast immobilization for 4 to 6 weeks. These injuries, especially those with volar or dorsal-radial comminution, must be monitored closely for displacement because of the high incidence of carpal instability. Large displaced fractures and any fractures with evidence of carpal instability require open reduction and internal fixation.[22] Volar avulsions can impair perfusion and put the entire lunate at risk for osteonecrosis. Fixation is accomplished with compression screws and K-wire fixation for substantial osseous fragments[23] (Figure 7, B). Suture anchor repair with K wire stabilization to adjacent carpal bones can be used when the osseous fragment is too small to fix and carpal instability is present. The lunate can be offloaded by distracting the third ray and placing a K wire through the scaphoid into the capitate, which may help in more complex fracture patterns.

Outcomes in lunate fractures are highly dependent on the amount of initial displacement. In a review of 34 lunate fractures, nondisplaced fractures were found to overwhelmingly progress to union without complication. In 14 cases of displaced lunate fracture with associated carpal dislocation, eight were complicated by osteonecrosis and nonunion or required a salvage procedure.[22] Therefore, aggressive management is warranted in cases with fracture displacement and/or carpal instability to avoid these outcomes.

## Capitate

Capitate fractures are most often high-energy injuries. Nearly 80% of patients with capitate fractures will have an associated fracture of the wrist and hand, with most these cases being transscaphoid, transcapitate perilunate dislocations.[24] The capitate is the recipient of numerous intrinsic and extrinsic ligaments of the wrist, predominantly on the volar aspect. The proximal pole is dependent on a retrograde blood supply which can lead to an increased risk of delayed union and nonunion.[25]

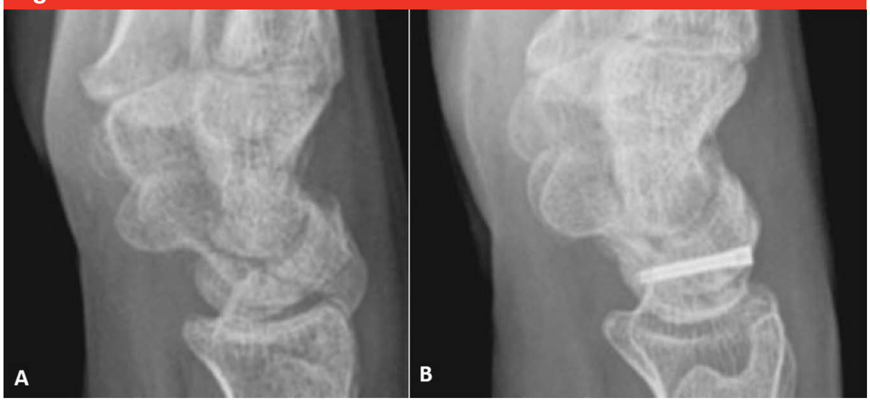
Physical examination of a capitate fracture, given the high likelihood of surrounding osseous and soft-tissue injury, will demonstrate diffuse swelling and ecchymosis of the midhand. The bone can be palpated dorsally by first palpating the crucifixion fossa (scapholunate junction) and moving distally in-line with the third ray until the hard, flat surface of the dorsal capitate is palpated. Flexion of the wrist will assist with palpation.[7] Standard hand radiographs (PA, lateral, and oblique) are generally sufficient to diagnose a capitate fracture. PA radiographs with radial and ulnar deviation may assist with identifying minimally displaced fractures. In cases where there is concern for occult fractures, both MRI and CT have been used with acceptable sensitivity for diagnosis.[26,27]

There are three main fracture patterns that can occur with capitate fractures: body, tip avulsion, and shear depression[24] (Table 1). The most common is a transverse fracture at the waist which often occurs in conjuncture with a scaphoid waist fracture and subsequent perilunate dislocation, formally called scaphocapitate syndrome.[28] This injury occurs during forced extension of the wrist, with the dorsal aspects of both the scaphoid waist and the capitate waist impinging on the dorsal ridge of the distal radius (Figure 8). As the wrist returns to neutral position, one of three things can occur: (1) the proximal pole fragment can rotate 180°, (2) the capitate fracture can reduce without malrotation, or (3) the carpus can remain dislocated. Nondisplaced neck fractures can be managed nonsurgically with short arm casting 6 to 8 weeks, given an expected increased duration of healing. Displacement of the neck may disrupt blood supply to the proximal pole and should therefore be managed with open reduction and internal fixation via headless compression screws. Nondisplaced coronal and sagittal avulsion fractures can be managed with 4 to 6 weeks of short arm cast immobilization. Displaced fractures should undergo fracture fixation or fragment excision with ligamentous repair. The dorsal approach through the interval of the third and fourth extensor compartments provides access to the capitate—the surgeon should attempt to minimize dissection off the dorsal distal capitate because this is the blood supply for the proximal pole in most cases. If the proximal pole is inverted, the wrist can be flexed to expose the proximal pole and allow for reduction. Bone loss secondary to impaction can be augmented with allograft versus autograft.

**Figure 6**

Fluoroscopic radiograph demonstrating pin orientation of a trapezium body fracture with CMC dislocation now after open reduction and pin fixation.

**Figure 7**




Imaging of a lunate body fracture treated with open reduction and internal fixation. Preoperative radiograph demonstrates fracture displacement with intra-articular extension (**A**). A posterior-to-anterior compression screw has been placed for fixation (**B**). (Reproduced with permission from Hsu AR, Hsu PA: Unusual Case of Isolated Lunate Fracture Without Ligamentous Injury. *Orthopedics* 2011;34:e785-e789. With permission from SLACK Incorporated.)

Capitate fractures are notorious for developing nonunion and proximal pole osteonecrosis, attributable to the retrograde blood supply.[29] This dogma is based on early case series and reports that demonstrated a high prevalence of these complications. The largest early study was by Rand et al,[30] published in 1982 on a series of 13 patients, four of whom developed nonunion. More recently, a large review of 53 patients with capitate fractures revealed the actual incidence of nonunion and osteonecrosis may be much less than initially thought, and midcarpal arthrosis may be a more common complication.[24] This however could be related to the improvement in surgical techniques and early intervention.

## Hamate

Hamate fractures may be more common than previously thought, with a recent study demonstrating that they

**Figure 8**

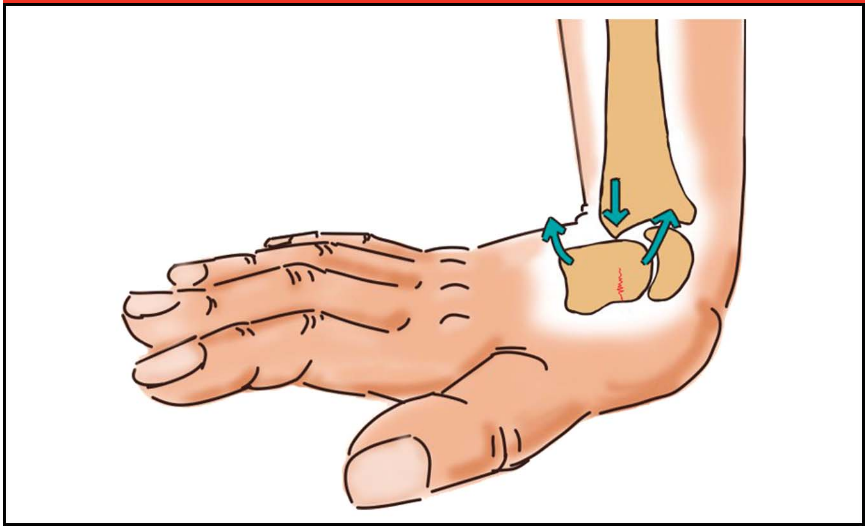
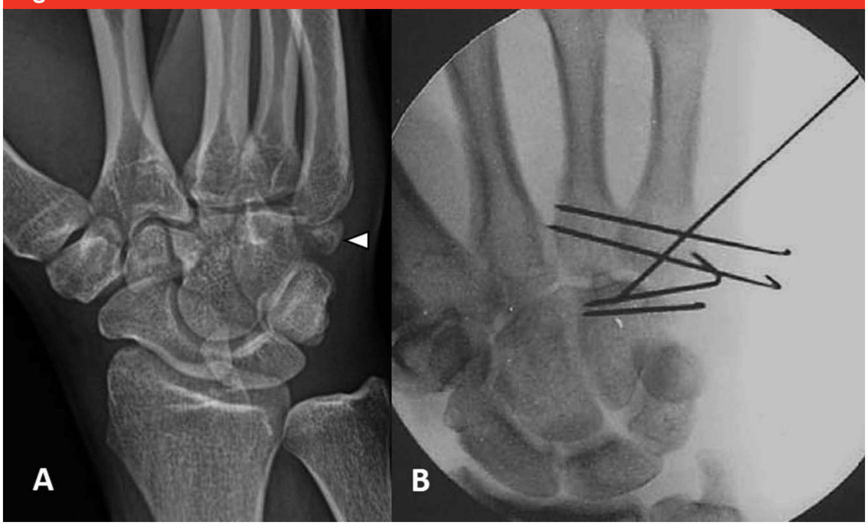


Illustration depicting the mechanism for capitate waist fractures. With the wrist in hyperextension, the force of the distal radius ridge (blue down arrow) causes a compressive force on the dorsal capitate, whereas the surrounding ligamentous and osseous connections produce a distracting force on the volar cortex (blue arrows).

**Figure 9**




Imaging of a hamate body fracture that was treated with open reduction and internal fixation (**B**). Preoperative radiograph demonstrates dorsal dislocation of the CMC joint (**A**). The metacarpals have been pinned to assist with maintaining the reduction.

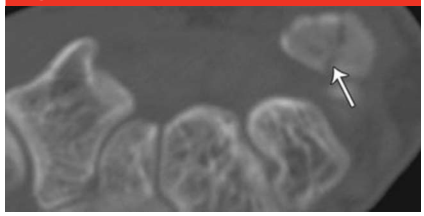
are one of the most frequent hand injuries in professional-level baseball.[31] The hamate articulates distally with the fourth and fifth metacarpals and proximally with the lunate and triquetrum. The volar hook serves at the origin for the hypothenar muscles and transverse carpal ligament and as the borders of the carpal tunnel and Guyon's canal. The proximal pole is covered by articular cartilage and depends on an intrinsic retrograde blood supply, whereas the body receives volar and dorsal blood supplies. The hook is dependent on volar vasculature, which results in a watershed zone at the base of the hook.[32]

Acute hook fractures may demonstrate swelling in the ulnar palm, ecchymosis over the volar hamate, and point tenderness. Chronic injuries may only have point tenderness over the hook, which can be palpated approximately 2 cm distal and 1 cm midline to the pisiform on the volar aspect of the hand.[7] Owing to the proximity to the neurovascular bundle, the patient may complain of ulnar nerve paresthesia. Becauce the flexor tendons use the hook as a pulley, patients will classically complain of pain with resisted small finger flexion and wrist ulnar deviation. Loss of the knuckle contour for the fourth or fifth metacarpal head is suggestive of a CMC dislocation. On radiographs, body fractures can be better evaluated with a 45° pronated oblique view (Figure 9, A). The carpal tunnel view is useful in evaluating hook fractures. The "ring sign," seen as discontinuity of the cortical ring on a PA view, has a sensitivity and specificity of 57.5% and 93.1%, respectively, and is the most sensitive sign of a hook of hamate fracture on a PA view.[33] Plain radiographs have an overall sensitivity of 70% to 80% for hamate fractures, therefore CT is still often necessary for identification.[33]

Hamate fractures are classified based on the fracture location in the body (type 1) or hook (type 2)[34] (Table 1). Transverse fractures are associated with perilunate fracture-dislocations, with the proximal pole shearing off during translation. Coronal fractures of the hamate are associated with CMC fracture-dislocation and are the most commonly injured CMC articulation outside of the first digit[35] (Figure 9). Body fractures that are nondisplaced and extra-articular can be treated with an ulnar gutter cast for 3 weeks, followed by a short arm cast for 3 weeks. Fractures with displacement or intra-articular extension can be managed initially with closed reduction and percutaneous pinning. If the fracture is unable to be reduced, open reduction and internal fixation is appropriate. Achieving optimal articular congruity is paramount for the hamate CMC articulation and to that of the trapezoid CMC. This is in relation to the increased mobility of the fourth and fifth CMC, as opposed to the inherently stable second/third CMC, which makes the joints more mobile and therefore more prone to posttraumatic arthritis. A dorsal approach should be used to address the body fracture, and fixation can be achieved with interfragmentary screws, plating, or K-wires. Any screws driven dorsal to volar for fixation should be done with care because the motor branch of the ulnar nerve is near the volar cortex. If subluxation/dislocation of the metacarpals has occurred, they will need to be reduced with longitudinal traction and reduction maintained with K-wires driven through the fourth and fifth metacarpals into the third metacarpal and/or capitate (Figure 9, B). Acute hook of hamate fractures can be managed initially with an ulnar gutter cast for 3 weeks, followed by a short arm cast for 3 weeks that limits wrist and ulnar digit motion, thereby limiting potential tendon irritation. Alternatively, the hook can be surgically excised if there is notable displacement, given the likelihood of nonunion. Chronic symptomatic hook nonunions should be excised. For hook excision, an approach through Guyon's canal limits the risk for injury to the ulnar nerve branches, ulnar artery, and flexor tendons.[36]

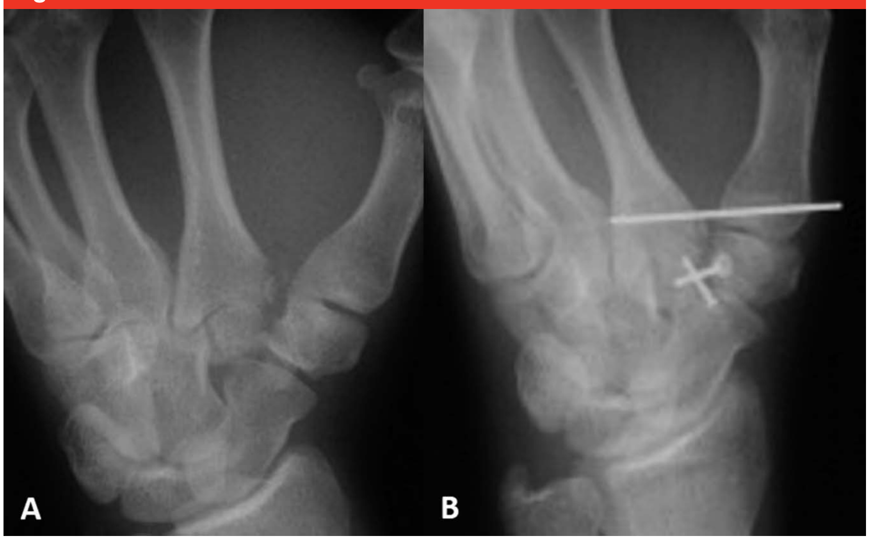
Hamate fractures have approximately a 10% nonunion rate, particularly hook fractures treated nonsurgically.[32] Hamate body fractures, even when properly reduced, can result in posttraumatic arthritis, and the proximal pole, given the retrograde blood flow, is at risk for osteonecrosis.[32] Surgical excision of the hook has a 25% incidence of postoperative transient ulnar nerve dysfunction with the sensory branch being affected in 70% of cases.[37]

**Figure 10**



Axial CT imaging of a sagittal pisiform fracture with minimal displacement. (Reproduced with permission from Kaewlai R, Avery L L, Asrani A V, et al: Multidetector CT of carpal injuries: Anatomy, fractures, and fracturedislocations. *RadioGraphics* 2008; 28:1771-1784. With permission from the Radiological Society of North America.)

**Figure 11**




Imaging of a trapezoid fracture treated with open reduction and internal fixation (**B**). Preoperative radiograph demonstrates fracture displacement with intra-articular extension (**A**). Fixation included pinning of the first and second metacarpals to maintain length (**B**). (Reproduced with permission from Kain N, Heras-Palou C: Trapezoid fractures: report of 11 cases. *J Hand Surg Am* 2012;37: 1159-1162.)

## Pisiform

Pisiform fractures are rare, although they are highly associated with fractures elsewhere in the wrist and hand.[38] The pisiform is a pea-shaped sesamoid bone within the flexor carpi ulnaris tendon and rests on the volar surface of the triquetrum.

Examination will reveal a swelling of the hypothenar eminence and tenderness over the pisiform. The pisiform can be consistently palpated by finding the palmar prominence formed at the ulnar base of the hypothenar eminence.[7] Flexion and ulnar deviation of the wrist will activate the flexor carpi ulnaris (FCU) and can be painful if a fracture is present. Radiographic views for the pisiform fractures should include the 45° supinated oblique view and the carpal tunnel view.

Fractures typically take on three patterns: sagittal, transverse, and comminuted (Table 1). The classic low energy fall pins the pisiform between the impacting surface and the triquetrum, resulting in a sagittal fracture line (Figure 10). A similar mechanism with higher energy will result in fracture line propagation and comminution. Alternatively, a strong pull by the FCU can result in a transverse avulsion fracture. Nondisplaced fractures are managed with 3 to 6 weeks of ulnar gutter cast immobilization. At the surgeon's discretion, severely displaced pisiform fractures can be managed initially with pisiformectomy and FCU repair, given the high risk of nonunion. Patients with symptomatic nonunion should undergo pisiformectomy, which has been shown to have good outcomes without notable functional impairment.[39]

Outcomes data on pisiform fractures are limited, given the rarity of the injury. However, sequelae of the injury are generally limited and well tolerated. Nonunion of the pisiform is the most cited complication, which often remains asymptomatic. Symptomatic nonunions respond well to excision. Palmieri[20] reported on five patients with symptomatic pisiform nonunions, and after surgical excision, all patients were able to return to work with a symptomatic relief.

## Trapezoid

This carpal bone has the lowest incidence of injury which can be attributed to the protected location of the bone within the distal carpal arch. The trapezoid is wedge-shaped, widest at the distal end, and fits into the distal carpal row as a keystone in an arch between the capitate and trapezium.

Standard hand radiographs are sufficient to diagnosed fracture-dislocation injuries. Nondisplaced fractures may be difficult to identify on plain radiographs, given the osseous overlap in which case CT is helpful in establishing the diagnosis.

Injuries about the trapezoid are most often due to an axial load through the second metacarpal, which creates a coronal fracture pattern with displacement (Figure 11). Nondisplaced fractures can be managed with short arm-thumb spica casting for 4 to 6 weeks. Displaced fractures are best managed with open reduction and internal fixation with K-wires and compression screw fixation through a dorsal approach.

The literature would suggest that isolated trapezoid fractures have good outcomes with limited complications. Case reports and limited case series indicate that reduced fractures heal without complication. Displaced fractures, even when presenting in a delayed fashion, do well with surgery without reported complication.[40] The lack of negative outcomes in this case may be a misleading artifact, given the low incidence of cases.

## Summary

Nondisplaced and stable carpal fractures can largely be treated with immobilization. Owing to the complex ligamentous network about the carpal bones, many fracture patterns are associated with carpal instability and thus require surgical fixation. CT and MRI should be used for complex fracture patterns and concerns for occult injury. Early intervention can decrease the risk of posttraumatic degenerative changes. The orthopaedic surgeon should be aware of the common fracture patterns associated with instability and how to optimally intervene.

## References

Levels of evidence are described in the table of contents. In this article, reference 1 is level I and V study. Reference 5 is level II and III study. Reference 21 is level IV study.

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