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Traumatic Injuries of the Hand and Wrist. Part I

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Have you ever missed a hand or wrist injury? One that comes back to you as a call from the orthopedist office on how incompetent those ER docs are? Well, I have and, I suspect, so have so many of my colleagues. Nobody misses midshaft femur fractures, but the hand and wrist anatomy is so complex, the injury patterns have great variation, and the radiographs are often subtle, that it is easy to understand why these injuries are missed. This two-part article starts with a review of the functional anatomy of the hand and wrist followed by discussions of the important injuries. After reading these this two-part article, you should learn, as I have learned, to avoid sending a patient out of the ED with a diagnosis of "wrist sprain."

—J. Stephan Stapczynski, MD, FACEP, FAEEM, Editor

Clinical Anatomy and Examination of the Wrist and Hand

Bones and Joints. The intricate anatomy of the 27 bones of the human hand and wrist permits a wide range of motion allowing individuals to manipulate their immediate environment. (*See Figure 1.*) The eight bones of the wrist (carpus) are arranged in two rows each containing four bones. The proximal row starting from the radial side includes the scaphoid, lunate, triquetrum, and the more volar pisiform. Of these, the first three form what has been described as an "intercalated segment," a highly mobile unit, transmitting forces between the radius and the distal carpal row. The distal row proceeding from the radial side includes the trapezium, trapezoid, capitate, and hamate.

Within the proximal row, only the scaphoid and lunate articulate with the radius at the radiocarpal joint. The ulna is attached

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to the triquetrum and lunate bones, as well as the distal radius, via a series of chondro-ligamentous supports collectively known as the triangular fibrocartilage complex (TFCC). The TFCC is also responsible for a smooth articular surface for the triquetrum and lunate of the proximal row and stability of the distal radioulnar joint (DRUJ). The TFCC inserts on the ulnar styloid, which frequently is a site of injury when a patient falls on an outstretched hand.[1]

On the dorsum of the wrist, midway from the radial styloid, is an osseous prominence known as Lister's tubercle. The tubercle serves as an important landmark for the palpation of the capitate and lunate. Just distal to the tubercle with the hand in neutral position is a depression, the floor of which is occupied by the capitate bone of the distal carpal row. With flexion, the lunate bone rotates dorsally into this depression and becomes palpable at this location. Normally, Lister's tubercle, the lunate, and capitate all align with the third metacarpal.

The anatomic snuffbox is palpable just distal to the radial styloid. The styloid comprises the base of the triangular snuffbox, whose two sides are bounded by the extensor pollicis longus (EPL) tendon on the ulnar side, and the extensor pollicis brevis (EPB) and abductor pollicis longus (APL) tendons radially. The floor of the snuffbox contains the scaphoid, the palpation of which is facilitated by slight wrist ulnar deviation. The scaphoid has the largest articulation with the radius, and forms a large mobile link within the wrist, hence its propensity for injury. Distal to the snuffbox, the mobile trapezium is palpable during thumb flexion and extension.

On the wrist's dorsomedial side is the ulnar styloid, a round prominence on the distal aspect of the forearm. Just distal to the styloid with the wrist in radial deviation, the triquetrum becomes palpable. On its volar side is the pisiform, a sesamoid bone contained within the flexor carpi ulnaris tendon. Distal to the pisiform is the hook of the hamate, which forms the lateral aspect of Guyon's canal through which the ulnar nerve and artery travel together.

The bones of the wrist are stabilized by a complex array of ligaments. While the extrinsic ligaments connect the carpal bones to the radius, ulna and metacarpals, the intrinsic ligaments connect the carpal bones to one another. The scapholunate and lunatotriquetral ligaments of the proximal row are especially injury prone given the proximal carpal row's position and relative mobility.

Normal wrist range of motion (ROM) includes flexion and extension of approximately 80 and 70 degrees, respectively, from neutral, and radial and ulnar deviation of 20 and 30 degrees respectively. Smooth motions require normal bony shape, intact ligaments, smooth articular surfaces, and an intact TFCC.[2-4]

The carpometacarpal (CMC) joints of the index and middle fingers rigidly articulate with the trapezoid and the capitate, although the CMC articulations of the ring and small fingers allow for 10-20 degrees of flexion and extension. Normal CMC joint function is necessary for the hand to mold when gripping objects of varying size and dimension.

The CMC joint of the thumb allows for a significant amount of movement including flexion, extension, abduction, adduction, opposition, and retropulsion. Injury to either of the articular surfaces of the joint or significant ligamentous injury may produce long-term impairment of joint stability or motion. This is particularly true if the volar ligament, the major stabilizer of the joint, is involved.[5,6]

The metacarpophalangeal (MCP) joints, commonly known as the knuckles, are most easily palpable in flexion. The MCP joint of the second through the fifth digits is formed by the articular surfaces of each round metacarpal head and the corresponding concave surface of the corresponding proximal phalangeal base. The MCP joints are each stabilized by volar cartilages, which are bound by the transverse metacarpal ligament. Lateral support is the result of ulnar and radial collateral ligaments and the buttressing effect of the adjacent joints, as well as the interosseous and lumbrical muscles. Thin joint capsules and the extrinsic tendons surround each MCP joint.[5,6]

In flexion of the MCP joints, there is maximal contact of the bones to one another and the collateral ligaments are relatively taught. In this position, the joints are relatively fixed. In extension, however, the opposite is true and there exists a wider range of motion. Except for the thumb, the MCP joints should be able to flex to 90 degrees from neutral and extend to about 30 degrees.

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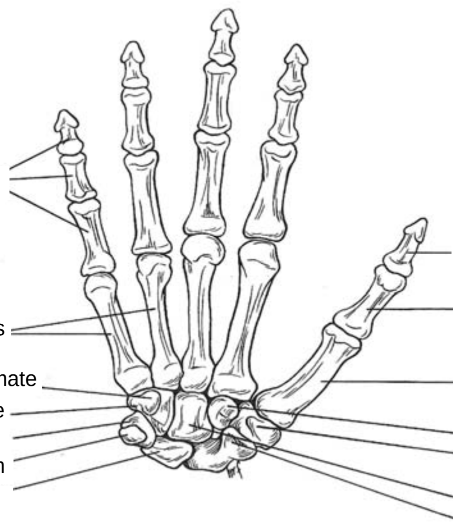
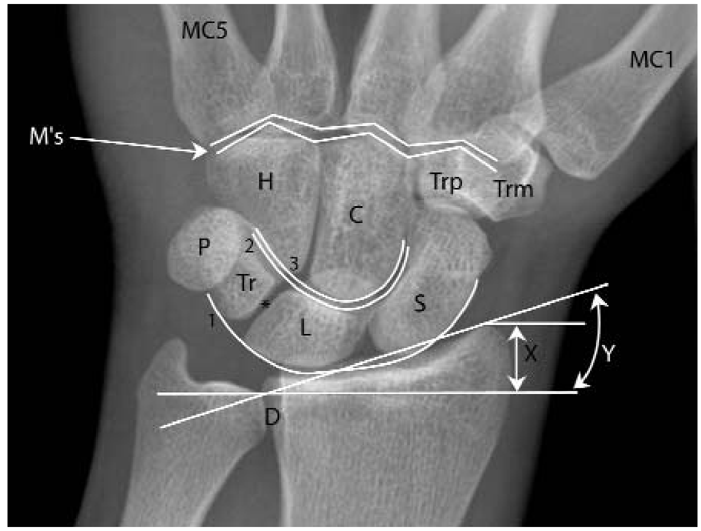
Figure 1. Bones of the Hand and Wrist



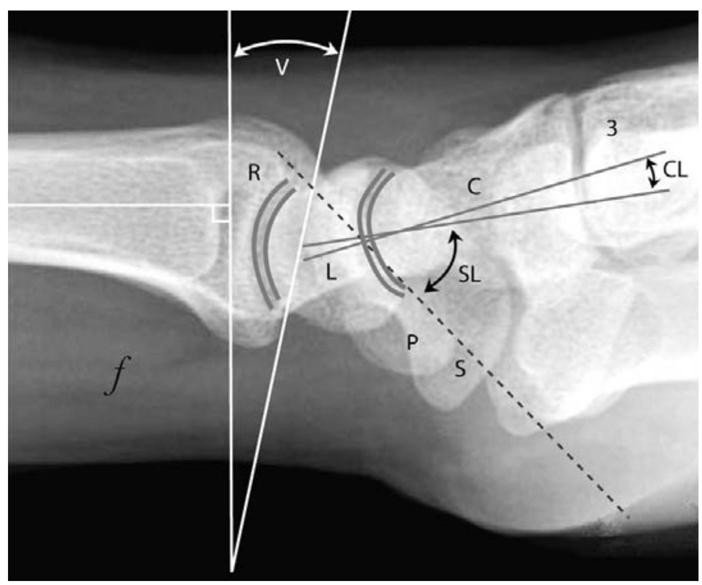
Adapted with permission from Muelleman RL, Wadman M. Injuries to the hand and digits. In: Tintanalli J, ed. *Emergency Medicine: A Comprehensive Study Guide*. 6th ed. 2004. McGraw Hill & Co. p. 1666.

Figure 2. AP Radiograph of the Wrist



Proximal Row: S, Scaphoid; L, Lunate; Tr, Triquetrum; P, Pisiform. **Distal Row:** Trm, Trapezium; Trp, Trapezoid; C, Capitate; H, Hamate; MC1, 1st Metacarpal; MC5, 5th Metacarpal; M's, Approximately parallel M's of the carpometacarpal joint; 1,2 and 3, The smooth 1st, 2nd, and 3rd carpal arcs.
* Equivalent spacing between the bones not usually greater than 2 mm; D, DRUJ; X radial height distal to the ulna, usually approximately 10-13 mm; Y, radial inclination, usually approximately 21-25 degrees. Graphics: Jennifer Rolfsema.

Figure 3. Lateral Radiograph of the Wrist



R, Radius, L, Lunate, C, Capitate, S, Scaphoid, P, Pisiform, 3, 3rd metacarpal; V, Volar tilt, usually approximately 10-15 degrees; SL, Scapholunate Angle, usually 30-60 degrees; CL, Capitolunate Angle, usually less than 20 degrees; f, fat pad. Also note four approximately coaxial Cs (drawn out) which are representing the distal radial articular surface, the proximal lunate articular surface, the distal lunate articular surface, and the proximal articular surface of the capitate. Graphics: Jennifer Rolfsema.

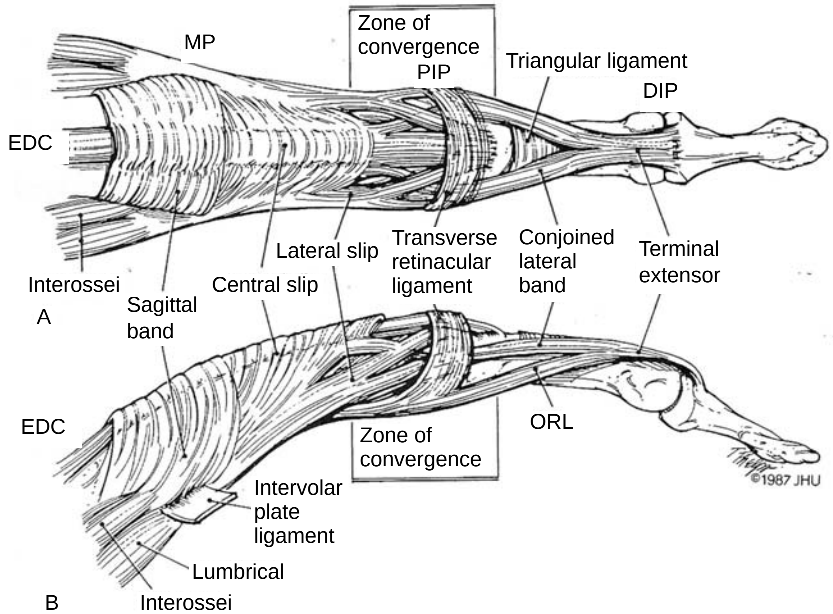
The shapes of the articular surfaces of the thumb MCP joint allow for a much greater range of motion and have less intrinsic bony stability. Instead, the joint's stability is more dependent on the surrounding ligaments, as well as the insertion of the digit's intrinsic and extrinsic muscles. The MCP of the thumb should flex to 50 degrees but will not extend normally beyond neutral. Because of this relative mobility and lack of stability, dislocations of the thumb MCP joint occur more often than MCP dislocations of the other digits.

The bony hand is comprised of five rays, which are the five metacarpals and the corresponding phalanges of each finger: thumb, index, middle or long, ring, and small. Alternatively, the digits may be described by a numbering system, from the thumb being number one to the small finger being number five. The second and third metacarpals are firmly anchored within the palm and to their respective carpometacarpal joints, thus forming a stable platform for the rest of the hand. In contrast, the fourth and fifth metacarpals are more mobile within the palm.

Except for the thumb, there are three phalanges per digit: proximal, middle, and distal. Between the three phalanges there are two interphalangeal (IP) joints on each finger, the proximal interphalangeal (PIP) and the distal interphalangeal (DIP) joints. The thumb has only two phalanges, the proximal and distal, and a single IP joint. The numbering system has the potential for confusion if the documentation is imprecise, such as "laceration of finger # 3," which could be misunderstood as referring to the long or ring finger. The use of names—index, ring, and so on—leaves no room for confusion and is recommended.

The PIP and DIP joints of the index through the small fingers and the IP joint of the thumb are pure hinge joints with move-

Figure 4. Extensor Mechanism



At the Zone of Convergence there is a merge of the intrinsic and extrinsic extensor tendons into the extensor insertion.
Used with permission from Thompson J, Peimer C. Extensor tendon injuries: Acute repair and late reconstruction. In: Chapman M, ed. *Operative Orthopedics.* 2nd ed. 1993. J.B. Lippincott Co. p. 1208

ment in flexion and extension only. Each of these joints has a cartilaginous volar plate and two strong collateral ligaments arranged in a three-sided box configuration. The extrinsic and intrinsic tendons provide additional stability. A normal finger DIP joint should flex to 90 degrees, as will the thumb IP joint. The more mobile finger PIP joints can normally flex to 100 degrees. Minimal extension beyond neutral occurs normally at any of these joints. Proper PIP joint function is highly dependent on the extensor insertions to the middle phalanx, as discussed below.[3,6-8]

Radiographic Anatomy. A working knowledge of the radiographic anatomy of the hand and wrist is essential for the emergency physician since the real-time analysis of these films in most hospitals is their responsibility alone. Emergency department imaging of the injured wrist can usually be adequately accomplished by plain radiography, although several caveats are worth noting. First, emergency department patients frequently are uncooperative for a variety of reasons, which may lead to suboptimal imaging. Second, a fracture may only be visible on one projection. Third, there is often more than one abnormality on the film. Finally, plain films can never conclusively exclude a bony or soft-tissue injury.

A standard wrist series should include at least a PA (*see Figure 2*) view taken with the hand in full pronation, a true lateral (*see Figure 3*), and one or two obliques taken at 45 degrees of oblique pronation. On a true PA film, the ulnar styloid projects from the lateral margin of the ulna. The adequacy of the lateral film is determined by the scaphopisocapitate relationship. Simply stated, the ventral border of the pisiform bone should lie between the ventral cortex of the distal scaphoid and the head of the capitate.

On the normal PA view of the wrist several things are noteworthy. The distal ulna lies 1-2 mm proximal to the distal edge of the radius at its articulation and just touches or slightly overlaps the distal radius. Any significant separation or overlap implies disruption of the DRUJ. The "radial inclination" is measured from a line drawn from the tip of the radial styloid to the ulnar aspect of the distal radius and a second line drawn perpendicular to the long axis of the radius. (*See Figure 2.*) It usually is approximately 21-25 degrees. The radius projects further distally at its styloid than at its distal articulation with the ulna (radial height). This distance normally averages 10-13 mm.

Cortical step-offs may be subtle and should be searched for diligently. Additionally, the radiocarpal articulation, the distal aspect of the proximal row of carpal bones, and the proximal aspect of the distal carpal bones should be inspected. These should form three smooth arcs. Finally, the spaces between the carpal bones should be uniform and generally should not exceed 2 mm. (*See Figure 2.*)

The lateral radiograph is of crucial importance in the diagnosis of wrist dislocation, determining angulation of distal radial factures and small avulsion fractures of the carpus. The normal lateral wrist demonstrates the rounded articular surfaces of the distal radius, proximal and distal lunate, and proximal and distal capitate to be roughly colinear. Essentially, this amounts to four Cs lined up. (*See Figure 3.*) The long axis of the radius, lunate, and capitate should be approximately parallel, with a variance of more than 20 degrees being abnormal. (*See Figure 3.*)

Assuming a technically adequate lateral film, the normal 10-15 degree "volar tilt" of the distal radius should be maintained. (*See Figure 3.*) Furthermore, the scapholunate angle is normally 30-60 degrees. (*See Figure 3.*) Disruption of this relationship implies carpal instability. Finally, the normal fat pad of the pronator quadratus may be distorted or obliterated by hemorrhage from an occult fracture. (*See Figure 3.*)

Additional plain views such as a dedicated scaphoid view or a carpal tunnel view may be obtained and will be covered later. Although not usually part of the initial evaluation, computed tomography (CT) scan, magnetic resonance imaging (MRI), or radionuclide bone scanning all have utility given their higher sensitivity for fracture and their ability to define specific fracture anatomy and soft tissues. These generally are ordered after discussion with a hand specialist to assist with definitive treatment.

When ordering hand films on a patient, the radiology technician should be made aware of the specific areas of concern,

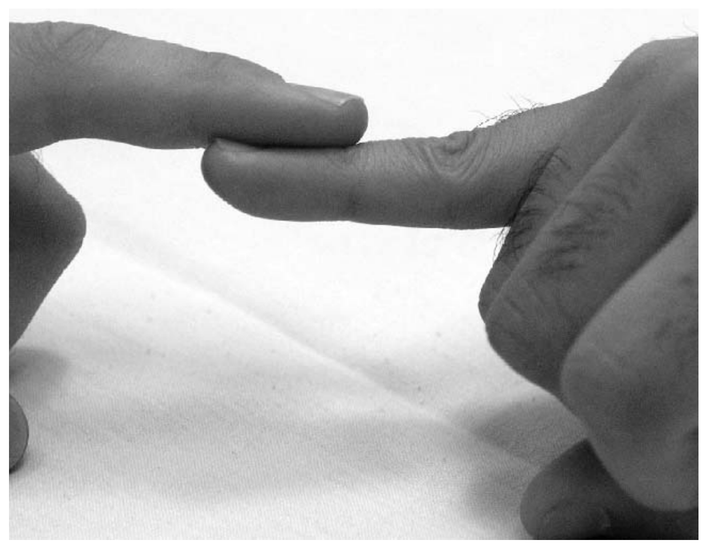
Figure 5. Testing Extensor Digitorum Communis

The MCP joint is isolated for the examination.

Figure 6. Testing Extensor Indicis Proprius

The other fingers are held flexed at the MCP joint.

Figure 7. Testing Extensor Digiti Minimi



The other fingers are held flexed at the MCP joint.

since a film of the entire hand is less accurate for fracture than the views of individual digits. This is especially true of the thumb. Lateral films of the hand superimpose the metacarpals on one another, rendering them difficult to evaluate on that projection. If a specific digit is specified, it can be isolated on the radiograph.[9-12]

Soft Tissues

Extrinsic Extensors. On the dorsum of the wrist the extensor retinaculum holds the extensor tendons to the wrist preventing bowstringing during wrist extension. From the retinaculum, fibrous connective tissue extends to bone forming six distinct compartments through which the extensor tendons traverse. All of the extensors are innervated by the radial nerve.

The first compartment contains the abductor pollicis longus (APL) and the extensor pollicis brevis (EPB) tendons. The APL inserts on the base of the thumb metacarpal, extending and abducting the thumb at the CMC joint. The EPB inserts on the base of the thumb proximal phalanx extending the thumb at the MCP joint. These are both tested by asking the patient to spread his hand against resistance.

The primary wrist extensors, extensor carpi radialis longus (ECRL) and extensor carpi radialis brevis (ECRB) occupy the second extensor compartment. Normal function of these tendons is crucial for grasp strength since maximal grasp strength is attained with the wrist in slight extension. Both muscles originate on the humerus with their tendons inserting on the bases of the index and middle metacarpals, respectively. The tendons are easily palpable when the patient extends the wrist against resistance. Of note, a normally functioning extensor carpi ulnaris (ECU—discussed below) is necessary for the wrist to extend in a straight manner as its adduction force counter balances the abduction force of the ECRL and ECRB.

The third compartment contains the tendon of the extensor pollicis longus (EPL). The EPL tendon turns obliquely around Lister's tubercle and enters the third compartment inserting on the base of the distal phalanx of the thumb forming the ulnar border of the snuffbox. It is the only tendon that can forcibly extend the thumb IP joint and is best tested by having the patient place his or her palm flat on a table and then asking the patient to lift the thumb off the table against resistance.

The fourth compartment contains the extensor digitorum communis (EDC) tendons and the extensor indicis proprius (EIP). The EDC originates on the humeral lateral epicondyle with its individual tendons inserting on their respective digits as part of the "extensor expansion" (discussed below). Each individual EDC tendon is connected to its neighbors by inter-

Figure 8. Named Creases of the Hand, Flexor Zones, and the Pulley System

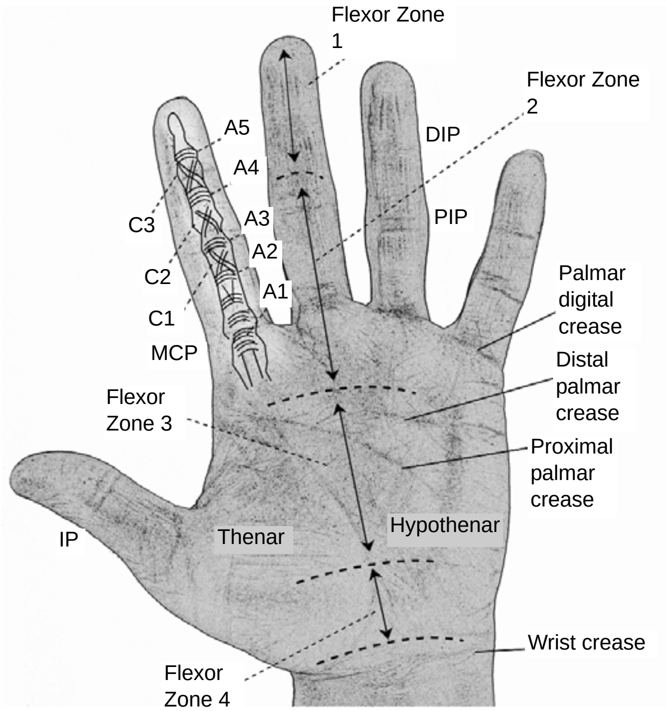


Illustration: Jennifer Rolfsema.

Figure 9. Testing Flexor Digitorum Superficialis

The other fingers are held in extension.

tendinous connections known as the juncturae tendinum. These prohibit full extension at any one digit's MCP joint by the EDC if the other digital MCP joints are held in flexion. This is important clinically since some MCP extension may be possible—even with a complete laceration of an EDC tendon at the proximal wrist owing to the action of the juncturae tendinum.

The EDC tendons course superficially over the dorsum of the hand, making them prone to injury. Emerging from beneath their respective sagittal hoods at the MCP joint, the tendons trifurcate at the mid-proximal phalanx. The middle portion of the tendon—the "central slip"—receives tendinous fibers from the lumbricals and interossei before inserting onto the base of the middle phalanx. (*See Figure 4.*) The two lateral portions also fuse with fibers from the tendons of the lumbricals and interossei, forming the conjoined lateral bands. These conjoined lateral bands fan out as the terminal extensor expansion that inserts on the dorsal distal phalanx. (*See Figure 4.*)

The area between the mid-proximal phalanx and the central slip's insertion on the middle phalanx has therefore been described as a "zone of convergence" where each part of the extensor mechanism receives fibers from both the intrinsic and extrinsic tendons. This is important clinically since finger extension distal to the MCP joint is the result of both intrinsic and extrinsic muscle function. Examination of the extrinsic EDC tendons therefore requires isolated testing of extension at the MCP joint. (*See Figure 5.*)

The EIP originates in the forearm, travels on the ulnar side of the index finger EDC tendon and inserts into the extensor expansion of that finger. It may be tested by having the patient extend the MCP joint of the index finger while the hand is in fist position thereby eliminating the EDC. (*See Figure 6.*)

Having traversed the forearm from the lateral epicondyle, the extensor digiti minimi (EDM) passes through the fifth extensor compartment, along the ulnar side of the EDC tendon inserting on the extensor expansion of the small finger. Again, isolated testing of the EDM requires that the influence of the EDC be eliminated by having the patient make a fist and then extend the small finger's MCP joint against resistance. (*See Figure 7.*)

The last (sixth) compartment contains the extensor carpi ulnaris (ECU) that also originates on the lateral epicondyle. It inserts on the base of the fifth metacarpal and extends and adducts the wrist. Testing is accomplished by asking the patient to extend and adduct the wrist against resistance.

Four lumbrical muscles arise from the flexor digitorum profundus (FDP) tendons in the palm. They insert on the radial side of the respective fingers by merging with the tendinous insertions of the interossei muscles and then participating in the extensor expansion. (*See Figure 4.*) Innervation of the lumbrical muscles is divided between the median and ulnar nerves. The radial two muscles are innervated by the median nerve while the ulnar two muscles are innervated by the ulnar nerve. The lumbricals act to flex the MCP joint and extend the DIP and PIP joints.

There are four dorsal and four volar interossei muscles, all of which are innervated by the ulnar nerve. They arise from between the metacarpals and serve to flex the MCP joint and extend the PIP and DIP joints via their contribution to the extensor expansion. (*See Figure 4.*) The palmer interossei also serve to adduct (closing movement) the fingers while the dorsal interossei

Figure 10. Testing Flexor Digitorum Profundus

The DIP joint is isolated.

provide for finger abduction (opening movement). To assess the strength of the lumbricals and interossei the patient may be asked to adduct and abduct the fingers toward or away from the third digit.[3,8,14-17]

Extrinsic Flexors. Unlike their extensor counterparts, each finger flexor tendon is encased in its own synovial sheath. The ramification of this is that infection within a sheath is, in essence, a closed space infection. Spreading is rapid, and treatment includes surgical drainage. Additionally, the tendons course beneath a series of pulleys formed by thickenings of the synovial sheaths that prevent bowstringing during flexion. The pulleys are denoted as either annular (A), formed by fibers that traverse the digit in the sagittal plane or cruciate (C), which crisscross. (*See Figure 8.*) They are numbered A1-A5 and C1-C3. The smooth gliding of the tendons within their sheaths and pulleys may be compromised by adhesions resulting from trauma or infection. (*See Figure 8.*)

Hand surgeons commonly refer to five distinct flexor "zones" on the palmar side of the hand. (*See Figure 8.*) Injuries in each zone present a unique set of issues for management and long-term outcome. In zone 2, for instance, the tendons of the FDS and FDP overlie one another coursing under the pulleys within the fibrous synovial sheath. Owing to this complex anatomy and to a tenuous vascular supply, prognosis of zone 2 injuries is less favorable.

The palmaris longus (PL) tendon is the most superficial of the flexor tendons. Its muscle is innervated by the median nerve. While not providing strength to hand or wrist flexion, it inserts on the palmar aponeurosis to assist with wrinkling of the palmar skin for better grip. While it is absent in a minority of the population, when present, it can serve as an important landmark to the emergency physician. If an adequately explored wrist laceration remains superficial to the PL, the underlying tendons should be intact.

Deep to the plane of the PL, beneath a connective tissue band known as the flexor retinaculum, lay the major flexors of the wrist–flexor carpi ulnaris (FCU) and flexor carpi radialis (FCR). They are innervated by the ulnar and median nerves, respectively. The FCU inserts on the hook of the hamate, pisiform and base of the fifth metacarpal and is best examined by palpating the tendon as the patient flexes and adducts (ulnar deviation) the wrist. The FCR inserts on the bases of the second and third metacarpals, and may be examined by asking the patient to flex and abduct (radially deviate) the wrist against resistance. The tendon should be easily palpable on the volar side of the wrist just to the radial side of the midline.

The deepest of the flexor tendons, the flexor digitorum superficialis (FDS) and the flexor digitorum profundus are the extrinsic flexors of the proximal and distal IP joints of the fingers. The FDS is innervated by the median nerve. The FDPs of the small and ring fingers are innervated by the ulnar nerve. The FDPs of the long and index fingers are innervated by the median nerve. The FDS tendon lies superficial to the FDP tendon for its course through the wrist. It then divides in half at the level of the proximal phalanx allowing the deeper FDP to course through the division. The FDS then reunites deep to the FDP before it again splints in two and inserts on the base of the middle phalanx. The FDP tendons act in unison and insert on the bases of their respective distal phalanges.

When testing FDS function (*see Figure 9*), the action of the FDP must be eliminated. This can be done by holding all of the patient's fingers in full extension except for the finger being examined. The patient is then asked to flex the PIP joint against resistance. Since the FDP tendons must act as a unit, holding the other fingers straight eliminates FDP function. On the other hand, FDP function can be tested simply by holding each middle phalanx in extension and asking the patient to flex the distal phalanx. (*See Figure 10.*)[4-15,18-19]

Thumb Movement. Motion of the thumb is the result of its extrinsic musculature as well as the four intrinsic muscles of the thenar eminence: the abductor pollicis brevis (APB), opponens pollicis (OP), adductor pollicis (AdP), and the flexor pollicis brevis (FPB). The APB and OP are innervated by the median nerve, the AdP is innervated by the ulnar nerve, and the FPB's innervation is varied between the median and/or ulnar nerves.

The flexor pollicis longus (FPL) travels in the carpal tunnel before inserting on the base of the distal phalanx of the thumb. Its innervation is via the median nerve. Testing is done by having the patient flex the thumb at the IP joint against resistance while the proximal phalanx is fixed.

The FPB originates on the flexor retinaculum and inserts on the base of the proximal phalanx, flexing the thumb at the MCP joint. It is examined by having the patient flex the thumb tightly into the palm. The physician then attempts to forcibly extend the MCP joint by hooking a finger around the digit and pulling outward on the proximal phalanx. The thumb extensors (EPB and EPL) have been previously discussed.

Thumb adduction (movement of the thumb into the plane of the palm and against the index finger) is the primary responsibility of the AdP. If a patient with a weak AdP is asked to hold a piece of paper tightly between the radial side of the index finger and the straightened thumb, he will flex the thumb IP joint to substitute FPL function to compensate for weakness of the AdP. This is known as Froment's sign.

Abduction of the thumb (movement of the thumb perpendicular to the plane of the palm) results from the action of the abductor pollicis longus and brevis muscles and their respective tendons. Strength is noted by asking the patient to abduct the thumb from the plane of the palm against resistance. Thumb opposition (touching of the tip of the thumb with the tips of the other fingers) involves two intrinsic muscles, the thenar opponens pollicis and the hypothenar opponens digiti minimi, which is innervated by the ulnar nerve.

Hypothenar Eminence. The mass of the hypothenar region is comprised of the abductor digiti minimi, the opponens digiti minimi, and the flexor digiti minimi brevis, all innervated by the ulnar nerve. The abductor is tested by assessing strength when the patient abducts the small finger against resistance. During opposition to the thumb the muscle belly of the opponens digiti minimi tenses within the hypothenar eminence and may be palpated. The flexor digiti minimi may be assessed by having the patient flex the fifth MCP against resistance while the DIP and PIP are maintained in extension.[3,8,14-15,18-20]

Integument and Fascial Planes. Inspection of the skin of the hand allows for a rapid assessment of deformity, swelling, induration, and perfusion. The palmar (volar) side of the hand is demarcated by several named creases. (*See Figure 8.*) Using this nomenclature will facilitate discussions with consultants not physically present in the ED. The skin of the volar side of the hand is tightly bound to the underlying palmar aponeurosis by fibrous septa allowing for a tight grip. On the dorsum of the hand there is a layer of loose areolar connective tissue beneath the skin, creating a potential space that allows for marked swelling, even when trauma or infection are located elsewhere in the hand. For this reason, the palm should be examined even when the predominance of swelling is on the hand's dorsum.

Fibrous septae create three potential deep spaces within the hand: thenar, hypothenar, and midpalmar. Infection within one of these deep spaces will produce local swelling and tenderness. The more superficial spaces of the hand are not compartmentalized, allowing for a more diffuse pattern of swelling with infection or trauma. Deep space infections are most often the result of penetrating trauma or extension from tenosynovitis. The thenar space is most commonly affected. A patient with a deep space infection of the thenar compartment will often hold the thumb in an abducted position to maximize the space within the compartment. A loss of the normal palmar concavity may herald a midpalmar infection. Hypothenar deep space infections often produce less dorsal swelling and usually are isolated to that region.[8,21]

At the distal fingertip, fibrous septae and adipose tissue form a matrix resulting in a fleshy pad that assists in the gripping and manipulation of objects. Distal to the insertion of the long flexor tendon on the distal phalanx, these septae fuse and insert on bone to create another deep compartment known as the pulp space. Penetrating injury to the distal fingertip may result in abscess of this area, commonly known as a felon.

On the dorsum of each fingertip the fingernail grows from its germinal matrix whose tissues extend 5-7 mm proximal to the eponychium (nailfold). The nail tightly adheres to the nail bed below. The white arc at the proximal end of the nail is known as the lunula which marks the distal aspect of the germinal matrix. Injury to the eponychium, germinal matrix, or nail bed may result in a permanent loss of the nail or abnormal growth.[8,22]

Vascular Anatomy. The vascular supply of the hand and wrist is the result of several anastomotic arches between the ulnar and radial arteries, each a terminal branch of the brachial artery. The ulnar artery enters the hand deep to the FCU tendon traveling with the ulnar nerve through Guyon's canal. It forms the major contribution to the superficial palmar arch. The superficial arch is formed by an anastomosis of the ulnar artery and a smaller superficial branch of the radial artery. It generally supplies blood to the ulnar three digits. A line drawn along the axis of the fully extended thumb continuing across the palm of the hand marks the approximate location of the superficial arch. Its location is about 1 cm distal to the deep arch. The superficial arch is protected only by the insertion of the palmaris longus and palmar aponeurosis, thus making it vulnerable to injury with penetrating trauma to the palm.

Upon reaching the wrist, the radial artery travels laterally and dorsally deep to the tendons of the first dorsal compartment (EPB, APL) to reach the anatomic snuffbox. Having reached the snuffbox, the artery gives off branches to the thumb and index finger and then continues to become the larger contribution to the deep palmar arch. The deep palmar arch lies approximately at the level of the proximal metacarpal bases.

While considerable variation in individual anatomy exists, almost all digits receive a contribution from both the superficial and deep arches. Branches of the superficial palmar arch proceed forward within the intermetacarpal spaces and receive branches from the deep arch. They then divide to form the proper palmer digital arteries that travel along the medial and lateral sides of the digits. The vascular supply to the thumb varies greatly but is generally derived directly from the deep palmar arch. Unlike the other digits, the thumb has four digital arteries instead of the usual two.

The Allen test can be used to help evaluate the integrity of flow from each of the radial and ulnar arteries individually and the integrity of the anastomosis between the two. The patient is asked to make a tight fist to exsanguinate the hand. The examiner then compresses both the radial and ulnar arteries to occlude all arterial flow. The patient is then asked to open the fist. The hand should remain blanched. The artery being tested is then released. The hand should reperfuse as manifested by a flush within several seconds if the artery in question is intact and the anastomosis is functional. The test is then repeated for the other artery. The test should be performed on all patients with suspected arterial injury. Even with a proximal arterial injury, a distal pulse may be present, owing to retrograde flow through the radial-ulnar anastomosis. The Allen test, however, would likely still be abnormal.[8,23]

Neuroanatomy. The radial, ulnar, and median nerves are the hand's principal nerves. Pathology anywhere from the spinal roots distally may cause symptoms in the hand and wrist. As is the case elsewhere in the body, arteries and nerves in the upper extremity frequently lie adjacent to one another, and an injury to one should strongly raise the possibility of injury to the other. As such, blind clamping or suturing of arterial bleeding is to be avoided since inadvertent peripheral nerve injury may result. Sensation is best tested by assessing two-point discrimination. Two-point discrimination should be individually tested on the ulnar and radial side of each volar pad. Normal discrimination is approximately 3 mm in the distal fingers, although this increases slightly with age.

The radial nerve traverses the middle and distal aspect of the upper arm in close proximity to the humeral shaft and may be injured if it is fractured. After supplying fibers to the extensor carpi radialis longus and brachioradialis muscles, it divides just above the elbow into the posterior interosseous nerve and the superficial radial nerve. The posterior interosseous nerve is the motor innervation to the extrinsic extensors of the hand and wrist (previously discussed). The superficial radial nerve provides sensation to the radial three-quarters of the dorsum of the hand and posterolateral forearm. The radial nerve is a pure sensory nerve in the hand, and testing may be accomplished by examining the skin of the dorsal web space between the thumb and index fingers.

The ulnar nerve has both motor and sensory functions in the hand. Its sensory branches provide sensation to the ulnar aspects of the forearm, wrist, and ulnar one and a half fingers. Upon reaching the wrist, the ulnar nerve passes superficially to the flexor retinaculum then courses lateral to the pisiform before entering Guyon's canal with the ulnar artery between the hamate and pisiform. Any of these contents may be injured with fractures of the adjacent bones. Sensation is tested on the small finger.

Ulnar nerve motor function includes innervation to the FCU, FDP 4 and 5, lumbricals 4 and 5, the intrinsic hypothenar muscles, adductor pollicis, and FPB, all of which have been previously discussed. Motor function, therefore, may be assessed in a variety of ways, including having the patient spread the fingers against resistance or flexing the DIP joints of the small or ring fingers.

The median nerve also has both sensory and motor function in the hand and supplies sensation to most of the volar side except for the ulnar one and a half digits. Additionally, the median nerve supplies sensation to the distal dorsal aspects of the thumb, index, long, and half the ring fingers. Sensory testing can be accomplished on the volar aspect of the index finger.

After innervating the FPL, FCR, FDS, PL, and FDP of the second and third fingers, the nerve enters the wrist through the carpal tunnel. Within the carpal tunnel the nerve gives off its recurrent branch that innervates muscles of the thenar eminence. It also innervates the first and second lumbricals. Motor testing may be done in several ways, including thumb IP joint flexion against resistance, thumb opposition, or thumb abduction.[8-9,14-15,20]

Approach to the Patient

Acute hand or wrist trauma rarely threatens a patient's life. Thus, fundamental ATLS principles should be followed and more dangerous pathology diagnosed and treated first. While initial resuscitation is under way, acute extremity trauma may be temporarily splinted. Direct pressure and elevation should control most bleeding. As noted previously, bleeding vessels should not be clamped or ligated blindly to avoid injury to other structures. Amputations, neurovascular compromise, and impending compartment syndromes are true orthopedic emergencies and must be dealt with accordingly.

Any potential surgical candidate should be made NPO on arrival. Rings and watches should be removed. Antimicrobial and tetanus prophylaxis should be given for open wounds as indicated clinically. Judicious use of analgesia is also important, but a sensory examination is crucial before any infiltrated anesthetics are used. Patients should be queried with respect to the mechanism and timing of injury, history of previous hand or wrist injury, hand dominance, occupation, and hobbies.

On examination, the physician should note any obvious open injury or deformity, the color of the skin, as well as the attitude of the hand in a relaxed position. An abnormal lie of a finger may indicate a tendinous injury, fracture, or dislocation. The initial goal of the examination is to determine that the hand's neurologic and vascular status are normal. Thereafter, palpation of the bones, joints, and soft tissues should proceed with the mechanism of injury guiding a goal-directed examination.

Tendons should be tested systematically as noted above with the understanding that partial tendon lacerations may not produce significant weakness. Exploration of open wounds requires adequate hemostasis, lighting, analgesia, and patient cooperation. Hemostasis may be achieved by a brief use of a tourniquet. For providing a bloodless field for a finger laceration, a wrapped half-inch Penrose drain works well. If, despite an adequate visual exploration of a wound, there remains a high index of suspicion for a retained foreign body, several different imaging modalities may be helpful, including plain radiographs, ultrasound, CT, or MRI. Where bony injury is a concern, plain radiography is the initial diagnostic test used for the vast majority of ED patients. That said, the physician should bear in mind that hand or wrist fractures may be occult on plain film and that significant soft-tissue injury with potentially disabling consequences is never ruled out with plain radiography. Patients with suspicious examinations should be empirically splinted and referred for consultation and further imaging.[2,3,6,14-19,24-26]

Acute Orthopedic Injuries to the Wrist

Distal Radius Fractures. Fractures of the distal radius are a heterogeneous group of injuries that account for approximately 17% of all fractures seen in the ED.[27] These injuries are com-

Figure 11. Colles' Fracture

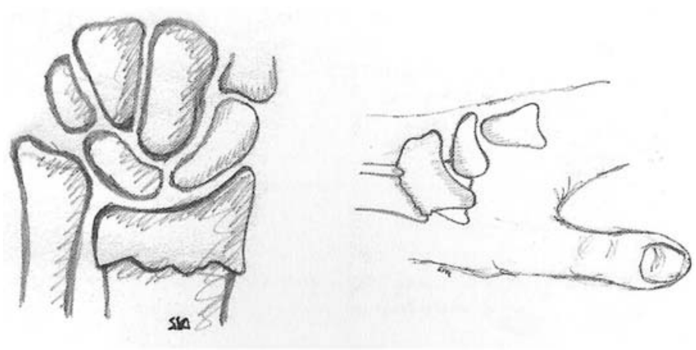


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Figure 12. Smith's Fracture

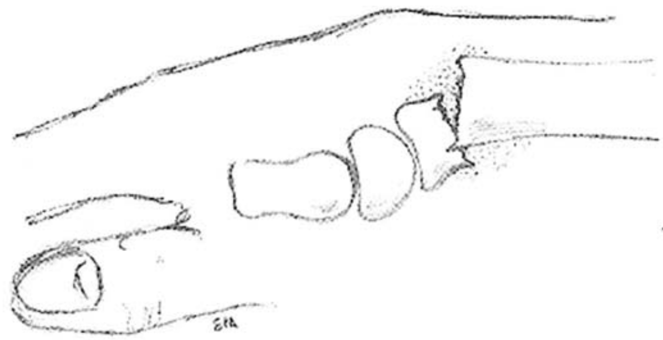

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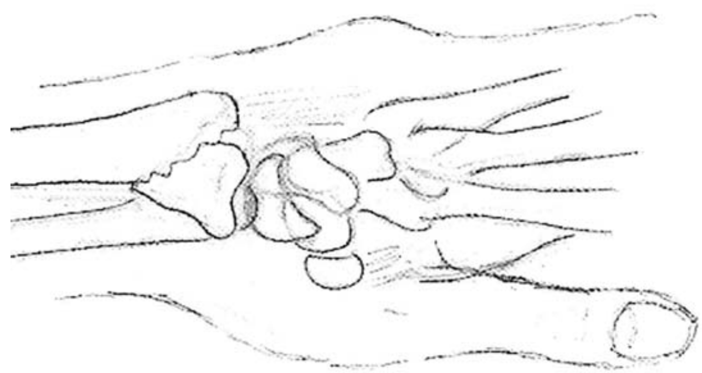
Figure 13. Barton's Fracture



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mon in the elderly, owing to the high frequency of osteopenia in this group, and more commonly affect women. Older individuals sustaining distal radius fractures may be at increased risk for subsequent fracture of other bones such as the hip or axial spine. With the percentage of older individuals in the population increasing, it can be expected that the incidence of these injuries will rise over the next several decades. It is also noteworthy that in the skeletally immature patient, the distal radius is the most common site for growth plate injury.[28] While eponyms and several classification systems exist for the naming and management of these fractures, it is better to accurately describe the radiographic anatomy of the injury to an off-site consultant.

A fall on the outstretched hand (FOOSH) has relatively predictable consequences based on the patient's age. Torus fractures and greenstick fractures occur most commonly in children in the elementary school years. Older children are more susceptible to distal radial Salter-Harris type injuries. Fundamental to understanding the patterns of injury seen in younger adults vs. the elderly is the assumption that the forces needed to break healthy bone are much greater than those needed to break osteopenic bone. Thus, the younger patient with a distal radial fracture is more likely to have done so via a high-force mechanism with a higher likelihood of concomitant injuries.[2,29]

Approximately 2 cm proximal to the radiocarpal joint, there is a transition from diaphyseal cortical bone to weaker cancellous metaphyseal bone. This predisposes this transition zone to failure when axially loaded. The particular type of fracture incurred will be dependent on the health of the bone, the attitude of the hand upon impact, and the subsequent forces transmitted (axial, shear, or rotational). An extension type mechanism resulting in the classic Colles' fracture (*see Figure 11*) or a similar injury is most common. A flexion force such as that which occurs with a fall on a palmar flexed hand or a direct blow to the dorsum of the wrist produces a fracture with volar displacement, known as a Smith's fracture or reverse Colles' fracture. (*See Figure 12.*) Shear forces across the joint may produce an intra-articular variant called a Barton fracture (*see Figure 13*) with either volar or dorsal displacement. A sudden torque may produce oblique fractures involving the radial styloid, commonly known as Chauffeur's fractures. (*See Figure 14.*) Finally, axial loads transmitted across the radiocarpal joint will drive the proximal carpal bones into the distal radial articular surfaces causing a "die punch" fracture of the distal radius.

Extension Fractures: Colles' Fracture and its Variants. Usually these injuries result from the FOOSH mechanism, with the hand extended upon impact. These fractures involve the radial metaphysis just proximal to the radiocarpal joint with dorsal angulation of the distal fragment. There may be significant radial foreshortening, loss of the joint's normal radial inclination, displacement, comminution or impaction. The original fracture described by Abraham Colles in 1814 (*see Figure 11*) was a transverse extra-articular metaphyseal fracture.

Concomitant fractures or ligamentous injuries to the carpus are not uncommon. In one series of intra-articular fractures, the

Figure 14. Chauffeur's Fracture

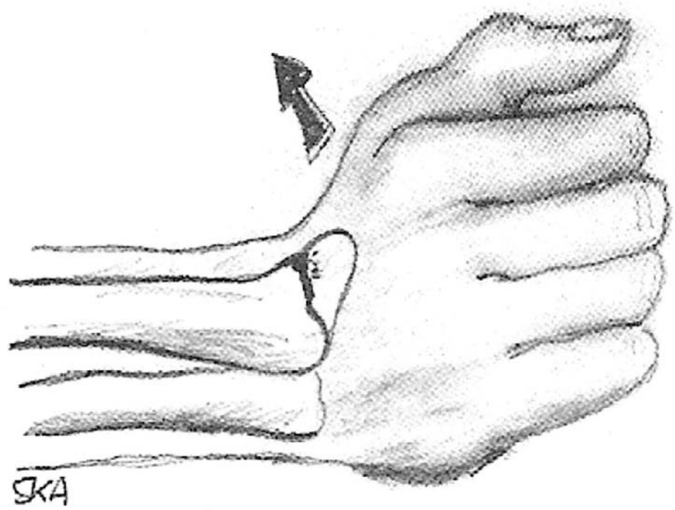

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Figure 15. "Dinner Fork" Deformity in Colles' Fracture

likelihood of a concomitant soft-tissue carpal injury was nearly 50%.[30] Intra-articular involvement of the radiocarpal joint or DRUJ may occur resulting in loss of joint surface integrity. Injury to the TFCC is often heralded by an associated fracture of the ulnar styloid. The more proximal the ulnar styloid fracture, the more likely the TFCC is to be disrupted. TFCC injury may disrupt the normal relationship between the ulna, lunate, and triquetrum as well as cause injury to the DRUJ, which may become frankly dislocated. Vascular injury may result from vessel laceration on sharp bony fragments. Finally, injury to the median nerve resulting from traction, direct trauma, or high pressures within the carpal tunnel from swelling or bleeding may occur. Less commonly branches of the radial nerve or the ulnar nerve may be involved.

Deformity may range from local pain and swelling to the classic "dinner fork" deformity. (*See Figure 15.*) With all cases, the initial examination should focus on the neurovascular status of the hand. Median nerve sensory or motor palsy should be sought and the results clearly documented. Nerve dysfunction most likely results from contusion or acute carpal tunnel syndrome owing to bleeding or swelling. An overlying laceration may indicate an open fracture.

Careful palpation of the distal radius, ulnar styloid, snuffbox, and wrist should be done to seek out maximal tenderness and suggest associated injuries. Tenderness discovered anywhere along the axis of loading force from the hand to the glenohumeral joint of the shoulder or clavicle suggests a possible associated fracture or dislocation.

On radiographic examination, attention should be paid to the following: degree of dorsal angulation, loss of radial inclination, radial foreshortening, articular involvement of either the radiocarpal joint or DRUJ, and translation of the fracture fragments. The radiocarpal joint should be closely scrutinized for bony step-offs or gaps. Where the anatomy requires more detailed analysis of comminution or joint involvement, CT or MRI may be used. The latter will also assess soft-tissue anatomy. These techniques provide a more precise analysis of gaps and step-offs at the radiocarpal articular surfaces, in addition to demonstrating fracture extension to the DRUJ. Both of these are common sources of chronic pain and disability. Obtaining studies beyond plain radiography will usually be made in conjunction with a consultant and generally may be deferred in the ED.

Vascular compromise constitutes a true emergency, and reduction should proceed without delay. Open fractures warrant antimicrobial and tetanus prophylaxis as well as immediate orthopedic consultation for surgical management. In cases where median nerve function is a concern due to persistent pain, paresthesia, or weakness, fracture reduction should be undertaken on an urgent basis. If this does not remedy the situation, measurement of carpal tunnel pressures or surgical carpal tunnel release may be undertaken by the consulting hand specialist.

Closed, extra-articular fractures that are uncomplicated may be reduced by the emergency physician, splinted, and referred for outpatient orthopedic follow-up. Due to the high frequency of complications, loss of reduction due to inherent fracture instability and the high potential for required surgical intervention, complicated fractures should be discussed with an orthopedic surgeon, if one is available. If surgery is not needed emergently, close outpatient follow-up should be assured. Complicated fractures include those with intra-articular involvement at either the radiocarpal joint or DRUJ, comminution, foreshortening greater than 1 cm, and persistent angulation greater than approximately 20 degrees.

A fundamental principle of treatment is that better functional outcomes occur when the final healed result closely approximates normal anatomy. The goal of treatment is to restore radial length, maintain the usual volar tilt, preserve DRUJ function, and eliminate articular gaps and step-offs at the radiocarpal joint. A step-off as little as 2 mm may result in premature arthritis of the joint. In general, younger patients and more physically robust older patients will require a more aggressive approach to ensure as anatomic a result as possible. Elderly sedentary patients may achieve satisfactory outcomes with less aggressive measures.

There is currently no evidence-based, universally accepted, definitive approach to all fractures. While a percentage of patients may achieve adequate results with closed reduction and casting, percutaneous pinning, external fixation, and open reduction with internal fixation all may be employed at the discretion of the treating surgeon.[2,4,10,27-29,31-36]

If reduction is to be undertaken by the ED physician, adequate analgesia is a prerequisite to working with a cooperative, relaxed patient and offers the best chance for a good result. This may be accomplished by the judicious use of narcotic analgesics as well as a hematoma block. Having all splinting materials at the ready for immediate use following reduction is important since the forces exerted by the extrinsic extensors will act to cause a loss of a successful reduction. The patient should be placed in finger traps with the elbow flexed to 90 degrees and 8-10 pounds of weight suspended from the elbow. This allows for distraction of the fragments to occur. After approximately 10 minutes reduction is attempted. This is done with the physician's thumbs pushing the dorsal fragment in a volar direction all the while maintaining traction. The wrist is then immobilized in neutral forearm rotation and in 15 degrees of flexion and 15 degrees of ulnar deviation. A sugar tong splint should be applied and post-reduction films obtained.[4,28]

Flexion Fractures: Smith's Fractures. The Smith's fracture (*see Figure 12*) is a distal radial metaphyseal fracture with volar angulation, opposite to the Colles' fracture. Not surprisingly, the mechanism is a fall on the flexed wrist or a direct blow to the dorsum of the wrist. Concomitant injuries may occur and are similar to Colles' fractures discussed above. If significant angulation and displacement have occurred, the patient may present with the "garden spade deformity." The same principles as described for Colles' fractures apply in this circumstance, and stable fractures may be managed non-operatively. Following reduction, these patients may be placed in a sugar tong splint. Since these fractures are frequently the result of higher force mechanisms, early orthopedic consultation should be considered.

Shearing Injuries: Barton's Fractures. Barton's fractures are obliquely oriented distal radial fractures involving the radiocarpal joint. (*See Figure 13.*) The carpus may translocate with the distal radial fragment and either the dorsal or volar rims of the joint may be involved. These are usually associated with high-force mechanisms, often the result of motor vehicle accidents or sporting activities and frequently involve younger adults. In one series the mean patient age was 36 years.[38] The volar and dorsal variants are the result of flexion and extension mechanisms respectively, with the dorsal variant being the more common.

Because these fractures usually result from higher force mechanisms, comminution, associated carpal injuries, or involvement of the DRUJ or TFCC are not uncommon. While the median nerve remains a concern, the dorsal variant may also result in sensory radial nerve palsy.

Barton fractures will exhibit an oblique fracture line extending into the radiocarpal joint, as opposed to the transverse fracture of the Colles' and Smith's fractures. On the PA film, overlap of the carpus with the distal radius may be seen owing to the displacement of the carpus with the distal fragment. The lateral film will reveal the intra-articular oblique nature of the fracture and determine which rim is involved, dorsal or volar. The larger the degree of articular surface involvement, the more likely the fracture is to be unstable and require open reduction. CT scanning or MRI may provide useful adjuncts for better definition of anatomy and identifying associated injuries.

Closed reduction may not be possible due to intrinsic instability, and these fractures most often require operative intervention; in one series 19 of 20 patients were managed surgically.[38] If possible, these injuries should be discussed with a consultant. On occasion, a non-displaced rim fracture may be placed in a sugar tong splint and referred for outpatient follow-up.

Radial Styloid Fractures: Chauffeur's Fractures. The Chauffeur's fracture (Hutchinson's fracture) (*see Figure 14*) was historically the result of the backfiring of early automobiles. The recoiling crank handle transmitted force through the driver's thenar eminence, placing a large and sudden torque force on the wrist. This resulted in sudden, forceful radial deviation that caused impaction of the scaphoid and lunate on the distal radius. An oblique distal radius fracture resulted, with its distal fragment containing the radial styloid. Due to the high forces involved, these frequently occur with associated fractures of the proximal carpal bones or rupture of the scapholunate ligament. Additionally, since the radial collateral ligament attaches to the styloid radial, instability of the joint may occur.

On examination there is usually pain and swelling over the radial styloid. Palpation of the scaphoid and lunate bones may also elicit tenderness. Plain radiography will demonstrate an intra-articular fracture of the radial styloid. The size of the distal fragment may vary widely. Careful attention should be paid to the appearance of the scaphoid and lunate bones and the space between the two, which should not exceed 2 mm. Once again, CT and MRI can be useful to evaluate associated bony and ligamentous injuries and will usually be ordered in consultation with the treating surgeon.

Early orthopedic consultation is warranted owing to the high frequency of associated injuries. Non-displaced fractures may be splinted with a radial gutter splint and discharged with close orthopedic follow-up. Displaced fractures require operative management to restore the anatomy of the joint, immobilize the distal fragment, and repair any associated damage to the extrinsic or proximal row intrinsic ligaments.

Complications and Pitfalls of Distal Radius Fractures. Mechanically unstable distal radial fractures will frequently either fail to achieve or lose the initial reduction after splinting. In these cases operative reduction often will be in the patient's best interests. Radiographic malunions are relatively frequent although nonunion is rare. Associated bony or ligamentous carpal injuries may result in long-term carpal instability or nonunions. Articular surface gaps and step-offs at either the radiocarpal joint or DRUJ may result in premature arthritis with resultant chronic pain, stiffness, or both. These outcomes may occur even following a successful reduction.

Long-term pain with pronation and supination suggests DRUJ dysfunction. Forced pronation and supination against resistance will elicit pain in these patients.[37] Tendon lacerations may occur on sharp bony fragments and delayed tendon ruptures have also been reported. Acute or chronic carpal tunnel syndrome may ensue, resulting in median nerve dysfunction.[2,4,9-10,28,38-39]

Potential ED pitfalls are numerous. Failure to recognize associated injuries such as DRUJ separation, carpal fractures, and ligamentous injuries can lead to under-treatment, delayed consultation and a poor outcome. Failure to appreciate the predictors of early instability—comminution, intra-articular involvement, or significant angulation (all of which may be subtle on plain radiography)—may lead to failed attempts at closed reduction.

Additionally, the function of the median, radial, and ulnar nerves should be monitored before and after reduction and documented on the chart. Patients should be instructed to return if symptoms of acute carpal tunnel syndrome develop. Since a percentage of these patients may lose their initial reduction, counseling them regarding this and for the possibility of a future surgical procedure will go a long way in preventing any ill feelings should the injury eventually require more aggressive management, or should the long-term outcome be less than ideal.

Fractures and Dislocations of the Proximal Carpal Row. A fall with the wrist in extension produces forces that are transmitted along an axis from the capitate to the distal radius. This violent force places the ligaments of the volar wrist under extreme tensile stress. The most likely point of ligamentous failure is at the midcarpal joint. Additionally, the bent-peanut- shaped scaphoid, being the functional bridge between the two rows, is at highest risk for fracture.[9]

The articulations of the carpal bones are constructed in such a way that axial loading forces from the constant tension of the extrinsic hand tendons would cause the collapse of the wrist in a zig-zag fashion across the midcarpal joint. This is prevented by the stability imparted by the wrist's intrinsic ligaments as well as the buttressing effect of the scaphoid bridge across the two carpal rows. A simplistic view of this would be to envision the distal radius, proximal carpal row, and distal carpal row as three links in a bicycle chain, with the middle link being analogous to the proximal row. Starting with the chain straight, compression of the two end links toward the middle would cause a buckling of the normally straight chain. In the wrist, this is prevented by a bridge that extends from the distal radius to the distal carpal row, namely the scaphoid bone.

On the lateral radiograph the normal position of the lunate, coaxial with the long axis of the capitate and radius, is maintained by a balance of palmar flexion forces imparted on the bone by the scaphoid (via the scapholunate ligament) countered by extension forces from the triquetrum (acting through the lunotriquetral ligament). The normal position of these bones is, in effect, the result of a constant tug of war between extension and flexion forces across the proximal row, acting through the lunate in the middle. A significant fracture or a ligamentous tear will upset the fragile balance between these forces across the proximal row causing an abnormal spatial appearance of the bones relative to one another, as seen on a plain lateral film, termed carpal instability.

Injuries to the carpus resulting from a fall on the outstretched hand with the hand in extension tend to follow a predictable sequence of events moving from radial to ulnar around the lunate. Initially there is a fracture of the scaphoid or rupture of the scapholunate ligament. Next, forces cause injury to the dorsal lunate ligaments allowing the capitate to dissociate from the lunate, termed a perilunate dislocation. Finally, there is complete dislocation of the lunate into the carpal tunnel.[40] These injuries will be considered further in Part II of this series.

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Physician CME Questions

31. A disrupted TFCC should be suspected if:
    A. there is swelling over the dorsal third MCP joint.
    B. there is a widened scapholunate interval (Terry Thomas sign).
    C. there is an avulsion of the base of the ulnar styloid.

Emergency Medicine Reports
CME Objectives

To help physicians:

- quickly recognize or increase index of suspicion for specific conditions;
- understand the epidemiology, etiology, pathophysiology, and clinical features of the entity discussed;
- apply state-of-the-art diagnostic and therapeutic techniques (including the implications of pharmaceutical therapy discussed) to patients with the particular medical problems discussed;
- understand the differential diagnosis of the entity discussed;
- understand both likely and rare complications that may occur.

D. there is tenderness over the thumb MCP ulnar collateral ligament.

32. Which of the following statements is true of Colles' fractures?
A. The mechanism is forced dorsi-flexion of the wrist.
B. The mechanism is forced palmar-flexion of the wrist.
C. The ulnar nerve is frequently injured.
D. Elderly patients require a more aggressive approach.

33. All of the following are complications of Colles' fractures *except*:
A. the median nerve may be injured.
B. carpal tunnel syndrome may occur.
C. chronic arthritis.
D. carpal instability such as the DISI deformity.

34. When the proximal row of carpal bones demonstrates an abnormal spatial appearance on a plain lateral film, carpal instability is a major consideration.
A. True
B. False

35. Which of the following is true regarding testing motor function of the extensor digitorum communis?
A. The DIP joint should be isolated on examination.
B. The juncture tendinum allows the extensor indicis and proprius to compensate for nearly a complete tendon laceration.
C. The MCP joint should be isolated on examination
D. Laceration of the tendon can cause a positive Froment's sign.

36. Sensory testing of the radial nerve is best done in which of these locations?
A. Ulnar aspect of ring finger
B. Dorsal web space between thumb and index
C. Over the carpal tunnel
D. Distal index finger

37. Colles' fractures are simple and can always be adequately treated in the emergency department.
A. True
B. False

38. Which of the following statements regarding radial styloid fractures is *not true*?
A. They are often high-force mechanisms with a high incidence of associated bone or soft-tissue trauma.
B. Radiocarpal joint instability may occur.
C. They are usually extraarticular
D. Non-displaced fractures may be splinted in the emergency department and discharged with careful follow-up plans in place.

39. A patient with an ulnar nerve palsy secondary to a wrist laceration will likely have which of the following?

A. Weakness of thumb palmar abduction
B. Weakness of the intrinsic interossei muscles
C. Weakness of extensor carpi ulnaris
D. Weak flexion at the finger DIP joints

40. An abnormal attitude of the proximal carpal row bones relative to one another is known as:
A. carpal collapse.
B. carpal instability.
C. interval widening.
D. perilunate dislocation.

CME Answer Key

31. C; 32. A; 33. D; 34. A; 35. C; 36. B; 37. B; 38. C; 39. B; 40. B

CME Instructions

Physicians participate in this continuing medical education program by reading the article, using the provided references for further research, and studying the questions at the end of the article. Participants should select what they believe to be the correct answers, then refer to the list of correct answers to evaluate their knowledge. To clarify confusion surrounding any questions answered incorrectly, please consult the source material. *After completing this activity, you must complete the evaluation form that will be provided at the end of the semester and return it in the reply envelope provided to receive a certificate of completion.* When your evaluation is received, a certificate will be mailed to you.

In Future Issues: **Hand and Wrist Injuries, Part II**

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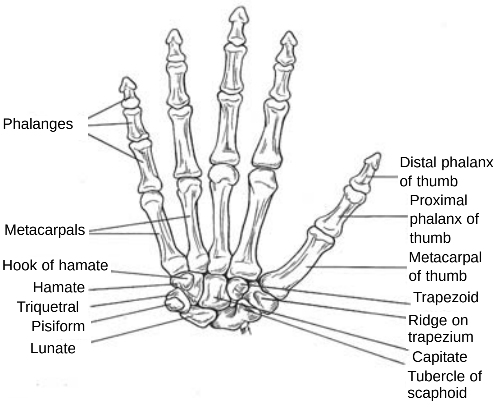
Hand and Wrist Injuries, Part I

Bones of the Hand and Wrist



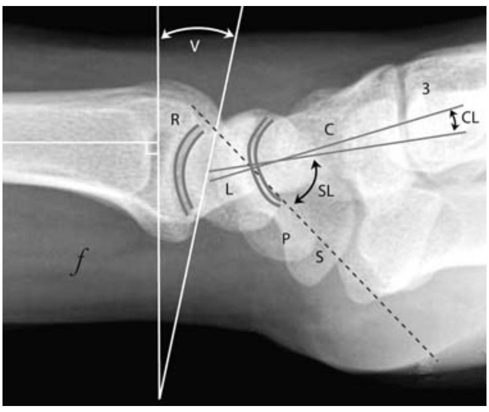
Adapted with permission from Muelleman RL, Wadman M. Injuries to the hand and digits. In: Tintanalli J, ed. *Emergency Medicine: A Comprehensive Study Guide*. 6th ed. 2004. McGraw Hill & Co. p. 1666.

AP Radiograph of the Wrist

Proximal Row: S, Scaphoid; L, Lunate; Tr, Triquetrum; P, Pisiform. **Distal Row:** Trm, Trapezium; Trp, Trapezoid; C, Capitate; H, Hamate; MC1, 1st Metacarpal; MC5, 5th Metacarpal; M's, Approximately parallel M's of the carpometacarpal joint; 1,2 and 3, The smooth 1st, 2nd, and 3rd carpal arcs.

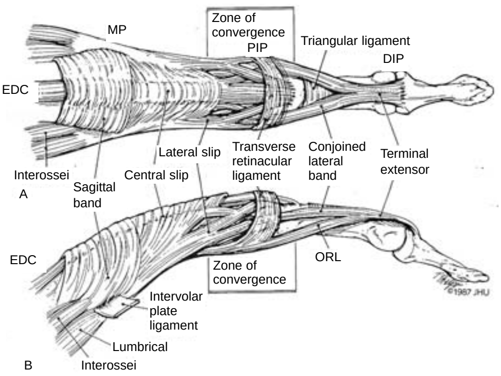
* Equivalent spacing between the bones not usually greater than 2 mm; D, DRUJ; X radial height distal to the ulna, usually approximately 10-13 mm; Y, radial inclination, usually approximately 21-25 degrees. Graphics: Jennifer Rolfsema.

Lateral Radiograph of the Wrist



R, Radius, L, Lunate, C, Capitate, S, Scaphoid, P, Pisiform, 3, 3rd metacarpal; V, Volar tilt, usually approximately 10-15 degrees; SL, Scapholunate Angle, usually 30-60 degrees; CL, Capitolunate Angle, usually less than 20 degrees; f, fat pad. Also note four approximately coaxial Cs (drawn out) which are representing the distal radial articular surface, the proximal lunate articular surface, the distal lunate articular surface, and the proximal articular surface of the capitate. Graphics: Jennifer Rolfsema.

Extensor Mechanism



At the Zone of Convergence there is a merge of the intrinsic and extrinsic extensor tendons into the extensor insertion.

Used with permission from Thompson J, Peimer C. Extensor tendon injuries: Acute repair and late reconstruction. In: Chapman M, ed. *Operative Orthopedics.* 2nd ed. 1993. J.B. Lippincott Co. p. 1208

Testing Extensor Digitorum Communis

The MCP joint is isolated for the examination.

Testing Extensor Indicis Proprius

The other fingers are held flexed at the MCP joint.

Testing Extensor Digiti Minimi

The other fingers are held flexed at the MCP joint.

Named Creases of the Hand, Flexor Zones, and the Pulley System

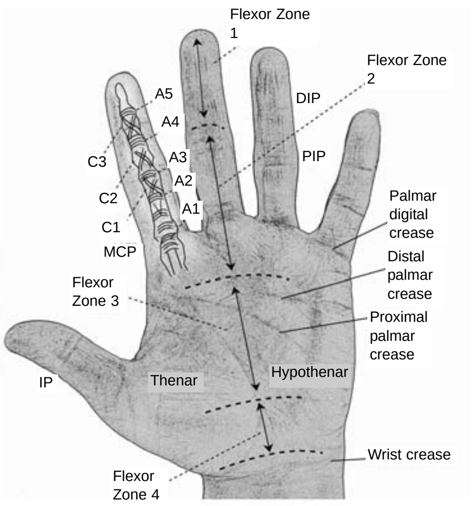
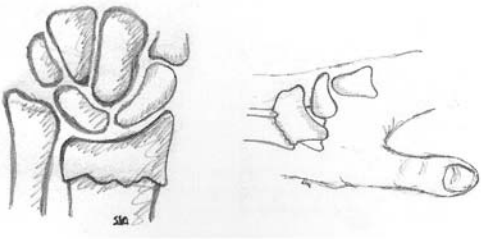


Illustration: Jennifer Rolfsema.

Testing Flexor Digitorum Superficialis

The other fingers are held in extension.

Colles' Fracture



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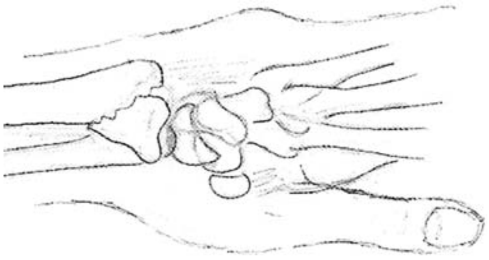
Barton's Fracture



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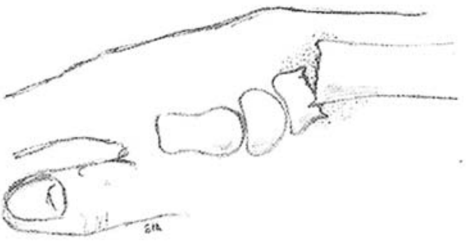
Testing Flexor Digitorum Profundus

The DIP joint is isolated.

Smith's Fracture



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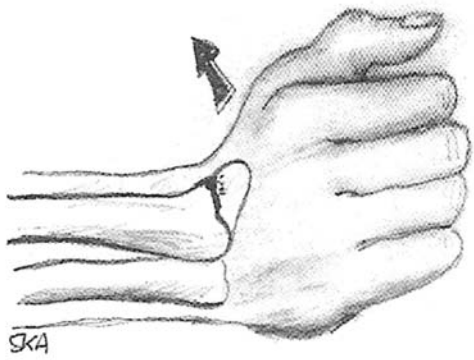
Chauffeur's Fracture



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"Dinner Fork" Deformity in Colles' Fracture

Supplement to *Emergency Medicine Reports*, August 6, 2007: "Traumatic Injuries of the Hand and Wrist. Part I." *Author:* **Thomas Germano, MD, FACEP**, Assistant Clinical Professor, Brown University Medical School, Attending Physician, Rhode Island Hospital, Providence, RI.