

# The Emergent Evaluation and Treatment of Hand and Wrist Injuries

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## KEYWORDS

- Hand and wrist injuries • Emergency physician
- Emergent evaluation • Treatment

Injuries to the hand and wrist can pose a challenge for the emergency physician. These injuries are not life threatening, however, the complexity of the area can pose many diagnostic and treatment dilemmas. The anatomy of the hand is complex, which allows for the dexterity, strength, and adaptability of the most functional aspect of the musculoskeletal system. The evaluation and management of injuries to this area can be time consuming and pose a significant medicolegal risk to the emergency physician. Improperly diagnosed and managed injuries can lead to chronic pain, inability to perform activities of daily living, and even seemingly minor injuries can lead to missed work causing a significant cost to the individual and society.<sup>1</sup> The purpose of this article is to review injuries to the hand and wrist and discuss diagnostic studies and treatment plans that the emergency physician can use to treat patients effectively and minimize their exposure to risk.

## ANATOMY

The wrist is comprised of 8 carpal bones arranged in 2 transverse rows. The proximal row is important in that it connects the radius and the ulna to the distal row of carpal bones. The proximal row of carpal bones, listed ulnar to radial, consist of the triquetrum, lunate, and scaphoid. The distal carpal row, listed ulnar to radial, is composed of the hamate, capitate, trapezoid, and trapezium. The eighth carpal bone, the pisiform, is actually a sesamoid bone enclosed in the sheath of the flexor carpi ulnaris tendon and is located

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in an anterior plane to the other carpal bones (**Fig. 1A**). Radiographically, the carpal bones form 3 arcs, commonly referred to as Gilula's carpal arcs. Arc I forms the proximal articulating surfaces of the triquetrum, lunate, and scaphoid. Arc II forms the distal articulating surface of the same 3 bones. Arc III outlines the proximal articulating surface of the capitate and hamate. In a normal wrist, these 3 arcs should form smooth curves and there should be no overlap between lines (see **Fig. 1B**). The anatomic snuff box is clinically significant in that it encompasses the scaphoid bone and a branch of the radial artery. The medial border of the box is the tendon of the extensor pollicis longus (EPL) and the lateral border is the tendon of the abductor pollicis longus (APL).

Moving distally from the carpal bones is a row of metacarpals. Distal to the metacarpals are 3 rows of phalanges, with the exception of the thumb, which has only 2 phalanges.

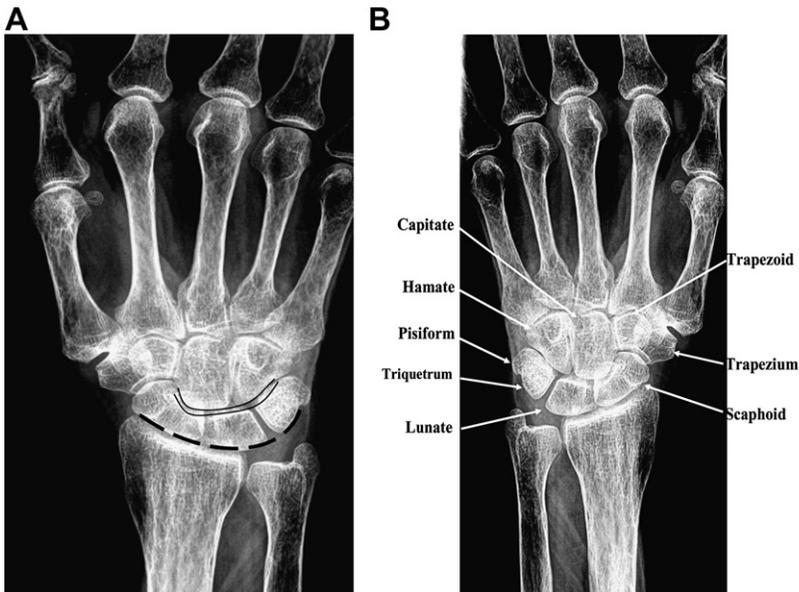
The 3 main nerves that control the hand and wrist are the median, ulnar, and radial nerves and their branches. Understanding of their course and areas of innervation are crucial to performing regional anesthesia and blocks. If there is significant injury to the hand or wrist patients may not tolerate a digital or hematoma block. In these cases, the use of ultrasound guidance can be helpful in localizing the nerve and reducing complications when performing regional blocks.

### FRACTURES OF THE HAND

It is estimated that half of all hand injuries are fractures and that phalanx and metacarpal fractures account for more than 40% of all upper extremity fractures.<sup>2</sup>

#### *First Metacarpal*

The dexterity of the human hand relies on the thumb and its functionality depends on its extensive mobility. The thumb is estimated to account for approximately 1 million emergency department (ED) visits per year.<sup>3</sup> The wide range of motion of the



**Fig. 1.** (A) Normal PA film of the hand with carpal bones identified. The articulation between the proximal row of carpal bones and the distal forearm should have a smooth curvature. (B) The lines between the distal and proximal carpal bones should also form an arc. Note the distance between the scaphoid and lunate is less than 3 mm.

carpometacarpal (CMC) joint allows for the first metacarpal to withstand a wide variety of forces without injury. However, when the thumb is injured it can lead to significant changes in patients' quality of life.

On physical examination one should attempt to evaluate the pinching strength of the thumb. This is known as Froment's sign. A change in strength is usually attributed to a ligamentous injury or fracture of the first metacarpal that produces an ulnar neuropathy. Plain films with specific attention to the thumb are usually sufficient to diagnose a fracture or dislocation. The most common fracture of the first metacarpal is a Bennett fracture that was first described in 1882 (Fig. 2). This fracture is defined as an intraarticular fracture at the base of the CMC joint of the thumb.<sup>4</sup> The fractured fragment is often a triangular piece of bone. Because of the ligamentous forces applied by the APL there is dorsal displacement of the first metacarpal. This injury is a result of an axial load on a partially flexed metacarpal, for example a closed-fist injury. A similar fracture is the Rolando fracture first described in 1910. This fracture is also an intraarticular fracture of the CMC joint, but in this case the fracture has a T or Y shape. Because of the pull of the APL there is once again dorsal displacement of the first metacarpal.<sup>4</sup>

These fractures are inherently unstable and will require placement of a splint in the ED and discussion with a hand specialist. In addition to the instability of the fractures, closed reduction in the ED can be difficult because of the dual innervation of the thumb. Both the median and radial nerves contribute to the innervation making a regional block difficult. Hematoma blocks are not recommended for these fractures as most are intraarticular, which will increase the rate of complications. The placement of a thumb spica or modified thumb spica splint is usually sufficient in the ED.<sup>3</sup> The long-term management of these fractures frequently requires an operative procedure,



**Fig. 2.** An example of a Bennett fracture of the thumb metacarpal. Notice the intraarticular component of the fracture and the triangular shape of the bone fragment.

whether open reduction with internal fixation or transcutaneous pinning. There is extensive debate over what the best definitive treatment is, which is beyond the scope of this article. These fractures should be discussed with your local hand surgeon to optimize the patients' treatment plan and follow-up.

### ***Digital Metacarpals***

The metacarpals account for approximately one-third of all hand fractures. They usually result from a direct axial load on the metacarpal row. Logically, for this to occur the proximal phalanges must be flexed as in a closed-fist injury. Fractures of the metacarpals can, however, also occur with blunt trauma directly to the metacarpals as in a crush injury.

The diagnosis of these injuries is based on obtaining plain radiographs of the hand in the posteroanterior (PA), lateral, and oblique views. The key to the management of these fractures is based on the amount of angulation and rotational deformity that is present. Fracture of the neck of the fifth metacarpal is known as a boxer's fracture and is the most common metacarpal fracture (**Fig. 3**). Reduction should be attempted if there is more than 35° to 40° of volar angulation. The second and third metacarpals, however, are allowed less angular deformity and as such need to be reduced if there is more than 5° to 10° of angulation, respectively. One simplified view is to allow 5°, 10°, 20°, and 30° of angulation for the index, middle, ring, and small fingers, respectively.<sup>5</sup>

Although angulation is determined by radiologic studies, the rotational deformity is usually based on the physical examination and is important in these fractures. There are 3 relevant examination findings based on the presence of rotational deformity. When the hand is uninjured all of the phalanges should point to the scaphoid when the fist is closed, there should be no finger overlap, and the nails should all lie in the same plane when the fingers are extended; the contralateral or injured hand can serve



**Fig. 3.** An oblique and PA radiograph of the hand showing an example of a fifth metacarpal, or Boxer fracture. Notice the angulation of the head of the metacarpal. This injury would necessitate reduction in the emergency department.

as a reference.<sup>4</sup> Rotational deformities may also be seen on radiologic studies. The width of the cortex of the bone on opposite sides of the fracture line should be the same size. A difference in width is usually caused by the distal fragment being rotated so that the bone is not in the same plane as the proximal portion.

Immediate reduction in the ED is warranted if there is any evidence of rotational deformity. However, rotation deformities are inherently unstable and it may be difficult to maintain any reduction obtained in the ED. Reduction of metacarpal shaft or neck fractures can be accomplished with local hematoma or wrist block anesthesia using 1% lidocaine with epinephrine. The fracture is then reduced using a maneuver described by Jahss<sup>6</sup> in 1938. In the Jahss' maneuver, the metacarpophalangeal (MCP) and proximal interphalangeal (PIP) joints of the affected metacarpal are flexed to 90°. The fracture is then reduced by pressing up on the proximal phalanx and pushing the proximal metacarpal dorsally. Patients should then be placed in an ulnar gutter splint with the wrist flexed at 30° and the MCP joint flexed at 90°. Fracture of the second (Fig. 4) and third metacarpals should be reduced as needed and placed in a volar or radial gutter splint. If there is a rotational deformity, the fingers should be buddy taped to prevent misalignment before placing the splint. It should be noted that all of these injuries ultimately require an evaluation by a hand specialist. The patients' occupation, age, and the details of the injury will dictate the timeliness of the follow-up.

### ***Phalangeal Fractures***

The proximal, middle, or distal phalanges are easily injured and fractures are common. Unlike most other bones in the body, the digits are unprotected from a force in almost any direction, which can result in fractures that are displaced, angulated, rotated, or any combination of these. There may also be an intraarticular component to the



**Fig. 4.** Fracture of the second metacarpal. Notice how the articular surface is angulated in the ulnar direction. This injury will be difficult to reduce in the emergency department. Proper treatment will require placement in a radial gutter splint and referral for open reduction and fixation.

fractures, making for a difficult and often impossible reduction in the ED. Despite proper treatment, the most commonly cited long-term complaint is joint stiffness.<sup>7</sup> The diagnosis of these injuries is made with conventional radiographs. All 3 views (PA, lateral, and oblique) must be obtained with specific instruction to the radiologist to focus on the affected digit.

Although patients may be in pain, and thus significantly limit the examination, examination of both flexor tendon and the extensor tendon mechanisms is crucial. In addition, a good neurologic and vascular examination should be completed before any digital or hematoma block. After patients are given proper analgesia, the examination of the tendons can be revisited, usually with more success. Previously, the teachings were that digital blocks should be done with 1% or 2% lidocaine without epinephrine. This practice has been challenged recently and the use of lidocaine with epinephrine is not only safe but preferred in the management of digital injuries.<sup>8</sup>

Damage to the proximal or middle phalanx, especially the dorsal aspect, is important because improper treatment can lead to a Boutonniere deformity. This deformity is described as a flexion at the PIP with hyperextension at the distal interphalangeal (DIP) joint. The difficulty for the emergency physician lies in the fact that this injury may not be immediately present on physical examination. A boutonniere deformity usually develops weeks after the patients' initial injury. The mechanisms that control the movement of the PIP joint are complex. The extension of the digit is not controlled by a singular tendon but by a combination of tendons and sheaths that attach to the dorsal surface of both the distal and middle phalanx. Flexion is controlled by the flexor digitorum profundus (FDP), which inserts on the distal phalanx, and the flexor digitorum superficialis (FDS), which inserts on the middle phalanx. The delicate balance between the extensor mechanism over the dorsal PIP joint and the flexors is altered because of the injury. As the healing progresses, the now-dominant FDS creates constant flexion at the PIP joint. Because the extensor tendon mechanism has slipped down toward the volar surface of the phalanx, the pull of the extensor tendon causes extension of the DIP joint, thus giving the characteristic presentation.<sup>9</sup>

Fractures of the proximal and middle phalanges should be treated with a gutter splint, either radial or ulnar, depending on the location of the injury. These splints should leave the wrist extended at 30° and the MCP flexed to 90°. This position will allow for the remainder of the uninjured digits to maintain mobility. Once again if there is rotational deformity the digits can be buddy taped before splinting. This procedure must be done with caution, however, because a rotational deformity can be exacerbated with splinting.

Fractures of the distal phalanx provide additional treatment challenges. These fractures, similar to the middle and proximal phalanx, have tendinous attachments that can result in deformities and functional disability. They also have a unique anatomic characteristic: the nail. Fractures of the distal phalanx are classified, from distal to proximal, as a tuft, shaft, or articular surface fracture. Diagnosis of these injuries requires 3 dedicated plain radiographs of the affected digit. Distal tuft injuries are common and can be time consuming for the emergency physician to manage. These injuries usually result from a crushing force to the digit, such as a hammer or car door. Along with the fracture, there is usually some injury to the nail and the nail bed. If the fracture is open patients should undergo intense irrigation, intravenous antibiotics, and tetanus prophylaxis. If the nail is intact and there is a subungual hematoma, the nail should be left in place and the hematoma drained. If, however, the nail is damaged, the nail should be removed and the nail bed repaired with absorbable sutures. After the repair of the nail bed, the nail should be replaced and used as a physiologic splint. This procedure can be achieved by placing a horizontal mattress suture at the base of the nail, with careful attention to avoid the nail

matrix. In the event that the nail is not damaged, but the fracture is open, the soft tissue must be repaired with attention paid to maintaining the anatomy as normal as possible.

Fractures of the shaft and articular surface of a phalanx can also pose problems. The most concerning of these is an avulsion fracture at the base of the distal phalanx. This fracture can be associated with a mallet deformity, in which patients cannot extend the distal phalanx. If this fracture is mismanaged, a swan neck deformity may occur. Just like the Boutonniere deformity develops weeks after injury, the swan neck deformity may take weeks to be recognized clinically (**Fig. 5**). The swan neck deformity is characterized by extension at the PIP with flexion of the DIP, caused by the unopposed action of the FDP.

Treatment of distal phalanx fractures includes splinting to ensure immobilization of the DIP joint. Every attempt should be made to leave full mobility of the PIP joint. Thus, unless there is also an injury of the more proximal bones, a gutter splint should be avoided. If there is concern for an avulsion injury on the dorsal aspect of the distal phalanx, the splint must keep the joint in full extension for 8 to 10 weeks.<sup>10</sup> Any joint mobility during this time could exacerbate the injury and render any healing useless.

Any open fracture of the finger requires emergent evaluation by a hand specialist, especially if amputation, either partial or full, is a component. Otherwise most injuries can be splinted and patients referred to a hand specialist. The patients' demographics (eg, age, occupation) can necessitate an orthopedic or plastic surgery consult even for a minor injury.

## DISLOCATIONS

Just as with any joint in the body, dislocations in the hand are possible. Dislocations of the DIP and PIP are more common than others, and in fact the PIP is the most dislocated joint in the body.<sup>11</sup> Most dislocations are evident on physical examination. A



**Fig. 5.** Lateral radiograph of a distal phalanx fracture. Although a seemingly minor injury, failure to properly treat this fracture can lead to a boutonniere deformity. Proper treatment is splinting the joint in full extension for 8 to 10 weeks.

plain radiograph should be obtained to ensure that there are no associated fractures. After a neurologic examination, the affected area can be anesthetized with a regional or digital block. MCP joints are rarely dislocated as an isolated injury. These dislocations commonly occur with a fracture. MCP dislocations are difficult to reduce and will need operative repair the majority of the time (Fig. 6).

PIP dislocations are common, especially during sporting events, making this a common injury among young, active individuals. Often the reduction is performed before evaluation in the ED. The dislocation can occur in the dorsal, volar, or lateral directions. Dorsal dislocations are usually easily reduced and treated with splinting in 20° to 30° of flexion. Volar dislocations are also easily reduced; however, their treatment is different. A volar dislocation can cause damage to the central extensor slip, which as discussed previously, predisposes patients to developing a boutonnière deformity. If a volar dislocation is treated the same as a dorsal dislocation, and splinted in flexion, the treatment will exacerbate the development of the boutonnière deformity. Therefore, volar dislocations must be splinted in full extension and necessitate follow-up with a specialist. Lateral dislocations can be reduced and buddy taped or splinted in slight flexion after reduction. The most common long-term complication of PIP dislocations is persistent swelling and stiffness.

#### LIGAMENT AND TENDON INJURIES

Ligament and tendon injuries can be challenging to correctly diagnosis in the ED. Aside from a laceration, where you can see damage to the tendon, the diagnosis often cannot be made by inspection alone. Further complicating the diagnosis is the fact



**Fig. 6.** A PA and lateral radiograph of a fifth metacarpophalangeal joint dislocation. These injuries can be difficult to reduce secondary to interposed soft tissue and will often need operative management.

that patients often do not present to the ED at the time of injury and conventional radiography is often normal. Diagnosis can be made by high-resolution ultrasound with fairly good accuracy.<sup>12</sup> This modality, however, is either not available or underutilized at many centers, decreasing its usefulness. Another modality that can be used in diagnosis and for operative planning is MRI.<sup>13</sup> Although becoming more practical, the use of MRI for non-life-threatening emergencies in the ED is controversial and usually not warranted. Unfortunately, improper treatment of these injuries may lead to boutonniere and swan neck deformities of the digits so early diagnosis is important to prevent these complications.

A commonly encountered sports-related injury is damage to the FDP. This injury is caused by a forced extension of the partially flexed DIP joint. This injury is usually seen in football and rugby players when the finger gets caught in the opponents jersey while trying to make a tackle, and is commonly referred to as a jersey finger.<sup>14</sup> Because of the physics and anatomy of the digits, the ring finger is most susceptible to this injury.<sup>15</sup> The key to this injury lies in the diagnosis. Because the limited range of motion caused by the injury to the FDP is attributed to pain and swelling, the injury is missed. The finger is placed in a splint in slight flexion for comfort, but this does not treat the injury. Treatment is usually operative, because the flexor tendon tends to retract and can retract as proximally as the palm.

Injury to the ulnar collateral ligament of the thumb, called game-keepers thumb, secondary to forced abduction is commonly seen in ski-pole injuries.<sup>16</sup> This injury is associated with damage to the ulnar collateral ligament and is associated with a metacarpal avulsion fracture. An injury with this mechanism is usually treated conservatively. Plain films should be obtained to assess for fractures. In the acute setting, an examination of the first CMC joint for laxity can be limited by pain and swelling. These patients should, without exception, be placed in a thumb spica splint and arranged for prompt follow-up with a hand specialist. The hand specialist can evaluate patients after the swelling has subsided and possibly determine the need for an MRI or ultrasound. Most cases will need operative management, although conservative treatment with casting can produce good outcomes.<sup>17</sup>

## INJURIES PERTAINING TO THE WRIST

The complex motions of the wrist are supported by an intricate framework of bones and their soft-tissue connections. Injuries to the wrist can have devastating functional results because of the small passages for the neurovascular bundles to traverse. Carpal bone fractures account for approximately 20% of all the fractures of the hand and wrist.<sup>18</sup>

### *Scaphoid Injuries*

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The scaphoid bone is located on the radial side of the proximal row of carpal bones. It is the most commonly fractured carpal bone and a delay in fracture diagnosis of 1 to 2 weeks can increase the chances of a poor outcome.<sup>19</sup> The mechanism of most injuries is an axial load to a hyperextended wrist as in a fall on an outstretched hand (FOOSH).<sup>20</sup> The issue with scaphoid fractures lies in the high incidence of avascular necrosis (AVN) and nonunion that results from its tenuous blood supply. The blood supply of the scaphoid enters from the dorsal side in the middle of the bone. The proximal surface of the scaphoid, the most important because of its articular surface, is supplied by nutrient arteries. Approximately 15% of fractures of the scaphoid waist result in malunion or nonunion. AVN will occur approximately 30%

of the time with more proximal fractures having a higher than 80% incidence of AVN.<sup>19-21</sup>

Diagnosis of these fractures (**Fig. 7**) can be difficult and, because of the risk for complications, there is a significant cost to the health care system from overtreatment of these injuries.<sup>22</sup> Diagnosis of scaphoid injuries should begin with a thorough physical examination and diagnostic imaging. Radiographs are required in all cases. The practitioner can obtain plain radiographs of the wrist with a dedicated scaphoid view, although these miss the diagnosis in almost 10% of fractures.<sup>23</sup> There is a significant debate as to whether the use of either CT or MRI is cost effective in the diagnosis of scaphoid injury. Studies have shown that the specificity and sensitivity of CT scans are approximately 90%, with a negative predictive value of 0.99 in one study, thus CT scans are unlikely to miss a fracture.<sup>24,25</sup> MRI has good specificity, sensitivity, and low interobserver variability; the issue with MRI lies in the limited availability and prohibitive cost.<sup>26-28</sup> The final modality that can be used in the diagnosis of a scaphoid fractures is a bone scan. This testing modality, however, is of limited utility in the emergent setting.

In a suspected fracture, with no definite evidence of fracture on imaging, placement of a thumb spica splint and referral to a hand specialist for follow-up in 7 to 10 days with repeat films is a commonly accepted practice. If there is a documented fracture, a placement of a long-arm thumb spica splint and immediate consultation with a hand specialist is necessary because of the long-term complications of these fractures.<sup>29</sup>

### ***Hamate Injuries***

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The hamate is located on the ulnar side in the distal row of carpal bones. Hamate fractures are rare and account for only 1.7% of all carpal bone fractures.<sup>30</sup> Fractures can occur in either the body of the hamate or the hook, with the latter being more



**Fig. 7.** PA view of the wrist providing an example of a scaphoid waist fracture and a distal radius fracture.

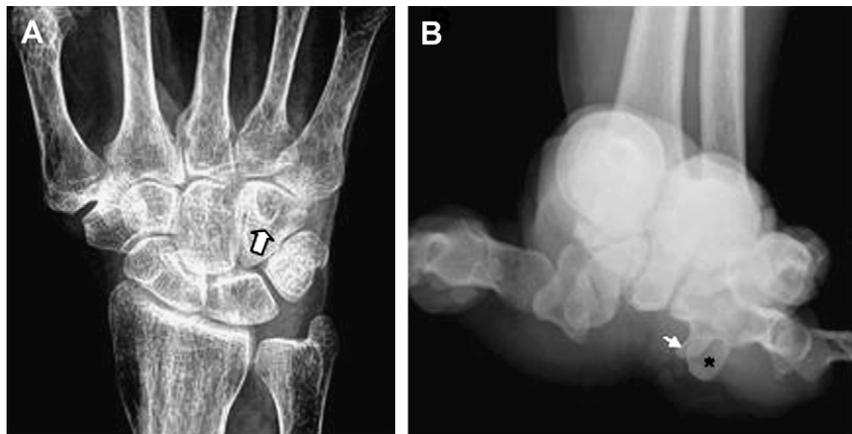
common.<sup>31</sup> Hook of the hamate fractures typically occurs in sports involving racquets, clubs, or bats. During a swing, the base of the club, bat, or racquet forcefully impacts the hook of the hamate causing a fracture. Other mechanisms of injury of the hamate include a FOOSH or the impact of power tools or machinery into the ulnar aspect of palm.

Patients with a fracture of the hook of the hamate will typically complain of ulnar-sided wrist pain and will have pain with palpation in the hypothenar area. Paresthesias in the ulnar distribution may also be found. Forcing patients to actively grasp with the affected hand will cause pain on the ulnar side of the palm.<sup>32</sup>

Although rare, hook of the hamate fractures should be suspected in patients with the appropriate antecedent history and any of the previously mentioned physical examination findings. Diagnostic imaging may include standard wrist films, specialized views, or CT. In standard radiography, a hook of the hamate fracture can be identified on the PA view of the wrist by the loss of the oval, dense cortical ring shadow over the hamate (**Fig. 8A**).<sup>30</sup> This finding can be missed if the radiograph is not done properly or if the fracture is at the base. Therefore, if a hook of the hamate fracture is suspected clinically and standard plain films do not show any abnormalities, special radiographic studies should be ordered. These studies may include a carpal tunnel view (see **Fig. 8B**), a supinated oblique view with the wrist dorsiflexed, or a lateral view projected through the first web space with the thumb abducted.<sup>33</sup> These views can sometimes be difficult to obtain in acutely injured patients when wrist mobility is limited by pain and swelling.

Recent literature has shown the sensitivity of plain radiography to be as low as 40% for detection of hamate fractures.<sup>18</sup> CT is superior to plain radiography in the detection of fractures of the hamate.<sup>18,34,35</sup> Because of the limitations and lack of sensitivity of plain films, CT should be considered in patients with clinically suspected fractures of the hook of the hamate and negative radiographs.

Early diagnosis of hamate fractures is important because missed fractures can lead to significant disability and serious complications, including tendon rupture.<sup>36</sup> Treatment in the acute setting involves immobilization with the wrist in slight flexion and



**Fig. 8.** (A) Normal PA view of wrist demonstrating the eye sign (*white arrow*). The eye sign is produced by an intact hook of the hamate bone. (B) Normal carpal tunnel view of the wrist. Arrow indicates the hook of the hamate. Asterisk denotes the pisiform. This view is used to more clearly demonstrate pisiform and hamate fractures.

the fourth and fifth MCP joints in maximum flexion. Immobilizing the thumb is also recommended to minimize the pull of the thenar muscles on the hook by the transverse carpal ligament.<sup>37</sup> Follow-up hand evaluation is recommended within 1 week.

Fractures through the body of the hamate are less common than fractures through the hook of the hamate and often occur as the result of an axial load to the clenched fist. These fractures are usually associated with concurrent injuries to the fourth and fifth CMC joints and metacarpal bases. Unlike fractures through the hook of the hamate, fractures through the body of the hamate can usually be identified by plain radiography. Early immobilization in a volar short-arm splint, with the hand in position of function, and hand follow-up is recommended for these fractures.

### ***Triquetral Injuries***

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The triquetrum is located on the ulnar side of the wrist in the proximal row of carpal bones. Triquetral fractures account for 18.3% of all carpal bone fractures, making the triquetral bone the second most commonly fractured carpal bone.<sup>30</sup> Triquetral fractures are classified as either chip fractures, which involve just the dorsal ridge, or triquetral body fractures.

Triquetral chip fractures are the more common of the two and occur with a fall onto an ulnarly deviated wrist in dorsiflexion. Triquetral body fractures are typically caused by direct force to the bone as the result of a high-energy impact. On examination, there may be swelling noted and limitation of wrist flexion and extension.

Imaging should include standard radiographs. The chip fracture is usually best identified on the lateral or oblique view as a bone fragment. The body fracture is most easily identified on the PA view.<sup>31</sup> Because fractures of the body of the triquetrum are often associated with perilunate fracture dislocations, care should be taken to carefully inspect the triquetrum in patients with greater arc injuries to prevent missing a triquetral body fracture. Likewise, identification of a triquetral body fracture should prompt a search for a perilunate ligamentous injury. If suspicion remains high for a triquetral fracture despite normal plain radiographs, a repeat radiograph with the hand in slight pronation or a CT scan should be considered.

Treatment of dorsal chip fractures consists of immobilization in an ulnar gutter splint and rarely requires more than 4 weeks of immobilization.<sup>37</sup> Treatment of the triquetral body fracture also involves immobilization but may require more immediate orthopedic follow-up if there is a suspicion for concurrent greater arc injuries.

### ***Pisiform Injuries***

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The pisiform bone is a sesamoid bone that lies on the volar surface of the wrist. It articulates only with the triquetrum. The pisiform is rarely fractured and accounts for only 1.3% of all carpal bone fractures.<sup>30</sup> Pisiform fractures are most often caused by a direct blow, such as might occur during a fall on an outstretched hand. Less commonly the pisiform can be avulsed by the flexor carpi ulnaris during forced wrist hyperflexion or from the strain of lifting a heavy object.

Patients with fractures of the pisiform complain of ulnar-sided wrist pain that is accentuated by resisted wrist flexion. Physical examination demonstrates pain over the pisiform. Occasionally, ulnar nerve palsy may result from a pisiform fracture because the pisiform serves as the ulnar wall of the Guyon's canal, which houses the ulnar nerve.<sup>38</sup>

Diagnosis of a pisiform fracture is difficult on standard radiographs because adjacent and overlying bones prevent an unobstructed view of the pisiform. If a pisiform fracture is suspected special views, such as a carpal tunnel view (see **Fig. 8B**) or a reverse oblique view with the wrist in 30° of supination, can be helpful in imaging

the pisiform. In children, diagnosis of pisiform fractures is made more complicated by the fact that the pisiform is the last carpal bone to ossify, and the multiple ossification centers may give this bone a fragmented appearance until 12 years of age.<sup>38</sup> CT can be used if clinical suspicion of pisiform fracture persists despite normal or nondiagnostic plain radiographs.

Treatment of a pisiform fracture is immobilization in an ulnar gutter splint for 3 to 4 weeks. If ulnar nerve palsy is present, hand-specialist consultation should be obtained for possible surgical decompression.<sup>39</sup> However, most ulnar nerve palsies that are present at initial presentation will resolve in 8 to 12 weeks and require only close observation.<sup>33</sup>

### **Capitate Injuries**

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The capitate is the largest carpal bone and is located centrally in the distal row of carpal bones. Capitate fractures are uncommon, accounting for only 1.9% of all carpal bone fractures, and generally occur in association with other carpal bone injuries, namely scaphoid fractures and perilunate dislocations. Isolated fractures of the capitate are rare, and in fact account for only 0.3% of all carpal injuries.<sup>30,40</sup> Because they are rare, capitate fractures should prompt a search for an associated perilunate ligamentous injury.

The mechanism of injury of the capitate is generally a direct blow to the dorsum of the hand or a fall on an outstretched hand. Capitate fractures can also occur as part of a greater arc injury in association with a perilunate dislocation. Patients with a fracture of the capitate will present with pain and swelling located in the dorsum of the wrist. Direct palpation of the capitate will accentuate the pain.

Standard radiographs of the wrist will most likely reveal the fracture on the PA view. However, isolated, nondisplaced fractures of the capitate can be subtle on plain radiographs. In one study, plain radiography had a sensitivity of 0% and failed to identify any capitate fractures, compared with CT, which had a diagnostic sensitivity of 100%.<sup>18</sup>

Early identification and diagnosis of capitate fracture is essential because the capitate, like the scaphoid, is at risk for AVN and nonunion. Nondisplaced fractures can be immobilized with a short-arm thumb spica cast,<sup>41</sup> whereas displaced fractures or those associated with carpal dislocations require immediate hand-specialist consultation.

### **Lunate Injuries**

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The lunate is located in the proximal row of carpal bones and sits between the capitate distally and the distal radius proximally. Lunate fractures account for 3.9% of all carpal bone fractures.<sup>39</sup> Isolated lunate fractures are uncommon except in the case of Kienböck's disease, also known as idiopathic avascular necrosis of the lunate. Associated injuries of the radius, carpals, or metacarpals occur 50% of the time.<sup>38</sup>

The typical mechanism of injury for a lunate fracture involves a fall on an outstretched hand. Patients with lunate fractures will present with pain over the dorsum of the wrist that is exacerbated by palpation of the dorsal aspect of the lunate. Axial loading of the third metacarpal can also accentuate the pain.

Standard wrist radiographs of the lunate often fail to demonstrate the fracture because visualization of the lunate is often obscured by superimposed bones.<sup>31</sup> CT has been found to be more sensitive than plain radiography at identifying fractures of the lunate.<sup>18</sup>

Early identification and management of these fractures is essential to prevent AVN, carpal instability, and nonunion. Patients with suspected or diagnosed lunate fractures

should be immobilized in a thumb spica splint with the hand and thumb in neutral position. Lunate fractures require a hand-specialist follow-up in 1 to 2 weeks.<sup>39</sup>

### ***Trapezium Injuries***

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The trapezium is located on the radial side of the distal row of carpal bones and forms a double-saddle articulation with the base of the first metacarpal. Fractures of the trapezium account for 4.3% of all carpal bone fractures and can be divided into fractures of the trapezium body and fractures of the trapezium ridge.<sup>39</sup>

Fractures of the trapezium body are most common and are often the result of an axial load through the thumb or forced hyperextension and abduction of the thumb. Fractures of the trapezium ridge are most often the result of a fall on an outstretched hand resulting in a direct blow to the trapezium or by avulsion of the trapezium by the transverse carpal ligament. Physical examination demonstrates point tenderness at the volar base of the thumb just distal to the scaphoid and pain with axial loading of the thumb. Pain may be exacerbated by resisted wrist flexion and pinch grasp.

Trapezium fractures are most easily identified on the oblique view because complete visualization of the trapezium is obscured by superimposed bones in the PA and lateral views. Specialized radiographs, including a pronated anteroposterior view, may better help visualize the trapezium-metacarpal articulation.<sup>38</sup> The carpal tunnel view is the best view for identifying fractures of the trapezium ridge. CT can be used to diagnose suspected fractures that are not identified on plain radiographs.<sup>18</sup>

Treatment of trapezium fractures is dependent on the type of fracture and presence of displacement. Nondisplaced triquetrum body fractures can be immobilized in a short-arm thumb spica for 4 to 6 weeks. All other types of fractures should be immobilized and referred for hand-specialist follow-up.<sup>39</sup>

### ***Trapezoid Injuries***

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The trapezoid is located in the distal row of carpal bones and positioned between the second metacarpal, capitate, scaphoid, and trapezium. Because it is well protected, it is the least commonly fractured carpal bone, accounting for only 0.4% of all carpal bone fractures.<sup>30</sup> The most common mechanism of injury is a high-energy axial load to a flexed second metacarpal, which most often produces a dorsally displaced fracture/dislocation of the trapezoid.

Physical examination of these patients demonstrates point tenderness over the dorsum of the wrist at the base of the second metacarpal. Pain can be exacerbated with movement of the second metacarpal. Using standard radiographs of the wrist, a fracture/dislocation of the trapezoid is most easily identified on the PA view as loss of the normal joint space between the distal scaphoid and the trapezium and trapezoid.<sup>42</sup> CT has superior sensitivity when compared with plain radiographs and may be necessary to diagnose trapezoid injury.<sup>18</sup>

Identification of a trapezoid injury is essential because complications of an untreated injury may lead to AVN of the trapezoid. Nondisplaced fractures may be treated with a short-arm thumb spica for 4 to 6 weeks. Displaced fractures and fracture/dislocations require prompt hand-specialist consultation.<sup>39</sup>

### ***Carpal Instability***

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Carpal instability resulting from forced wrist hyperextension has been described as a progressive spectrum of injury ranging from scapholunate dissociation (Stage I) to perilunate dislocation (Stage II) to lunotriquetrum disruption (Stage III) and finally to lunate dislocation (Stage IV).<sup>43</sup> The typical mechanism of injury is a fall on an outstretched hand or a high-impact force, such as might occur in a motor vehicle collision.

Physical examination typically shows a swollen tender wrist with limited range of motion secondary to pain. There is also the possibility of reduced grip strength. Median nerve palsy secondary to compression of the median nerve in the carpal tunnel by the lunate can be seen in Stage III and Stage IV injuries. Standard PA and lateral radiographs may be diagnostic of carpal instability, but the findings can be subtle. Nearly 25% of injuries were missed in a study of 166 cases of perilunate dislocations and fracture dislocations.<sup>44</sup>

Scapholunate dissociations (Stage I) involve disruption of the scapholunate interosseous ligament, which is sometimes associated with a fracture of the scaphoid waist. In patients with scapholunate dissociation, the PA radiograph will demonstrate a widening of scapholunate space of more than 3 mm. This widening is sometimes referred to as the Terry Thomas sign (**Fig. 9**). Another finding on the PA view is the cortical ring sign, which reflects the distal pole of the scaphoid seen on end. On lateral views, scapholunate dissociation is evidenced by an increased scapholunate angle of more than 60°. <sup>31</sup> Stress views can be used for diagnosis confirmation by accentuate widening of the scapholunate joint. These radiographs include anteroposterior (AP) views taken with a clenched fist and with ulnar deviation.

Perilunate dislocations (Stage II) involve disruption of the radius-lunate-capitate axis. The capitate, the entire distal row of carpal bones, and the radial portion of the proximal row of carpal bones displace dorsally with respect to the lunate. Sometimes this can be associated with a fracture of the scaphoid waist and is then referred to as a transscaphoid perilunate dislocation. Standard radiograph findings in patients with a perilunate dislocation include loss of congruity of the 3 carpal



**Fig. 9.** (A) PA radiograph showing a scapholunate dissociation. (B) When compared with normal PA it clearly shows an increase of greater than 3 mm in the scapholunate space.

arcs and an abnormal triangular configuration of the lunate on AP view. Perilunate dislocation can be identified more easily on lateral radiographs, which show normal alignment of the lunate and distal radius, with all the other carpal bones located posterior to the lunate (**Fig. 10**).<sup>39</sup>

Lunotriquetral disruptions (Stage III) are caused when the triquetrum exerts torque on the lunotriquetral ligament leading to a tear in the ligament or an avulsion fracture of the triquetrum. Standard radiographs appear similar to a perilunate dislocation but include a dislocation of the triquetrum that is most easily identified on the PA view as overlap of the triquetrum on the lunate or hamate.

Lunate dislocations (Stage IV) are the result of dorsal radiocarpal ligament disruption, which allows the displaced capitate to push the lunate in a volar direction into the carpal tunnel. Lateral radiographs of lunate dislocations result in a spilled-tea-cup appearance, which is a reflection of the lunate tilting so that its distal articular surface faces the palm (see **Fig. 10**). PA views of the hand have a similar appearance to radiographs demonstrating perilunate dislocations.<sup>45</sup>

Management of perilunate and lunate dislocations in the ED requires emergent hand-specialist consultation for immediate reduction and immobilization. Although closed reduction could be attempted in the ED to reduce compression on the median nerve, the best results for long-term recovery are achieved with open reduction and internal fixation.<sup>46</sup>



**Fig. 10.** The image on the left shows a perilunate dislocation. The entire distal row of carpal bones is dislocated dorsally. The lunate, however, remains articulated to the radial head. Note the ulnar styloid fracture, which often occurs in conjunction with a perilunate dislocation. In comparison, the image on the right shows a lunate dislocation and a scaphoid fracture, which shows the classic spilled-tea-cup sign, where the lunate is pushed in the volar direction into the carpal tunnel.

## FRACTURES OF THE DISTAL RADIUS AND ULNA

Fractures of the distal radius and ulna are the most common type of fractures in patients younger than 75 years of age.<sup>47</sup> Historically eponyms have been used to describe these fractures, and although eponyms are still in use today, several more recent classification systems have been developed to better characterize these fracture patterns relative to their management and prognosis.<sup>48</sup>

A fall on an outstretched hand is a common mechanism of injury for a transverse fracture of the distal radial metaphysis, with dorsal displacement and angulation. This fracture is commonly referred to as a Colles fracture and can be associated with a fracture of the ulnar styloid.

Patients with this type of injury often complain of pain and swelling over the dorsum of the wrist and on physical examination demonstrate a dinner-fork deformity caused by the dorsal displacement and angulation of the fracture. Median nerve injury can occur with this fracture and a careful neurovascular examination both on initial presentation and following treatment is essential. Standard radiographs of the wrist will demonstrate the fracture through the radial metaphysis. The lateral radiograph is the best view to appreciate the degree of dorsal displacement and angulation and typically demonstrates loss of the normal volar tilt of the distal radial articular surface.

Management of Colles fractures should include closed reduction, which can be facilitated by the use of a hematoma block and finger traps. After successful reduction patients should be immobilized in a long-arm splint in neutral position or pronation with orthopedic follow-up in 7 to 10 days. Emergent orthopedic consultation is necessary if initial attempts at closed reduction are unsuccessful, if there is neurovascular compromise, or if there is an open fracture.<sup>39</sup>

A fall onto the dorsum of the hand with the wrist in flexion is the typical mechanism of injury for a transverse fracture of the metaphysis of the distal radius, with associated volar displacement and volar angulation. This fracture is commonly referred to as a reverse Colles fracture or a Smith fracture.

Patients with this type of fracture often present with pain and swelling of the wrist. On physical examination they have fullness noted on the volar aspect of the wrist. Like the Colles fracture, median nerve injury can occur with this type of fracture and a careful neurovascular examination both on initial presentation and following treatment is essential. Standard PA radiographs will demonstrate the fracture line through the distal radius, but the degree of volar angulation will be best appreciated on the lateral view.

Like the Colles fracture, the Smith fracture is treated with closed reduction. Following reduction, patients should be placed in a long-arm splint in supination.<sup>49</sup> Emergent orthopedic/hand-specialist consultation is recommended for these fractures because they are more likely to be unstable and urgent surgical management is more often necessary.<sup>39</sup>

A distal radius fracture with dislocation of the radiocarpal joint is commonly referred to as a Barton fracture. This fracture generally occurs from a high-energy impact to the radiocarpal joint. If the impact occurs while the wrist is volarly flexed, the fracture affects the volar rim of the radius and is referred to as a volar Barton fracture. If the impact occurs while the wrist is in dorsiflexion, the fracture affects the dorsal rim of the radius and is referred to as a dorsal Barton fracture.

Patients with this type of fracture will present with wrist pain and swelling, and on physical examination will have deformity of the wrist. Standard radiographs will demonstrate the fracture, which is distinguished from a Smith or Colles fracture by the radiocarpal dislocation. The lateral radiograph is the best view for demonstrating the degree of articular surface involvement and the amount of associated

displacement. These fractures require emergency orthopedic/hand-specialist consultation for early operative management.<sup>49</sup>

An intraarticular fracture through the radial styloid process caused by a direct blow or a fall on the radial side of the wrist is commonly termed a Hutchinson fracture. Patients with this type of fracture will typically present with pain and swelling of the wrist. Standard radiographs of the wrist demonstrate the fracture best on PA view as a transverse fracture of the radial metaphysis with extension through the radial styloid. Nondisplaced fractures can be managed with a short-arm splint and routine orthopedic/hand-specialist follow-up. Displaced fractures require reduction and immobilization. Accurate anatomic alignment following reduction is essential because multiple ligaments of the wrist attach to the radial styloid process and inappropriate alignment can cause future complications.

### DISTAL RADIOULNAR JOINT DISRUPTION

Disruption of the distal radioulnar joint (DRUJ) may be seen as an isolated injury, or more commonly, in association with distal radius fractures. In the former, the injuries are typically the result of a traumatic dislocation of the distal ulna and can be characterized as either volar or dorsal dislocations.

Fracture	Splint	Referral
Phalanx	Splinted in	Nonemergent referral
Distal	FULL extension	
Dorsal	Slight flexion	
Volar	Radial/ulnar gutter	
Middle	Radial/ulnar gutter	
Proximal		
Metacarpal	Thumb spica	Nonemergent referral necessary
First	Volar/radial gutter	for all fractures with good
Second	Volar/radial gutter	anatomic alignment after
Third	Ulnar gutter	reduction
Fourth	Ulnar gutter	Emergent referral for
Fifth		nonreducible fractures or
		neurovascular involvement
Scaphoid	Thumb spica: long or short	Definite fracture: emergent referral
		Suspected fracture: nonemergent referral
Hamate	Thumb spica with wrist	Specialist referral within 1 week
Hook	flexed and MCP at 90°	
Body	Short-arm cast	
Lunate	Short-arm splint	Referral in 1 to 2 weeks
Triquetral	Short-arm splint	Nonemergent
Pisiform	Short-arm splint	Emergent if signs of ulnar neuropathy
Capitate	Short-arm thumb spica	Emergent referral if associated with a dislocation
Trapezium	Short-arm thumb spica	Nonemergent
Trapezoid	Short-arm thumb spica	Emergent if displaced, otherwise nonemergent

Dorsal dislocations are the most common and are typically the result of a fall on to an outstretched arm with a rotational pronation force to the impact. Physical examination reveals excessive prominence of the ulnar head and lack of forearm rotation secondary to pain when the wrist is supinated. Standard radiographs demonstrate overlap of the distal ulna with the distal radius on the PA view with the ulnar head displaced in the dorsal direction on the lateral projection.

Volar dislocations are typically the result of a fall on an outstretched arm with a rotational supination force to the impact. Physical examination demonstrates loss of the typical dorsal prominence of the ulnar head and lack of forearm rotation secondary to pain when the wrist is pronated. Standard radiographs demonstrate overlap of the distal ulna with the distal radius on the PA view with the ulnar head displaced in the volar direction on lateral projection.

Displaced distal radius fractures can also be associated with injury to the ulnar side of the wrist, causing disruption in the supporting structures of the DRUJ. Radiographic signs of DRUJ instability are<sup>50</sup>

- Ulnar styloid fracture involving the base with more than 2 mm displacement
- Irreducible dislocation of the DRUJ
- Fractures involving the sigmoid notch of the radius
- Wide displacement of the DRUJ
- Radial shortening.

If DRUJ instability is suspected based on clinical examination or radiographic studies an emergent orthopedic/hand-specialist consultation should be obtained for reduction and immobilization (**Table 1**).<sup>49</sup>

## SUMMARY

The intricate anatomy of the hand and wrist, which allows for significant functionality, also allows for several complex fractures and dislocations. Despite the complexity of these injuries, a complete history, thorough physical examination, and pertinent imaging studies can prevent delays in diagnosis. Particular attention should be given to the neurovascular examination and mechanical function of the structures in question. If an injury is suspected based on the history and physical examination, but is not supported by standard radiographs, further imaging studies, such as CT or MRI, may be needed or empiric treatment provided until orthopedic/hand-specialist follow-up can be obtained. Careful and complete evaluation of patients presenting to the ED with injuries of the hand and wrist is essential because missed diagnoses can cause significant pain and long-term disability.

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