Carpal Fractures

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Learning Objectives

- List the relative frequency of 7 carpal fractures.
- Discuss the mechanism of injury for each carpal fracture.
- Review the clinical presentations of carpal fractures.
- Identify the best imaging modalities for diagnosing carpal fractures.
- Offer surgical and nonsurgical treatment options for each carpal fracture.

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Carpal fractures are exceedingly rare clinical entities and are often associated with concomitant injuries. In this review, we focus on fractures of the carpus, excluding the scaphoid, and provide an update on the current consensus as to mechanism, diagnosis, management, outcomes, and complications after such injuries. *(J Hand Surg Am. 2014;39(4):785–791. Copyright © 2014 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Carpal fracture, hamate, lunate, trapezium, triquetrum.

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FRACTURES OF THE CARPALS OTHER than the scaphoid are exceedingly rare and comprise approximately 1.1% of all fractures.[1] The mechanism of injury, most frequently a fall onto an outstretched hand, often dictates the fracture pattern. The injuries can be divided into 3 main groups: perilunate injuries, axial injuries, and avulsion/impaction injuries.[2] Clinical suspicion should be high and a detailed physical examination must be undertaken, because the clinical signs may be subtle and standard radiographic

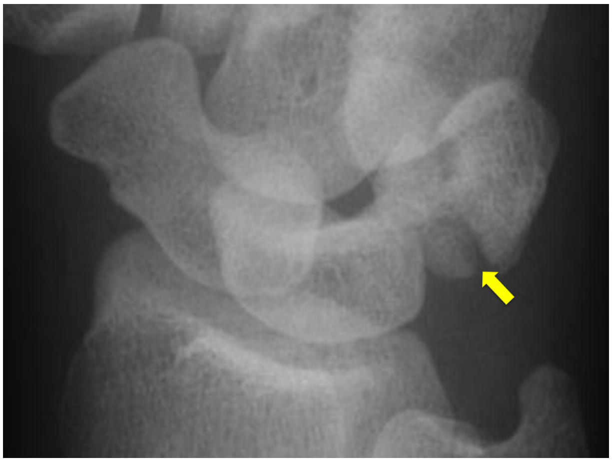

FIGURE 1: Plain radiograph demonstrating a triquetrum fracture (arrow).

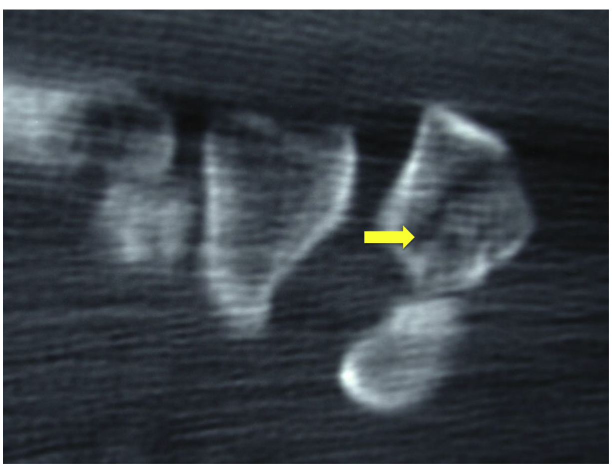

FIGURE 2: Corresponding CT image showing a fracture of the triquetrum (arrow).

examination is frequently insufficient to demonstrate a clear fracture. Therefore, given the unique osseous and ligamentous anatomy of the individual carpals, an understanding of each bone is required to best manage these rare injuries. In this review, we discuss the more common fractures involving the individual carpals, excluding the scaphoid, and outline their presentation and subsequent management.

TRIQUETRAL FRACTURES

Triquetral fractures are the second most common isolated carpal fracture after scaphoid fractures (about 15%) (Figs. 1, 2).[3,4] Three main patterns have been described: (1) dorsal cortical fractures, (2) triquetral body fractures, and (3) volar avulsion fractures.[5] Various theories have been proposed to describe the different patterns of fracture propagation; most commonly, wrist dorsiflexion and ulnar deviation precipitates fractures of the dorsal cortex of the triquetrum.[3,6] Although considered by some authors as a compression fracture from a prominent ulnar styloid or hamate, they are typically avulsion fractures from the attachments of the radiotriquetral (dorsal radiocarpal) and triquetroscaphoid (dorsal intercarpal) ligaments at their apex and are the most common type of triquetral fracture.[3,7,8]

Focal tenderness over the dorsum of the triquetrum is suggestive of a triquetral avulsion fracture in the context of a fall onto an outstretched hand. Lateral radiographs and/or 45° pronated oblique views profile the bony avulsion fragment. Management is usually nonsurgical. Because the injury is a hallmark of avulsion of the important dorsal wrist ligaments, cast immobilization of the wrist for 3 to 4 weeks is recommended to facilitate ligament healing, followed by progressive return to range of motion and strengthening of the wrist. Reduction in pain generally occurs within 6 to 8 weeks with good return of wrist motion and minimal residual functional deficit.[8]

The next most common fracture is a triquetral body fracture that can occur in a variety of fracture patterns, largely depending on the mechanism of injury. Sagittal fractures are associated with crush injuries or axial dislocations, medial tuberosity fractures are from a direct blow, transverse fractures are associated with perilunate injuries, and comminuted fractures are from high-energy trauma.[2,6] Other carpal fractures or lunotriquetral ligament injuries may be present.

Focal triquetral tenderness is the hallmark of the injury. Although fractures may be seen on plain posteroanterior (PA), lateral, and 45° pronated radiographs, computed tomographic images (CT) may be required to further delineate the extent of the fracture and any associated injuries, and help determine subsequent management. The degree of fracture displacement and the presence of associated injuries will determine operative versus nonsurgical treatment. Rare nonunions of the triquetrum requiring future operative intervention have been reported in the literature; however, immobilization for an isolated body fracture for 4 to 6 weeks is the treatment of choice.[9,10]

Given the mechanism of injury, the examiner should maintain a high index of suspicion for an associated lunotriquetral ligament injury. If disrupted, pinning across the lunotriquetral interval is recommended. For body fractures that are notably displaced, open reduction internal fixation with a compression screw and/or Kirschner wires may be required. Literature results are sparse and often obscured by associated injuries.

Volar triquetral avulsion fractures are the third type of fracture pattern that has been described.[11] These are considered avulsions of the palmar ulnar triquetral ligament or the lunotriquetral ligament. Radial deviation radiographs may need to be taken to demonstrate the fracture. Because this fracture may be a harbinger of carpal instability, magnetic resonance imaging may be helpful for further assessment. Treatment should be directed at addressing the carpal instability and not the small avulsion fracture.

Complications of these fractures are more frequent with concomitant bony or ligament injuries, including nonunion, persistent ligamentous instability, and future pisotriquetral arthritis.

TRAPEZIUM FRACTURES

The third most commonly fractured carpal is the trapezium (1% to 5%).[12] Multiple authors have attempted to categorize the main fracture patterns with varying degrees of complexity. Generally, they are described as body fracture, trapezial ridge fractures or fracture dislocations. Walker et al[13] further divided these fractures into 5 main patterns: vertical intra-articular, horizontal, dorsal radial tuberosity, anterior medial ridge, and comminuted.

Vertical intra-articular trapezium fractures are the most common fracture pattern and are most often the result of an axial compression force from the thumb metacarpal. This fracture type frequently accompanies the Bennett fracture. Less commonly, horizontal fractures occur as a result of a horizontal shear load against the trapezium. Dorsoradial fractures develop from a vertical shear force between the metacarpal and radial styloid, ridge fractures from axial loading or avulsion by the transverse carpal ligament, and comminuted fractures from high-energy injuries.

Clinically, body fractures generally exhibit overlying ecchymosis and point tenderness is elicited on physical examination. Standard PA, pronated anteroposterior, lateral, and Bett radiographs may be useful for identifying the fracture, although CT imaging may be required for greater delineation of the size and degree of displacement of the fracture fragments, and also the extent of articular involvement.

Treatment is dictated by fracture displacement. Nondisplaced fractures are usually treated in a thumb spica cast for 4 to 6 weeks and evaluated periodically for potential loss of reduction. Displaced fractures should be treated operatively in young active individuals, because the potential for trapeziometacarpal or scaphotrapezium-trapezoid arthritis with residual articular stepoff is high. Percutaneous Kirschner wire fixation, oblique external traction, and open reduction and internal fixation have all been reported in the literature as successful options. Gelberman et al[14] reported on a small series of patients who underwent oblique external traction for trapezial body fracture and demonstrated full and pain-free range of motion of the thumb in and out of traction, with union at 8 to 10 weeks. McGuigan et al[15] showed excellent results with open reduction and screw fixation in 11 patients, with no statistical difference found in thumb or wrist motion, and grip or pinch strength between the injured and uninjured postsurgery.

Fractures of the trapezial ridge are often missed; hence, a high degree of clinical suspicion is necessary. Point tenderness along the trapezial ridge on the palmar surface near the base of the thenar eminence may be the only indication of a fracture. Standard radiographs may not demonstrate the fracture; however, a carpal tunnel view can be helpful, and CT scan is definitive. Type 1 fractures are located at the base of the ridge and heal reliably with thumb spica cast immobilization for 4 to 6 weeks. type 2 fractures are smaller avulsion injuries with a higher incidence of symptomatic nonunion. Consequently, consideration for early operative excision of symptomatic type 2 lesions should be discussed with the patient.

Fracture dislocations frequently occur as a result of injuries, and are often missed as a result of concomitant injury. Management should be directed at reducing the fracture dislocation followed by stable internal fixation, taking into consideration other fractures that are present. Common associated injuries include fractures of the scaphoid, trapezoid, capitate, neighboring metacarpals, and the distal radius.[16,17] Consequently, there should be high level of suspicion for associated injuries at the time of initial assessment.

Complications after these fractures include carpometacarpal (CMC) joint stiffness and associated contracture of the first webspace, posttraumatic arthritis, nonunion, carpal tunnel syndrome, flexor carpi radialis tendinopathy with late rupture, and painful loss of pinch strength and function.

CAPITATE FRACTURES

Capitate fractures (1% to 2%) have been reported in isolation or, more commonly, in conjunction with a perilunate injury.[18–20] They are the fourth most common carpal fracture and have been described based on the fracture pattern: transverse pole, transverse body, verticofrontal, and parasagittal fractures. Transverse body fractures are the most common and are typically associated with perilunate injuries.[2]

Because of its relatively protected location within the central portion of the carpus, the mechanism of injury is debated. Although they can occur from a direct axial load down the third metacarpal base, they most commonly occur from a fall onto an extended wrist in ulnar deviation. Higher-energy injuries typically feature a perilunate fracture dislocation with or without fracture of the scaphoid and/or radial styloid (also known as a trans-scaphoid, trans-capitate fracture dislocation). Very rarely, the scaphocapitate syndrome occurs; this represents an unusual carpal fracture dislocation in which the proximal capitate fragment rotates 180° in the sagittal plane.[21] Capitate fracture patterns are mostly descriptive and do not reliably dictate management.

Given the high-energy mechanism and its propensity to be found in conjunction with other carpal fractures and ligament injuries, patients with capitate fractures will typically present with a swollen and painful wrist. The diagnosis is made with radiographs and supplemented by advanced imaging techniques as needed to delineate occult fractures, fracture displacement, and associated ligament injury.

Management is determined by fracture location and concomitant injuries. Capitate head fractures are entirely covered with articular cartilage, and their intrasynovial location may delay union. For capitate neck fractures, rigid internal fixation will likely expedite treatment; cast immobilization may extend for several months with potential concomitant wrist stiffness. For all but nondisplaced fractures, operative intervention using headless compression screws is preferred.

The most common complication is nonunion, which is often related to delays in diagnosis.[22,23] Other complications include avascular necrosis of the capitate, posttraumatic arthritis, and malunion of the capitate leading to carpal collapse and progressive degenerative arthritis.[24,25]

PISIFORM FRACTURES

Pisiform fractures (2%) are described as transverse, parasagittal, comminuted and pisiform-triquetral impaction fractures.[5] They occur from a direct blow, commonly in sports, and less often from repetitive trauma. A sudden contraction of the flexor carpi ulnaris tendon, which contains the pisiform, may create an avulsion fracture variant.[26]

Focal pain is the presenting problem, and can radiate deep within the hypothenar musculature. Rarely ulnar nerve symptoms may be present. Plain radiographs do not show the fracture well and a 30° supinated view or 45° supinated oblique view in slight extension and a carpal tunnel view can be diagnostic, albeit sometimes difficult to obtain.[26]

The fracture pattern does not dictate fracture management; however, parasagittal fractures, which are in line with the flexor carpi ulnaris tendon, or nondisplaced transverse intra-articular fractures often heal readily with cast immobilization. For markedly displaced fractures, those with flexor carpi ulnaris dysfunction or comminuted fractures, pisiform excision can provide excellent results with no loss of range of motion and reliable relief of pain. Symptomatic nonunion or posttraumatic pisotriquetral arthritis is most frequently treated with pisiform excision.

TRAPEZOID FRACTURES

Trapezoid fractures are the least common carpal fracture reported in the literature (< 1%) and are broadly classified as dorsal rim or body fractures.[5] Given their protected position within the distal row and keystone architecture, isolated fractures are exceptionally rare and trapezoid fractures are most often found in conjunction with other carpal fractures or carpometacarpal dislocations.[27]

The mechanism of injury may be high-energy trauma, direct trauma, forced flexion-extension, or an axial load through the index metacarpal.[28] Patients with isolated trapezoid fractures report poorly localized pain at the base of the index metacarpal and nearby anatomical snuffbox. Dorsal swelling has been reported in the literature and may be related to a displaced dorsal fragment. Routine PA, lateral, and oblique radiographs may demonstrate the fracture. Unstable fractures may be characterized by an overlap between the index metacarpal and trapezoid resulting from proximal and dorsal subluxation of the metacarpal. Computed tomography scan is often required to accurately delineate the fracture and its degree of displacement. For detection of occult fractures, magnetic resonance imaging scan has been shown to be useful.[29]

Undisplaced fractures may be treated with short arm cast immobilization for 4 to 6 weeks. Severely displaced fractures or those that demonstrate articular incongruity are best treated with open reduction internal fixation using compression screws or Kirschner wires. Excision of trapezoid fracture fragments is contraindicated because of the risk of subluxation of the second metacarpal and progressive degenerative arthritis. In cases of severe comminution rendering anatomical restoration impossible, primary second carpometacarpal joint arthrodesis with bone grafting may be required.[30]

Because of the rarity of trapezoid fractures, there are few data regarding the long-term outcomes after such injuries. Blomquist et al[27] reported excellent functional results after cast immobilization for minimally displaced fractures. Displaced fractures treated

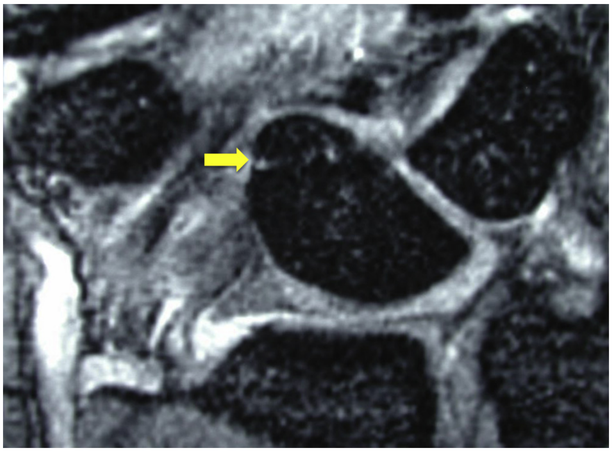

FIGURE 3: Magnetic resonance image of a volar chip fracture of the lunate (arrow).

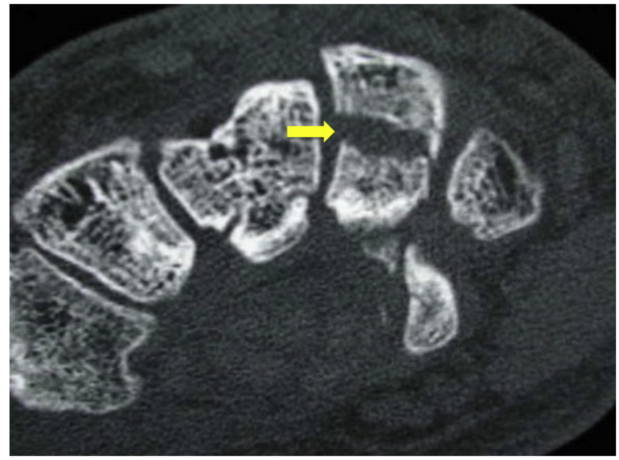

FIGURE 4: Computed tomography scan of a comminuted hamate fracture (arrow).

with open reduction internal fixation have also demonstrated both excellent union rates and functional results.[27] Complications include delayed union, nonunion, and posttraumatic arthritis.

LUNATE FRACTURES

Controversy exists regarding the relative frequency of lunate fractures in the literature, because Kienböck disease or congenitally bipartite lunates may confound the diagnosis of traumatic lunate fractures.[28,31] Lunate fractures comprise approximately 0.5% to 1% of all carpal fractures and are classified as palmar pole, distal pole, transverse, osteochondral, and transarticular body fractures (Fig. 3).[32,33]

The most common mechanism of injury for lunate fractures is axial compression from the capitate being driven into the lunate with the wrist held in dorsiflexion and ulnar deviation. Like most carpal fractures, dorsal wrist pain, focal tenderness and swelling may be clinically present. Standard PA, lateral, and oblique radiographs generally are diagnostic. Dorsal or volar translation of the capitate is often the hallmark of displaced volar or dorsal lip fractures. Computed tomography scan is recommended for greater definition of the fracture configuration and the degree of displacement, and to identify fractures that may be obscured by overlapping carpals on plain radiographs.

The first step in managing lunate fractures is to ascertain whether it is due to a pathologic process such as Kienböck disease, a congenital anomaly such as bipartite lunate, or an acute traumatic fracture.[31,33] Treatment strategies vary greatly depending on the cause of the fracture. For traumatic undisplaced fractures, it is recommended to cast immobilization for 4 to 6 weeks until bony union is achieved. For displaced fractures, ORIF is necessary, most commonly with screw fixation if sufficient bony purchase can be achieved.[34,35] Hsu and Hsu[34] showed bony union of an isolated lunate fracture treated with headless compression screws after 7 weeks with no evidence of osteonecrosis and restoration of normal wrist range of motion. However, if the comminution is substantial or fracture fragments are too small, Kirschner wire stabilization to the adjacent carpals should be performed.

In addition to the lunate fracture, there should be careful assessment of the scapholunate ligament and the lunotriquetral ligament, because this may affect management options.[35,36] For example, dorsal fractures of the lunate should be carefully assessed, because they may be the pathognomic sign of a dorsal scapholunate ligament avulsion. In this scenario, cast immobilization will be insufficient and the patient will require primary repair of the scapholunate interosseous ligament to prevent potential carpal instability and collapse. Similarly, volar chip fractures may also appear to be benign, but despite their small size, ORIF has been recommended to preserve the lunate vascular supply and restore its ligamentous attachments.[2] Complications after lunate fracture include nonunion, avascular necrosis, carpal instability, and posttraumatic arthritis.

HAMATE FRACTURES

Fractures of the hamate (2%) are broadly classified as those affecting the hook or the body (Fig. 4). Hook fractures are most often seen in racket sport athletes, baseball players, and golfers; direct compression of the hook of hamate is the most frequently cited mechanism of injury, although other mechanisms include avulsion fractures of the pisohamate ligament.[26] Further subdivision of these fractures has been described in the literature as occurring at the tip, base, or waist. However, management is often not dictated by the exact location of the hook fracture.[26]

These fractures often present as persistent pain at the base of the hypothenar eminence. Often, patients do not recall an acute injury; however, the pain is reliably reproduced with gripping and exacerbated by direct palpation over the hook of hamate or resisted flexion of the little and ring fingers. Ulnar nerve paraesthesia or hand weakness may also be present if the fracture is adjacent to the ulna nerve as it passes around the hook of hamate. Because of the overlap of the hook on the body of the hamate, standard radiographs are often not useful for diagnosis. More frequently, a carpal tunnel view and a supinated oblique view are required. Another potentially helpful radiograph involves a first webspace view with the wrist radially deviated away from the cassette. However, the reference standard investigation is a CT scan, which will clearly demonstrate the location and extent of the fracture.

Management of the various subtypes of hook of hamate fractures is similar. For undisplaced fractures, short arm cast immobilization may be attempted, but healing rates are approximately 50%, with waist and tip fractures having lower union rates owing to the poor vascularity of the hook distally.[37,38] Patients who elect nonsurgical treatment should be closely counseled about the prolonged immobilization and poor healing rate, as well as potential complications of nonunion. For fractures that are displaced, chronic, or present with ulnar nerve compression, we recommend early excision of the hook of hamate rather than ORIF, because multiple studies have shown no adverse sequelae on wrist range of motion or grip strength with excision.[39,40] Complications of hook of hamate fractures include symptomatic nonunion, ulnar neuritis, ulnar artery thrombosis (ie, hypothenar hammer syndrome), and flexor digitorum profundus tendon ruptures. Accordingly, prompt diagnosis and treatment are essential.[26]

The second type of hamate fracture involves the hamate body and is less common than hook fractures. As is the case with other carpal fractures, these fractures have been subdivided into proximal pole, medial tuberosity, sagittal oblique, and dorsal coronal fractures. The mechanism of injury is variable and includes shearing, direct blow, high-energy trauma, and axial loading, respectively. Clinical presentation is variable. These patients present with focal tenderness over the hamate and possible concomitant injuries, depending on the mechanism of injury. Standard radiographs may be sufficient to identify the fracture line but CT scan will further delineate the fracture displacement as well as any articular involvement of the hamate-metacarpal joints.

Undisplaced hamate fractures are relatively stable and can be treated with short arm cast immobilization for 4 to 6 weeks. For displaced fractures or for fractures compromising the little and ring finger carpometacarpal joint joints, ORIF is recommended. Compression screws or low-profile plates for fracture stabilization and Kirschner wires for joint stabilization may be necessary.

Wharton et al[41] demonstrated that undisplaced hamate body fractures treated nonsurgically could achieve good functional results; however, the authors highlighted the necessity of anatomical reduction with ORIF of displaced fractures for better clinical results, although the degree of radiographic restoration did not always correlate with functional outcomes. Other studies have also highlighted that soft tissue injury is an important component that dictates the degree of functional recovery after hamate body fractures. Close observation is required if nonsurgical treatment is chosen, because loss of reduction may occur within the cast and lead to hamatometacarpal subluxation.[42,43] Complications after these fractures include symptomatic nonunion, avascular necrosis, and carpometacarpal posttraumatic arthritis.

In conclusion, isolated carpal fractures are rare and are often difficult to detect owing to their subtle clinical features. They frequently require a high index of suspicion and the use of advanced imaging such as CT scan for definitive diagnosis. Management generally consists of an appropriate length of cast immobilization in cases of undisplaced fractures, with ORIF reserved for displaced or unstable fractures. Postoperative rehabilitation is initiated after bony union is confirmed and results are typically favorable, with restoration of range of motion and return to pre-injury activities. However, understanding of carpal biomechanics and the unique anatomy of each carpal is essential to tailor fracture management for optimal outcomes.

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JOURNAL CME QUESTIONS

Carpal Fractures

Which of the following carpals is most frequently fractured?

a. Triquetrum
b. Trapezium
c. Capitate
d. Lunate
e. Pisiform

Which of the following triquetral fracture patterns is most frequently encountered?

a. Triquetral body fractures
b. Dorsal cortical avulsion fractures
c. Volar avulsion fractures
d. Comminuted fracture
e. Transtriquetral perilunate fracture dislocation

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