Emergency Department Evaluation and Treatment of Wrist Injuries

Alina Tsyrulnik, MD

KEYWORDS

• Wrist injury • Dislocation • Carpal bone • Scaphoid

KEY POINTS

- Correct diagnosis of wrist injuries is critical in preventing prolonged pain and dysfunction.
- Plain radiographs cannot diagnose a large percentage of injuries.
- Distal radius fractures are treated by splinting. Colles fractures are splinted in neutral or pronation; Smith's fractures are splinted in supination.
- The scaphoid is the most commonly-injured carpal bone. If fracture is suspected but not seen on radiographs, it should be treated by thumb spica splinting to prevent complications.
- Carpal dislocations are relatively rare, but can lead to significant disfunction if not emergently treated. Emergent orthopedic consultation is warranted.

The wrist, although a comparatively small part of the human body, is complex in its mechanics and function and, when injured, can lead to significant morbidity.

- Approximately 2.5% of all emergency department (ED) visits in the United States are for wrist injuries.[1]
- Approximately 1.5% of all ED visits are for hand and/or forearm fractures.[2]
- Approximately 20% of hand and wrist fractures are carpal bone fractures.[3]
- The elderly have the highest rates of carpal bone injury, with most injuries occurring as a result of accidental falls in the home.[2]
- The scaphoid is the most commonly fractured carpal bone.[3]

Correct diagnosis of wrist injuries is critical in preventing prolonged pain and dysfunction. It is complicated in that plain radiographs cannot diagnose a large percentage of injuries. Wrist sprain is considered one of the most common yet most treacherous ED diagnoses[1] because radiographs do not always rule out all acute injuries. Knowledge of the anatomy, normal physical examination findings, and

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Department of Emergency Medicine, Yale University School of Medicine, 464 Congress Ave, New Haven, CT 06519, USA
E-mail address: alina.tsyrulnik@yale.edu

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physical examination abnormalities associated with different pathological conditions, is paramount in making the correct diagnosis. This article focuses on the anatomy, diagnosis, and ED management of acute wrist injuries, including fractures and dislocations.

NORMAL ANATOMY, RADIOGRAPHY, AND PHYSICAL EXAMINATION

Normal Anatomy and Radiography

The wrist, from proximal to distal, is comprised of the distal radius, ulna, and 8 carpal bones that are arranged into 2 arching rows (**Fig. 1**).

- The proximal carpal bones (from radial to ulnar direction) include: scaphoid, lunate, triquetrum, and pisiform (a sesamoid bone associated with the flexor carpi ulnaris tendon).[3]
- The distal carpal bones (from radial to ulnar direction) include trapezium, trapezoid, capitate, and hamate.

There is characteristic normal alignment of the 2 rows on posterior-anterior (PA) and lateral projections, with the “three lines of Gilula”[3] and the stacked C-shapes seen on each view, respectively.

- PA view: proximal and distal articular surfaces of the proximal row and the proximal surface of the distal row making up the “3 lines of Gilula” (**Fig. 2**).[4]
- Lateral view: the distal radius, lunate, capitate, and third metacarpal align in C-shapes (**Fig. 3**).[4]
- The radial height and palmar tilt angles are relevant in evaluating the distal radius (**Fig. 4**).[5]

Normal Physical Examination

On physical examination, the scaphoid can be palpated in the so-called snuff box, which is bordered by the tendons of the extensor pollicis longus and abductor pollicis longus.[3] Flexion of the wrist allows the palpation of the lunate just distal to the radius, ulnar to the scaphoid, and in line with the third phalanx. The triquetrum is distal to the ulna and the pisiform is palpated on the volar distal wrist in line with the fifth phalanx. The distal row of carpal bones is palpated just proximal to the metacarpals. The

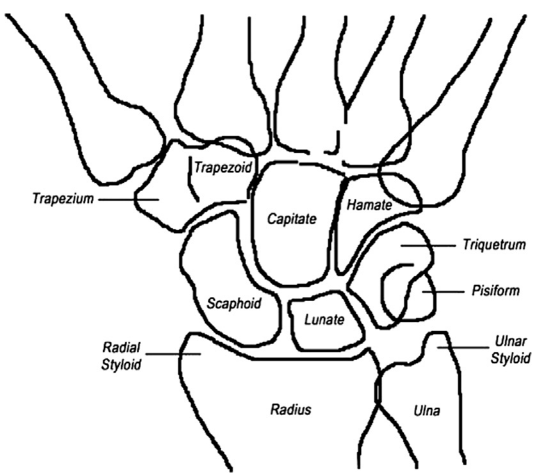

Fig. 1. Bony anatomy of the wrist.

Fig. 2. The lines of Gilula: normal alignment of the carpal bones.

trapezium, trapezoid, and capitate are proximal to the first through third metacarpals (in the radial to ulnar direction) and the hamate is proximal to the fifth metacarpal. The hook of the hamate is palpated in the palm where it extends 1 to 2 cm distal and lateral to the pisiform in the hypothenar eminence.[6]

DISTAL RADIUS FRACTURES

Background

Distal radius fractures are frequently encountered in the ED. The distribution of population affected is bimodal, including children younger than 16 years and women older than 50 years of age. In the younger age group there has been a steady increase in the frequency of these injuries, which is believed to be due to increased obesity and resultant higher impact during falls.[5]

- Distal radius and/or ulna fracture account for approximately 0.66% of ED visits.[5]
- The annual incidence of distal radius fractures in the United States is 640,000.[7]
- Women older than 50 years have a 15% lifetime risk of distal radius and/or ulna fracture.[5]
- Distal radius fracture is the most common fracture in children younger than 16 years.[5]
- Fifty percent of distal radius fractures are intraarticular.[8]

Several eponyms are used to describe the various types of distal radius fractures:

- Colles fracture is a transverse fracture of distal radial metaphysis with dorsal displacement and angulation[3] often resulting from a fall onto an extended wrist.

Fig. 3. Colinearity of the distal radius, capitate, and the third metacarpal.

- Smith fracture is a transverse fracture of the distal radial metaphysis with volar displacement and angulation[3] often resulting from a fall onto a flexed wrist.
- Barton fracture is a distal radius fracture with dislocation of the radiocarpal joint and either volar or dorsal angulation.[3,8]
- Hutchinson fracture is an intraarticular fracture through the radial styloid process often resulting from a direct blow or a fall onto the radial side of wrist.[3]

Diagnosis

On physical examination, Colles fractures present as the typically described silver fork or dinner fork deformity. Radiographic evidence of such fractures is accomplished with PA, anterior-posterior (AP), and lateral views, with particular attention paid to the radial height (AP and PA views) and volar tilt angle (lateral views) (see **Fig. 4**).[3,5]

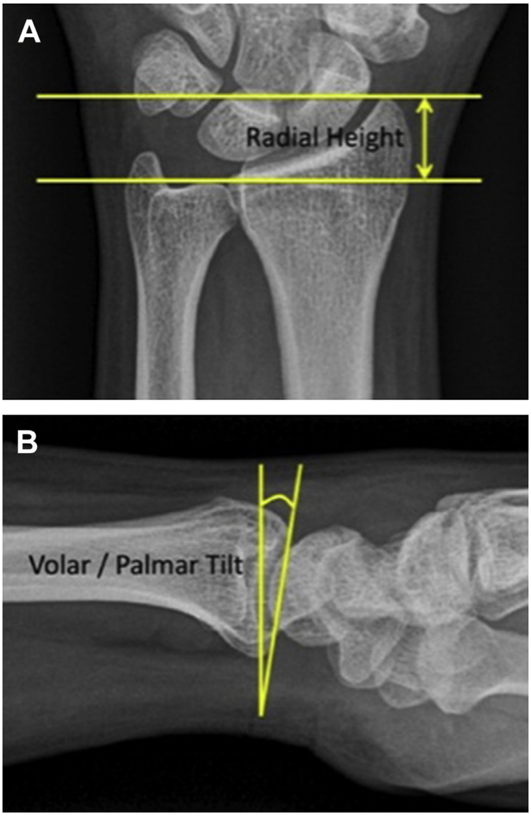

Fig. 4. (*A*) Radial height on AP view. (*B*) Palmar tilt angle on lateral view is normally 11°.

If distal radioulnar joint (DRUJ) instability is suspected, the fracture has significant intraarticular extension, or has significant comminution, a CT scan can provide additional information and aid in diagnosis and treatment (see later discussion).[8,9]

Treatment

Management of Colles and Smith fractures usually includes closed reduction. This is accomplished with regional anesthesia with a hematoma block and the use of finger traps. After reduction, a long-arm splint is applied.

- Colles fracture is splint in neutral position or pronation.[3]
- Smith fracture is splint in supination.[3]

With successful reduction of a closed Colles fracture without evidence of neurovascular compromise, the patient can wait to be seen by an orthopedist for a week to 10 days.[3] The wrist will be immobilized for 4 to 6 weeks.[5] Smith fractures have a higher incidence of instability and always require urgent specialist follow-up.[3] Barton fractures always require emergent orthopedic consultation for early surgical treatment.[3] Nondisplaced Hutchinson fractures are treated with a short arm splint and routine orthopedic follow-up. Displaced Hutchinson fractures require careful emergent reduction with complete anatomic alignment.[3] For this reason, emergent specialist consultation should be considered if alignment is not adequate.

Any open fracture requires an emergent orthopedic or hand surgery consultation, as well as administration of intravenous antibiotics and tetanus status assessment.[10]

Complications

There is a wide variance in the reported complication rate of distal radius fractures of between 6% and 80%, with an increased rate in open fractures.[10] Nerve injury occurs in up to 17% of distal radius fractures, with the median nerve being the most vulnerable, followed by the ulnar and radial nerves.[10,11] Immediate or delayed carpal tunnel syndrome (CTS) is the most common complication of distal radius fracture.[12] Transient neuropathy may also occur. The high frequency of median nerve involvement is due to its central location within the carpal tunnel as well as proximity to the distal radius.[11] Both Colles and Smith fractures can lead to median nerve injury. This complication is more likely with a higher degree of dorsal displacement of the distal fragment, more comminuted fractures, and those undergoing multiple closed reduction attempts.[3,5,10] Of note, CTS is a term used to describe the compression of the median nerve and its subsequent dysfunction that is acute and progressive. This compression is either from direct damage to the nerve or secondarily from swelling of surrounding tissues. Acute CTS develops rapidly after the injury whereas secondary CTS can happen months to years later.[12] CTS may require surgical intervention. In contrast, transient median nerve contusion, occurring in 4% of cases, resolves with conservative management.[11]

Factors that lead to instability and long-term disability after distal radius fracture include a dorsal angulation angle of more than 20° (with normal angulation being 11°) and greater than 5 mm of radial shortening.[5]

Another complication of a distal radius fracture is disruption of the DRUJ. This injury can occur in isolation (without associated fractures); however, this is less common. When isolated, it is the result of distal ulnar dislocation that can be in the volar or dorsal (more common) direction depending on the rotational component during impact. Radiographic evidence of this injury will be seen on PA radiographs as overlap of the distal radius and ulna; lateral radiographs will show ulnar displacement (dorsal or volar).[3,9]

- Dorsal dislocations are associated with pronation during impact and pain with supination on physical examination.
- Volar dislocations are associated with supination during impact and pain with pronation on physical examination.

Disruption of the supporting structures, including the triangular fibrocartilage complex (TFCC) of the DRUJ (without dislocation), is a complication of a displaced distal radius fracture. Up to 60% to 84% of distal radius fractures are associated with injury to the TFCC.[9] Signs of DRUJ instability are[3,9]

- Ulnar styloid fracture involving the base with more than 2 mm displacement
- DRUJ dislocation that can not be reduced
- Fracture of the sigmoid notch of the radius
- Wide DRUJ displacement
- Shortened radius.

DRUJ instability requires emergent orthopedic or hand surgery consultation for reduction and immobilization.[3,9]

Other common complications of distal radius fractures include arthrosis, malunion, nonunion, tendon rupture, chronic regional pain syndrome, ulnar impaction, loss of rotation, and finger stiffness.[12]

Isolated fractures of the distal ulna (within 5 mm of distal articular surface) are rare. However, they commonly occur with distal radius fractures.

- Sixty percent of distal radius fractures are associated with fractures of the ulnar styloid.[13]
- These fractures will often reduce during distal radius reduction.[13]

Many complications of distal radius fractures are iatrogenic, stemming from the treatment rather than the trauma that caused the injury.

- Splinting in extreme flexion increases carpal tunnel pressures, which causes median nerve damage.[10]
- Overlying skin of the distal radius can be very thin (especially in the elderly). Closed fractures can be converted to open fractures during reduction.[10]
- Compartment syndrome can occur acutely from the fracture itself or as a result of completely circumferential casting.[10,11]

SCAPHOID INJURIES

Background

The most commonly fractured carpal bone, the scaphoid,[3] is located at the anatomic snuff box. Fractures of the scaphoid occur as a result of a fall on an outstretched hand or during forced dorsiflexion of the wrist.[14] Initial diagnostic imaging should start with plain radiographs in 4 views: PA, lateral, radial oblique, and ulnar oblique.[15] Diagnosis of fracture is complicated by the frequency of false-negative radiographs.

- Prevalence of scaphoid fractures among patients with acute wrist injuries is 7%.[16]
- Incidence of false-negative initial radiographs for scaphoid fractures is 1% to 16%.[16,17]
- Sensitivity of initial plain radiographs for scaphoid fractures is 70% to 86%.[5]
- CT scan sensitivity is 89% to 100% and specificity is 85% to 100% for diagnosing acute scaphoid fracture.[16,18]
- MRI sensitivity is 98% to 100% and specificity of 100% for diagnosing acute scaphoid fracture.[16]

Diagnosis

Patients with tenderness on the physical examination that is suggestive of scaphoid fracture but negative radiographs deserve special consideration. Several recent studies have focused on the diagnostic value of physical examination, CT scan, and MRI in these situations. Physical examination findings most predictive of bony injury (any bone) in patients who had tenderness at the snuffbox and scaphoid tubercle after a fall on outstretched hand and negative radiographs were

- Thumb-index finger pinch with elicited pain at snuffbox: sensitivity of 73% and specificity of 75%[19]
- Pronation of the arm with elicited pain at snuffbox: sensitivity of 79% and specificity of 58%.[19]

Another study examined the sensitivity and specificity of combining the most common physical examination findings associated with scaphoid fractures[17]:

- Tenderness at the anatomic snuffbox
- Tenderness at the scaphoid tubercle

- Tenderness with longitudinal compression of thumb onto scaphoid
- Pain with active movement of the thumb.

The investigators found that

- The first 3 maneuvers had an individual sensitivity of 100%[17]
- The fourth maneuver (thumb movement) had a sensitivity of 69%[17]
- The specificities for these maneuvers were: 9%, 30%, 48%, and 66%, respectively[17]
- When the first 3 maneuvers where combined and tenderness was present on all 3, the sensitivity remained at 100% but the specificity increased to 74%.[17]

Another study compared the sensitivity of MRI and CT scan for detecting bony injuries in patients with snuffbox tenderness and negative radiographs. The investigators found that both imaging modalities had a sensitivity of 67% for detecting injury within 10 days of wrist trauma (with the gold standard being radiographs in 4 views at 6 weeks postinjury).[16]

Treatment

If a scaphoid fracture is definitively identified, the ED treatment includes application of a long-arm thumb spica splint and immediate hand surgery consultation.[3] Typically, when a scaphoid fracture is suspected without radiographic confirmation, a thumb spica splint should be applied with hand surgeon follow-up in 7 to 10 days. At that point, repeat imaging is done.[3] The argument for doing this has been that the cost of CT scan or MRI is too high to justify immediate use of these modalities. Recent studies looking at the costs incurred with prolonged immobilization (lost income, lost productivity, repeat imaging, follow-up appointments) versus immediate CT scan or MRI are showing mixed results.[14]

Complications

Avascular necrosis (AVN) and nonunion are the most common complications of scaphoid injury and the reason why even suspected fractures are treated with immobilization.

- Approximately 15% of scaphoid wrist fractures result in malunion or nonunion.[3]
- Approximately 20% of all scaphoid fractures result in AVN.[3]
- Approximately 80% of proximal scaphoid fractures result in AVN.[3]

The incidence of complications depends on the location and degree of displacement of the fracture. Nondisplaced fractures have a lower chance of poor outcomes. Furthermore, if the fracture is located in the middle or distal thirds of the scaphoid, the expected healing rate is 95% with short arm thumb spica for 10 to 12 weeks. Fractures in the proximal third of the scaphoid have a 34% chance of nonunion when treated conservatively.[5]

CARPAL FRACTURES EXCLUDING THE SCAPHOID

Compared with the incidence of scaphoid injury, other carpal bones are injured much less frequently. Nonscaphoid fractures account for 13% to 38% of carpal bone fractures.[20] See **Table 1** for a summary of carpal bone fractures, their ED treatment, and interval to specialist follow-up.[3]

Lunate

- Isolated lunate fractures are extremely rare because 70% of this bone sits on the radius and 30% articulates with the TFCC.[20]

Table 1
Carpal fracture splinting and referral recommendation

Fracture	Splint	Orthopedic Referral
Scaphoid	Thumb spica: long or short	Definite fracture: emergent Suspected fracture: nonemergent referral
Hamate Hook	Thumb spica with flexed wrist and metacarpophalangeal at 90°	Specialist referral within 1 wk
Hamate Body	Short-arm cast	Specialist referral within 1 wk
Lunate	Short-arm splint	Referral in 1–2 wk
Triquetral	Short-arm splint	Nonemergent
Pisiform	Short-arm splint	Emergent if signs of ulnar neuropathy
Capitate	Short-arm thumb spica	Emergent if associated with dislocation
Trapezium	Short-arm thumb spica	Nonemergent
Trapezoid	Short-arm spica	Emergent if displaced

- The mechanism of injury is extreme dorsiflexion with ulnar deviation.[20]
- Oblique radiographic views are necessary for the diagnosis of lunate fractures.[20]
- Emergent treatment includes immobilization with a short-arm cast for 6 weeks.[20]

Triquetrum

- Triquetrum fractures account for 4% to 20% of carpal bone fractures.[20]
- The mechanisms of injury are hyperextension with ulnar deviation or a fall on an outstretched hand.[20]
- Locations for triquetrum fractures include dorsal cortex (93%), body, or palmar cortex.[20]
- Treatment of dorsal cortical fractures is a wrist splint or short arm cast for 4 to 6 weeks.[20]
- Treatment of nondisplaced body fractures is a short arm cast for 6 weeks; displaced fractures require surgery.[20]
- Treatment of palmar cortical fractures is surgical.[20]

Pisiform

- Pisiform fractures account for 0.2% to 1% of all carpal fractures.[20,21]
- The pisiform is the last carpal bone to ossify (at age 8 to 12 years) thus making the distinction between incomplete ossification and fracture difficult in young children.[20,21]
- The mechanisms of injury are direct trauma to the hypothenar eminence, avulsion when the flexor carpi ulnaris resists forcible hyperextension (during strain to lift heavy object), or repetitive trauma associated with stick-handling sports (golf, tennis, baseball).[20,21]
- Patients may present with diminished grip strength and ulnar and/or medial nerve paresthesias.[21]
- Radiographic views, such as the reverse oblique of the wrist, clenched fist PA with ulnar deviation, wrist extension in 45° supination, and carpal tunnel view,[20,21] may aid in diagnosing pisiform fractures.
- Emergent treatment of pisiform fractures is immobilization for 4 to 6 weeks.[20,21]
- Complications include prolonged ulnar nerve palsy and diminished grip strength.[20,21]

Trapezium

- Trapezium fractures account for 3% to 5% of all carpal fractures.[20]
- The mechanisms of injury are a fall on an outstretched palm, axial loading through the first metacarpal, or hyperextension-abduction of the thumb.[20]
- An oblique radiographic view is necessary in the diagnosis of trapezium fracture (PA and lateral views fail to show the entire trapezium).[20]
- Missed diagnosis and/or inadequate treatment of this injury can result in permanent impairment of pinch and grip.[20]
- Trapezium fractures are emergently treated by short-arm thump spica cast for 4 to 6 weeks.[20]

Trapezoid

- Trapezoid fractures account for 0.2% of carpal bone fractures.[20]
- The mechanisms of injury are axial load on second metacarpal or extreme second metacarpal palmar flexion.[20]
- Plain radiography often miss the injury, CT scan may be required.[20]
- Nondisplaced fractures are treated with a short-arm thumb spica cast for 4 to 6 weeks.[20]

Capitate

- Capitate fractures account for 1.3% of carpal bone fractures.[20,22]
- Most capitate fractures are associated with scaphoid fractures.[20]
- The mechanisms of injury are a direct blow to dorsum of wrist; dorsiflexion force to wrist in neutral, ulnar, or radial deviation; force applied to second through fourth metacarpals; or a flexion force to the wrist.[22]
- Radiographic views that aid in the diagnosis of capitate fractures include PA radial and ulnar deviation views.[20]
- Clinically suspected injury that is not evident by pain radiography may warrant CT scan or MRI.[20]
- Nondisplaced fractures are treated with short-arm thumb spica cast immobilization for 6 to 8 weeks.[20]
- Displaced fractures are treated by closed or open anatomic reduction.[20]
- Complications of capitate fracture (most often resulting from delayed or missed diagnosis) include nonunion, AVN, and posttraumatic arthritis.[20]

Hamate

- Areas of fracture involve the body and hook (most common, accounting for 2% to 4% of all carpal bone fractures).[20,21]
- The mechanisms of injury are repeated microtrauma, a fall, a direct blow to hand, or stick-handling sports (golf, baseball, racquet sports).[6,20,21]
- Clinical presentation may include tenderness over the hypothenar eminence, pain with flexion of the fourth and fifth digit, pain on gripping, diminished grip strength, and ulnar and/or medial nerve paresthesias.[20,21]
- Radiographic views, such as the PA, lateral, supinated oblique, and carpal tunnel view, may aid in diagnosis.
- Plain radiography has a sensitivity of 71% (all views are combined). CT scan imaging has a sensitivity of 100%.[20,21]
- Emergent treatment of hamate fracture is an ulnar gutter short-arm cast for 3 weeks, followed by short-arm cast for 3 weeks.[20]
- Complications include ulnar and/or median nerve neuropathies and diminished grip strength.[6,21]

CARPAL DISLOCATIONS

Carpal dislocations and fracture dislocations are relatively infrequent (together they account for 7% of carpal injuries[23]). They occur as a result of carpal ligamentous injuries from hyperextension and ulnar deviation. Normally, equal spacing is seen between the carpal bones on PA imaging. There are 4 distinct stages of dislocation, each stage representing its own injury pattern[24]:

- Stage 1: scapholunate dissociation
- Stage 2: perilunate dislocation
- Stage 3: perilunate and triquetrum dislocation
- Stage 4: lunate dislocation.

Median nerve injury, acute or subacute CTS, scapholunate advanced collapse (SLAC) deformity, avascular changes, and degenerative changes are known complications of carpal dislocations.[1,23–25] A delay in treatment will increase the likelihood of a poor outcome.[26]

Scapholunate Dissociation

The normal space between the scaphoid and lunate in PA view should be 2 mm or less. Scapholunate dissociation is the widening of that gap, also known as the Terry Thomas sign, on radiographs (**Fig. 5**).[27] This widening can by accentuated by taking the radiograph while the wrist is in ulnar deviation with a clenched fist.[4] Another radiographic finding that indicates scapholunate dissociation is the signet ring sign (**Fig. 6**), which is the result of the scaphoid's rotary motion and repositioning of its distal pole in a palmar position.[4]

Lunate and Perilunate Dislocations

Injuries at and around the lunate are usually the result of hyperextension; high-energy trauma, such as fall on outstretched hand; or car or motorcycle accidents.

- Perilunate dislocation occurs when the head of the capitate dislocates from the distal surface of lunate (**Fig. 7**).

Fig. 5. Terry Thomas sign of scapholunate dissociation or dislocation.

Fig. 6. Signet ring sign of scapholunate dissociation or dislocation.

Fig. 7. Perilunate dislocation.

- Lunate dislocation occurs when the lunate no longer sits in the lunate fossa of the distal radius.

Although the more common injury is a perilunate dislocation, lunate dislocations are more severe.[1] Lunate and perilunate dislocations are often associated with other injuries:

- 61% to 65% are associated with scaphoid fractures[26]
- 26% are associated with polytrauma[26]
- 11% are associated with other upper extremity injuries.[26]

Although often accompanied by significant deformities, lunate and perilunate dislocations can be subtle and thus 16% to 25% are missed on initial presentation.[26]

Treatment of Carpal Dislocations

Carpal bone dislocations should prompt consultation of a hand specialist in the ED. For open dislocations, the patient needs operative management. Surgical intervention is also mandated if median nerve symptoms are present. For closed dislocations without median nerve damage, the dislocation can be managed by prompt closed reduction. Closed reductions are often unsuccessful, requiring open reduction with internal fixation by an orthopedic specialist.[26,28] Even if successfully reduced, early surgical correction is ideal for best outcomes because closed reduction and immobilization has been found to result in unacceptable failure rates.[25]

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