Hand

Chapter 50

Thomas Mailhot and Everett T. Lyn

Perspective

The hand is intricate, dynamic, and unique in function. It combines extreme mobility, precision, power, and sensation and is used to express and execute. Because the hands are used more to manipulate the environment than the rest of the body, they are commonly injured. Function depends on intact relationships among intrinsic structural components, musculotendinous units originating from more proximal areas, and motor and sensory connections with the central nervous system. Restoration of function rather than appearance is the primary goal in management of hand injuries and infections. Early recognition and timely initiation of therapy for limb-threatening conditions are essential to an optimal outcome. The fate of the injured hand depends largely on the physician who provides initial care. Mismanagement may result in unnecessary functional loss that may not be recoverable, even with the best convalescent care. An understanding of the functional anatomy of the hand is necessary for the appropriate evaluation and management of these disorders.

Epidemiology

Overall, hand injuries are reported to represent 5 to 10% of visits to an emergency department (ED), and approximately 6% of the patients have deep, significant injuries. Injuries have environmental, occupational, and recreational causes and are seen in all age groups. The spectrum of injury includes infections, lacerations, fractures, crush wounds, amputations, and burns. It is estimated that 10% of all patients with hand injuries require referral to a hand specialist, and most patients referred from EDs have fractures. The disability potential of hand injuries generally is high; such disability may involve loss of strength, flexibility, or sensation. According to available data, hand injuries account for 19% of lost-time injuries and for 9% of worker compensation cases. Approximately 3 to 4 million working days are lost each year as a result of hand injuries. Overall, hand and fingers are the most frequent body parts injured in the workplace and cared for in EDs.

Principles of Disease, Functional Anatomy, Physiology, and Examination of the Hand

Terminology

To avoid confusion, it is important that standard terminology for the surface anatomy of the hand be used (Fig. 50-1). The back of the hand and fingers is called the dorsal surface, and the palm side is called either the palmar or the volar surface. The borders of the hand are radial and ulnar. The five digits often are designated by numerals, but common names are preferable: I (thumb), II (index finger), III (long or middle finger), IV (ring finger), and V (little finger). Each finger has three joints: the metacarpophalangeal (MCP), the proximal interphalangeal (PIP), and the distal interphalangeal (DIP) joints. The thumb has an MCP joint and only one interphalangeal (IP) joint. There are proximal, middle, and distal phalanges in the fingers and only a proximal and a distal phalanx in the thumb. The thenar mass or eminence refers to the muscular area on the palmar surface overlying the thumb metacarpal. The hypothenar eminence is the muscle mass on the palmar surface overlying the little finger metacarpal.

Hand and digit motion has been standardized and is illustrated in Figures 50-2 through 50-6. The carpometacarpal (CMC) joint is more mobile in the thumb than in the other fingers and is the key to the grasp and dexterity that characterize the human hand. Motions of this joint include palmar abduction (also called flexion), radial abduction, retroposition (extension), adduction, and opposition (see Fig. 50-6). The IP joints are essentially hinge joints and are capable of only two motions: flexion and extension.

Structural Framework

Skin Cover

The hand has two skin surfaces, each with different functions. The skin of the palm is thick compared with the dorsal skin and is stabilized by fibrous connections on its deep surface. The skin creases in the palmar aspect of the hand are largely transverse and represent adherence between skin and underlying fascia, without intervening adipose tissue. These features facilitate flexion and limit the development of inflammatory edema in the palm. The other noteworthy characteristic of the palmar skin is the unique arrangement of epithelial ridges of the dermis that form cutaneous striations. These ridges have forensic importance in the pulp as “fingerprints” and play an important role in increasing friction for grasping objects.

The dorsal skin is relatively thin and mobile, permitting motion of the various joints. As a path of least resistance, the dorsum of the hand also swells easily after inflammation or trauma, which may limit flexion of the MCP joints. In addition, infection in the palmar aspect of the hand may cause dorsal swelling; this finding can be misleading without a careful physical examination.

Skeleton

The hand and wrist contain 27 bones: 14 phalangeal bones, 5 metacarpal bones, and 8 carpal bones (Fig. 50-7). The eight small...
The carpal bones in the region of the wrist are strongly united to one another by ligaments. These bones form synovial joints and are arranged in two rows, proximal and distal, with four bones in each row. Together the bones of the carpus present a concavity on their volar surface, which is bridged by a strong membranous band, the flexor retinaculum. In this way, the bridge and the bones form a tunnel, known as the carpal tunnel, through which pass the median nerve and the long flexor tendons of the fingers. The IP joints are inherently more stable than the MCP joint by virtue of their bicondylar configuration, which gives a modified tongue-in-groove appearance (Fig. 50-8).

The soft tissue supporting these joints includes the capsular ligamentous structures, which afford stability, and the tendinous structures, which generate mobility. The metacarpal and IP joints are stabilized on both sides by collateral ligaments and anteriorly by a palmar fibrocartilaginous “volar plate.” Because of anatomic

**Figure 50-1.** Surface anatomy of the hand. (From Burton Rl, et al: The Hand: Examination and Diagnosis, 3rd ed. New York, Churchill Livingstone, 1990, p 6.)

**Figure 50-2.** Supination and pronation of the hand.

**Figure 50-3.** Ulnar and radial deviation of the hand.

**Figure 50-4.** Wrist extension and flexion.

**Figure 50-5.** Finger flexion is volar and occurs at the metacarpophalangeal joint; extension and hyperextension are as shown.
differences between the metacarpals and phalanges, the IP collaterals are tight throughout the entire range of motion, whereas the collaterals of the MCP joint are tightest in flexion (Fig. 50-9). The IP joints are hinges, but the MCP joint has additional side-to-side mobility and rotational movement to facilitate efficient grasp. The clinical importance of these differences is that for minimization of the development of contractures after joint injuries, the preferred position of immobilization of the PIP joints is extension, whereas the MCP joints are more properly placed in flexion.

The structure and arrangement of the metacarpals are noteworthy. The metacarpals participate in three arches: the proximal (carpal) and distal (metacarpal) transverse arches and the longitudinal arch (Fig. 50-10). The index and long finger metacarpals form a fairly immobile segment because of their ridged articulation with the carpals. The adjacent metacarpals are more mobile. This unique anatomy gives the human palm a longitudinal and transverse concavity when the thumb is alongside the index finger; however, this changes to an oblique gutter when the thumb is extended.

The small bones of the child’s hand differ significantly from the bones of the adult and from other long bones because of the presence of an epiphysis or growth plate at one end of the bone. The phalangeal epiphyses and the thumb metacarpal epiphysis are located at the proximal end, and the finger metacarpal epiphyses are located at the distal end of the bone (Fig. 50-11). In boys the proximal phalangeal epiphysis appears at 15 to 24 months and fuses at 16 years. In girls it appears at 10 to 15 months and fuses at 14 years. The time of appearance and fusion is related to skeletal maturity and can be judged accurately until puberty from hand and wrist radiographs, because the sequence of development is age-specific.

Figure 50-6. Perpendicular view of thumb mobility.

Figure 50-7. Posteroanterior radiograph of the wrist and hand with the forearm pronated. (From Snell RS, Smith MS: Clinical Anatomy for Emergency Medicine. St. Louis, Mosby, 1993, p 650.)
Figure 50-9. The shape of the metacarpal head is eccentric, resulting in a cam effect that makes the collateral ligaments more taut in flexion than in extension. Distance A-A’ is less than A-A”. The cam effect is not present in the proximal interphalangeal joint. (From DeLee JC, Drez D Jr: Orthopedic Sports Medicine: Principles and Practice, 2nd ed. Philadelphia, Saunders, 2003.)

Figure 50-10. The three arches of the metacarpals. A, Sagittal view. B, Transverse view. (From American Society for Surgery of the Hand: Regional Review Course in Hand Surgery Syllabus, 10th ed. Aurora, Colo, ASSH, 1990.)

Muscle and Tendon Function

The muscles that power the hand may be divided into extrinsic and intrinsic muscles. The intrinsic muscles have their origins and insertions within the hand. The extrinsic muscles have origins in muscle bellies in the forearm and tendinous insertions on bones in the hand. They are divided further into extrinsic flexor and extensor muscles. The flexors of the digits in the hand lie on the volar surface of the forearm; the extensors are on the dorsal surface.

Intrinsic Musculature. The intrinsic muscles of the hand include the muscles of the thenar and hypothenar eminences, the adductor pollicis, the interossei, and the lumbricals (Fig. 50-12). The thenar muscles cover the thumb metacarpal. This group includes the adductor pollicis brevis, opponens pollicis, and flexor pollicis brevis. These muscles originate in the flexor retinaculum and on the carpal bones and insert at the base of the first metacarpal and first proximal phalanx. They act in concert with the long flexors and extensors to carry the thumb through its intricate range of motion. The muscles are evaluated by palpation of the thenar eminence for contraction as the patient brings together the tips of the thumb and little finger. They also can be tested by asking the patient to place the dorsum of the hand on a flat surface and to raise the thumb up straight to form a 90-degree angle with the palm. The thenar muscles usually are innervated by the motor branch of the median nerve. In some cases they may be partially innervated by the ulnar nerve.

The adductor pollicis arises from the index and middle finger metacarpals and inserts on the first proximal phalanx. This muscle is innervated by the ulnar nerve. Thumb adduction is tested separately by having the patient forcibly hold a piece of paper between the thumb and radial side of the index proximal phalanx. If the adductor pollicis is weak or nonfunctioning, the thumb IP joint flexes with this maneuver (Froment’s paper sign).10 In this evaluation, the two hands should be compared.

The lumbrical muscles arise from the sides of the flexor digitorum profundus (FDP) tendons; the interossei muscles lie between the metacarpal bones and originate from them. Both of these muscle groups insert in the extensor expansions of the index, middle, ring and little fingers and act on the fingers to flex the
MCP joints and extend the IP joints. The radial two lumbricals are innervated by the median nerve, and the ulnar two are innervated by the ulnar nerve. The seven interossei (three palmar and four dorsal) can be considered together. They lie on either side of the finger metacarpals and are innervated by the ulnar nerve. The dorsal interossei abduct the fingers away from the midline; the volar muscles adduct the fingers. For an accurate test that isolates their function from the extrinsic muscles, the patient should place the palm flat on a table, extend the digit, and move it from side to side.

The hypothenar group of intrinsic muscles includes the opponens digiti minimi, the flexor digiti minimi, and the abductor digiti minimi. These muscles arise from the carpal bones and in the flexor retinaculum and insert on the proximal phalanx and metacarpal of the little finger. The flexor digiti minimi and abductor digiti minimi flex the proximal phalanx and abduct the little finger respectively. The three muscles are evaluated as a group by having the patient place the wrist in a neutral position and abduct the little finger (move it away from the other fingers) against resistance. This muscle mass is palpated at that time, and a dimpling of the hypothenar skin is noted. All of the intrinsic muscles of the little finger are innervated by the ulnar nerve.

**Extensor Tendons.** The extensor tendons are on the dorsal side of the forearm, wrist, and hand. The nine extensor tendons cross the wrist joint dorsal to its axis of rotation, pass under the extensor retinaculum, and are separated on the dorsum of the hand by a series of six fibro-osseous canals or compartments. **Figure 50-13** outlines the compartments and their contents. The fibrous roof of these compartments prevents the tendons from bowstringing dorsally during active finger extension, particularly when the wrist also is extended.

The first dorsal wrist compartment contains the tendons of the abductor pollicis longus, which inserts at the dorsal base of the thumb metacarpal, and the extensor pollicis brevis, which inserts on the proximal phalanx of the thumb. The abductor pollicis longus serves to abduct the thumb ray, or thumb digit and metacarpal bone, radially, and the extensor pollicis brevis acts primarily to extend the thumb ray at the MCP joint. These tendons are evaluated by having the patient abduct and extend the thumb with resistance applied to the thumb; they can be palpated on the radial side of the wrist during this maneuver.

Two tendons lie in the second compartment: the extensor carpi radialis longus and brevis. These tendons insert at the dorsal base of the index and middle metacarpals. They act primarily to extend and deviate the wrist radially. These tendons can be palpated by having the patient extend the wrist against resistance while making a fist.

In the third compartment, a single tendon, the extensor pollicis longus, arises from the deep muscles of the midforearm, passes around a bony prominence on the dorsum of the wrist termed Lister’s tubercle, and inserts on the base of the distal phalanx of the thumb. This tubercle can be palpated just proximal to the wrist joint. The extensor pollicis longus forms the dorsal border of the anatomic snuffbox, and the abductor pollicis longus forms the volar border (Fig. 50-14). The floor of this area contains the radial artery and two carpal bones, the scaphoid and trapezium. The extensor pollicis longus functions to extend and adduct the entire first ray and extend and hyperextend the IP joint of the thumb. This muscle is evaluated by placing the hand flat on a table and having the patient lift only the thumb off the surface. Because the abductor pollicis brevis and the adductor pollicis add terminal extension, complete laceration of the extensor pollicis longus tendon may not eliminate the patient’s ability to extend the thumb.4

The tendons that extend the fingers—the extensor indicis proprius and the extensor digitorum communis—are in the fourth compartment. The extensor digitorum muscle divides into four tendons proximal to the wrist. In the dorsum of the hand, these tendons are joined distally by fibrous interconnections called juncturae tendinum which help stabilize them to their insertions in the extensor expansions of the index, middle, ring, and little fingers. The extensor digiti minimi is contained in the fifth dorsal compartment. Both the extensor indicis proprius and the extensor digiti minimi typically lie ulnar to their respective common

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**Figure 50-12.** Anterior view of the palm of the hand. The palmar aponeurosis and the greater part of the flexor retinaculum have been removed to display the median nerve, the long flexor tendons, and the lumbrical muscles. Segments of the tendons of the flexor digitorum superficialis muscle have been removed to show underlying tendons of the flexor digitorum profundus muscles. (From Snell RS, Smith MS: Clinical Anatomy for Emergency Medicine. St. Louis, Mosby, 1993, p 641.)
Complete severance of an extensor proximal to the juncturae can the proximal tendon end after distal transection of an extensor. The motion restriction is because of the juncturae, which also prevents retraction of the other digits. The middle finger and especially the ring finger have considerably limited independent extension. The motion restriction of muscle-tendon units of the long extrinsic extensor tendons occurs through the juncturae connections. The extensor digitorum communis (EDC) to the fingers and the extensor indicis proprius (EIP); the fifth, the EDQ; and the sixth, the extensor carpi ulnaris (ECU). The communis tendons are joined distally near the metacarpophalangeal joints by fibrous connections called juncturae tendinum. Beneath the retinaculum, the extensor tendons are covered with a synovial sheath. The properus tendons to the index and little fingers are capable of independent extension, and their function may be evaluated as depicted. With the middle and ring fingers flexed into the palm, the properus tendons can extend the ring and little fingers. The ECRB, extensor carpi radialis brevis; ECRL, extensor carpi radialis longus; EDQ, extensor digiti quinti proprius. (From Doyle JR: Extensor tendons—acute injuries. In Green DP [ed]: Operative Hand Surgery. New York, Churchill Livingstone, 1993, p 1927.)

Figure 50-13. A, The extensor tendons gain entrance to the hand from the forearm through a series of six canals, five fibro-osseous and one fibrous (the sixth dorsal compartment, which contains the extensor digiti quinti proprius [EDQP]). The first compartment contains the abductor pollicis longus (APL) and extensor pollicis brevis (EPB), the second, the radial wrist extensors; the third, the extensor pollicis longus (EPL), which angles around Lister’s tubercle; the fourth, the extensor digitorum communis (EDC) to the fingers and the extensor indicis proprius (EIP); the fifth, the EDQ; and the sixth, the extensor carpi ulnaris (ECU). The communis tendons are joined distally near the metacarpophalangeal joints by fibrous connections called juncturae tendinum. Beneath the retinaculum, the extensor tendons are covered with a synovial sheath. B, The properus tendons to the index and little fingers are capable of independent extension, and their function may be evaluated as depicted. With the middle and ring fingers flexed into the palm, the properus tendons can extend the ring and little fingers. ECRB, extensor carpi radialis brevis; ECRL, extensor carpi radialis longus; EDQ, extensor digiti quintus proprius. (From Doyle JR: Extensor tendons—acute injuries. In Green DP [ed]: Operative Hand Surgery. New York, Churchill Livingstone, 1993, p 1927.)

Figure 50-14. Surface anatomy of the wrist and hand. The tendons that are palpated with the thumb abducted and extended form an anatomic snuffbox.

Figure 50-15. The extensor digitorum communis (EDC) to the fingers and the extensor indicis proprius (EIP) to the thumb are the main extensor tendons of the hand. They flex the wrist and digits; three of them—the flexor carpi radialis, flexor carpi ulnaris, and palmaris longus—primarily flex the wrist and deviate the wrist radially or ulnarily (Fig. 50-16). The remaining tendons pass into the digits through the carpal tunnel. A single tendon, the flexor pollicis longus, inserts on the distal phalanx of the thumb, and two flexor tendons go to each remaining finger. The flexor digitorum superficialis (FDS) tendons bifurcate near the base of the proximal phalanges and surround the tendons of the FDP before inserting on the middle phalanges of the index, middle, ring, and little fingers (Fig. 50-17). The FDS flexes all the joints it crosses, including the wrist, PIP joints, and MCP joints. The profundus tendons lie deep to the superficialis tendons over most of their course in the forearm. At the level of the MCP joint, they perforate the superficialis tendon to emerge to a superficial position. They insert at the base of the distal phalanx and act primarily to flex the DIP joint and all joints flexed by the FDS. From the level of the MCP joint distally, the two flexor tendons become enclosed in a fibrous flexor sheath lined by synovium. Regions of thickening in this sheath form pulleys that help prevent bowstringing of the flexor tendons across the joint and assist smooth, effective flexion (Fig. 50-18).
After observation, each muscle-tendon unit is tested with a functional examination. The flexor carpi radialis, palmaris longus, and flexor carpi ulnaris are tested together by having the patient bend the tip of the thumb against resistance. FDP function attaches to the base of the distal phalanx of the thumb and flexes the wrist against resistance while the examiner palpates the adjacent neurovascular bundles. The FDP is more commonly lacerated in the finger because of its paradoxically superficial position.

If movement against resistance is intact but accompanied by pain or diminished strength, the involved tendon may be partially disrupted. Pathologic nodular swelling of one of the long flexor tendons may result in intermittent catching, or “triggering,” on a thickened flexor sheath anterior to the MCP joint. In this condition, known as trigger finger, a palpable and sometimes audible snapping can be appreciated when the patient is asked to flex and extend the fingers. On occasion, the patient may need to break the triggering effect by directly palpating the affected joint with the opposite hand.

**Synovial Spaces.** Bursae are synovial sheaths that cover tendons as they pass through osseofibrous tunnels. They contain synovial fluid and serve two essential functions: They decrease friction during tendon movement, and they help supply nutrients to the
of flexor tenosynovitis are caused by inflammation and distention of these synovial sheaths. Kanavel12 described the classic signs: a semiflexed posture of the digit, pain on passive extension of the digit, fusiform swelling, and tenderness of the synovial sheath.

Blood Supply

Arterial System. The hands and the digits have a dual blood supply (Fig. 50-22). The major blood supply to the hand is from the radial and ulnar arteries. The radial artery lies on the anterior aspect of the radius in the distal part of the forearm. It continues around the lateral side of the wrist onto the dorsum of the hand by passing deep to the tendons of the abductor pollicis longus and the extensor pollicis brevis. On entering the palm, the radial artery terminates as the deep palmar arch. The ulnar artery enters the hand anterior to the flexor retinaculum on the radial side of the ulnar nerve and pisiform bone. The artery gives off a deep branch and then continues into the palm as the superficial palmar arch. This complex arterial arch system anastomoses and sends branches to the individual digits and the deep palmar spaces. Because of extensive collateralization, the hand usually survives even if both vessels are transected at the wrist.13 The circulation of the hand is evaluated by palpation of the radial and ulnar arteries on the volar aspect of the wrist, by assessment of the color and warmth of the skin, and by testing of capillary refill. Because “normal” findings vary among patients, the injured hand should be compared with the unaffected side.

Although Allen’s test is an imperfect predictor of vascular compromise, it is commonly used to determine the patency of the arteries supplying the hand and the contributions to the circulation of the hand derived from each of the major vessels. The radial and ulnar arteries are compressed by the examiner at the wrist (Fig. 50-23). The patient opens and closes the hand repeatedly to...
exsanguinate it and then maintains a relaxed position. The radial artery is released. If the palm and fingers fill immediately with blood, the radial artery is patent, with good collateral flow into the ulnar artery system. To evaluate the ulnar artery, the same steps are repeated, but the ulnar artery is released. This method also can be used on a single digit to help evaluate the patency of each digital artery to that finger. Unilateral digital artery injuries may be well tolerated owing to adequate collateral circulation from the uninjured side. Bilateral digital artery injuries, although rare, tend to have poor outcomes.\(^{13,13a,13b}\)

**Venous and Lymphatic Systems.** The veins generally follow the arterial pattern in the deep system. The abundant dorsal, superficial veins are more extensive than the deep system and drain most of the blood from this region. The lymphatic vessels essentially follow the veins, with most lymph flowing into channels in the dorsal subcutaneous space. This vascular anatomy and the laxity of the dorsal skin account for palmar infections causing swelling on the dorsum rather than on the palmar surface of the hand.

**Nerve Supply**

The nerve supply to the hand comes from the radial, ulnar, and median nerves. All three nerves control movement of the wrist, fingers, and thumb. In the hand, the ulnar and median nerves are mixed motor and sensory nerves, whereas the radial nerve is purely sensory. Each of the three major nerves passes through a muscle in the forearm, and each passes points of potential entrapment en route to the hand.

**Motor Innervation.** The radial nerve (formed from nerve roots C6 through C8) passes through the supinator muscle and enters the dorsal aspect of the wrist between the radial styloid and Lister’s tubercle. At this level, the nerve has a purely sensory function. Its important motor function is to innervate the dorsal extrinsic muscles in the forearm, which extend the wrist and MCP joints and abduct and extend the thumb. No intrinsic muscles in the
A

B

C


The hand are innervated by the radial nerve. Motor function in this nerve is tested by having the patient extend the wrist against resistance. Proximal injury to the radial nerve causes a condition known as wristdrop: The fingers are held in flexion at the MCP joints, and the thumb is adducted (Fig. 50-24A).

The ulnar nerve (C7, C8, and T1) passes through the flexor carpi ulnaris muscle in the forearm and lies ulnar to the artery and superficial to the flexor retinaculum. It enters the hand at the wrist through the ulnar tunnel, or Guyon’s canal. The ulnar nerve innervates the hypothenar muscles, the seven interosseous muscles, the lumbrical muscles to the ring and little fingers, and the adductor pollicis. Innervation of the flexor pollicis brevis is variable. In the forearm, the flexor carpi ulnaris and the ulnar half of the FDP also are innervated by the ulnar nerve. Loss of motor function of the ulnar nerve results in inability to pinch a piece of paper tightly between the thumb and the index finger. A late characteristic of distal ulnar damage is Duchenne’s sign, manifested by clawing of the ring and little fingers (see Fig. 50-24B). The ring and little fingers are hyperextended at the MCP joints by the extensor digitorum communis (radial nerve) and flexed at the IP joints by the FDP (intact proximal ulnar nerve). In addition, the interosseous and hypothenar muscles are atrophied.

The median nerve enters the forearm through the pronator teres muscle. At that level, it innervates that muscle, the flexor carpi radialis, the FDS, the radial part of the FDP, the flexor pollicis longus, and the pronator quadratus. The branch of the median nerve that innervates the last three muscles is called the anterior interosseous nerve. The median nerve enters the hand through the carpal tunnel accompanied by the nine extrinsic flexor tendons of the digits. The thenar motor branch (recurrent median nerve) innervates the abductor pollicis brevis, the opponens pollicis variably, and the flexor pollicis brevis. Common digital branches innervate the lumbral muscles to the index and long fingers. Injury to this nerve occurs most commonly at the level of the wrist, by laceration or by compression in the carpal tunnel. Motor function is tested by having the patient appose the thumb to the wrist, by laceration or by compression in the carpal tunnel. Motor function is tested by having the patient appose the thumb to the wrist.

Sensory Innervation. The typical distribution of the sensory nerves to the hand is shown in Figure 50-25. Because some overlap occurs between various sensory nerves, it is preferable to test sensation in the areas least likely to have dual innervation. The anatomic area of least ulnar variation and overlap is the volar tip of the little finger. The median nerve exclusively innervates the volar tip of the index finger. The dorsal first web space is entirely within the radial nerve distribution.

Several methods exist to assess sensation. Two-point discrimination is one such method, although both the accuracy and objectivity of this test have been called into question. An uninjured hand is able to distinguish two points that are 2 to 5 mm apart at the fingertips and 7 to 10 mm apart at the base of the palm. The dorsum of the hand is the least sensitive region, with a normal threshold at 7 to 12 mm. Two-point threshold distances wider than these ranges indicate impaired sensory function. The threshold and two-point discrimination tests may be of limited value in children, patients with heavily calloused fingertips, uncooperative patients, comatose patients, patients in severe pain, or suspected malingerers. In such patients, submerging the hand in water and observing the skin for the development of wrinkles has been offered as a way to diagnose nerve impairment because denervated skin will not wrinkle.

Fingertip
The fingertip generally is defined as the area distal to the insertion of the flexor profundus and extensor tendons (Fig. 50-26). The
pulp is the tissue of the fingertip between the volar skin and the distal phalangeal bone. The fingertip is well padded by adipose tissue and is covered by highly innervated skin that is tethered to the distal phalanx by a series of fibrosepta. The dorsal skin is thinner and less vascularized than the volar skin. Sensation is supplied by nerves that travel with arteries bilaterally along the radial and ulnar aspects of the fingers. The arteries branch to form volar anastomoses or arches similar to those in the palm. Dorsal branches supply the nail bed and matrix.

Nail

The nail (or nail plate) consists of compacted scales that originate from cornified epithelial cells. The proximal part of the nail is called the root; it emerges from a groove in the skin to form the body of the nail, which is exposed. The root of the nail is covered by a fold in the skin called the proximal nail fold. A small portion of the epidermis of the nail fold extends out over the proximal body of the nail to form the cuticle, or eponychium. The floor of the nail plate or nail bed is composed of tissue known as the nail matrix. The distal skin of the nail bed complex is called the hyponychium. The skin overlying the nail laterally is called the perionychium. The semicircular white crescent region near the nail fold is called the lunula.

The nail bed complex is important in providing additional stabilization of the palmar soft tissues against compression and shear forces. The nail grows from the nail matrix along the nail bed and is firmly adherent to the bed. It is now believed that the entire nail bed is active in the generation and migration of the nail. As new nail forms, it glides forward over the nail bed at a rate of approximately 0.5 to 1.2 mm per week (toenails grow much more slowly). The nail itself is a hard, firm, and relatively translucent structure; the underlying vascular tissue showing through gives the nail its pink appearance. A smooth nail bed is essential to normal function. If the nail bed sustains injury that is not repaired accurately, granulation tissue forms scar that impedes normal nail production and growth. The result may be a split or absent nail that is cosmetically unappealing and sometimes functionally debilitating.

**CLINICAL FEATURES: SIGNS AND SYMPTOMS**

The initial evaluation of an acutely injured hand is crucial because it affords the best opportunity for accurate assessment of the extent of damage and for restoration of altered anatomy. Evaluation of any hand injury should begin by obtaining the historical facts of the patient’s age, occupation, hand dominance, and previous hand impairment or injury. In traumatic injuries, elapsed time since the injury, mechanism of injury, posture of the hand at the time of injury, and treatment before arrival in the ED all are useful data. In nontraumatic problems, pain, swelling, sensory change, contracture, timing of symptoms, presence of similar symptoms in other extremities, aggravating or alleviating factors, and functional impairment are useful historical points. A review of the medical history and a review of systems complete the evaluation.

After a detailed history is taken, the entire extremity should be exposed and evaluated when the hand is examined. A system of priorities, based primarily on threat to ultimate function, should direct the sequence of the examination. In order of priority, the examination includes evaluation of vascular and neurologic integrity, skin cover, skeletal stability, and joint and tendon function (Box 50-1). The general appearance of the hand should be noted, with focus on its color, presence of swelling or edema, and any abnormal posture or position. In traumatic injuries, the precise area of maximal tenderness should be localized. Rotational, angular, and shortening deformities should be noted with regard to direction and extent. Angular deformity may be seen best with the fingers in full extension. Rotational deformity is best observed during digital flexion. Digital or wrist block anesthesia may be helpful in some cases to accurately assess fracture deformity and stability during digital motion and, if necessary, stress testing. Open wounds should be assessed with regard to location, relationship to skin creases, direction and viability of skin flaps, extent of skin loss, degree of contamination of the wound, and extent of
soft tissue injury. The examiner should have good light, adequate exposure, and a nearly bloodless field for a thorough evaluation. The complete examination also may require an evaluation of active shoulder motion, elbow motion, and pronation and supination of the forearm and assessment of the contralateral hand.

**DIAGNOSTIC STRATEGIES: RADIOLoGY**

Despite the development of numerous new and sophisticated imaging techniques, plain radiography remains the most important imaging modality for the hand and wrist. The standard radiographic series of the hand should include a posteroanterior, a true lateral, and an oblique projection (Fig. 50-27). With correct positioning, the bones do not overlap on the film, allowing complete evaluation of each area for visualization of fractures, subluxation, dislocation, deformities, and retained radiopaque foreign bodies. On a hand series, the wrist is not properly positioned for radiographic examination, and vice versa; if the patient has injuries to the hand and wrist, separate radiographic series should be obtained.

For an adequate posteroanterior view, the forearm and hand should be fully pronated so that the palm rests flat on the film. This view forms the basis for all assessments but is poor at showing fractures of the articular surface of the metacarpal head. The lateral view normally is a radioulnar projection and is made by positioning the palm and forearm at 90 degrees to the film with the fingers splayed. This view is essential to show displacement of

![Figure 50-27](image-url)
fracture fragments and joint dislocations. If the projection is not a true lateral view, joint dislocation, avulsion fractures, or fractures through the articulating surface of the base of the phalanx may be overlooked. The oblique view is obtained with the hand and forearm pronated at 45 degrees to the film. It is particularly useful for assessing dislocation of the MCP and CMC joints and fractures at the base of the metacarpal bones. When injury is confined to the distal end of a single digit, radiologic evaluation should be limited to that digit, but the same projections are used (Fig. 50-28).

Special views are used to diagnose specific injuries. The standard views of the hand do not give true posteroanterior and lateral projections of the thumb because the plane of the thumb is at 90 degrees to that of the fingers. Separate posteroanterior and lateral views of the thumb should be requested. The posteroanterior projection of the thumb is obtained with the hand and forearm hyperpronated so that the dorsal surface of the thumb and the thumb metacarpal rests flat on the film. The lateral view is obtained by pronating the hand and forearm to allow the lateral surface of the thumb to lie on the film. Stress views are used most often to rule out ligamentous injury to the first MCP joint. Localized widening of the joint space or subluxation may indicate a significant collateral ligament injury. Plain radiographs taken in multiple projections can help detect and localize soft tissue foreign bodies. Whether an object can be visualized will depend on its composition, configuration, size, and orientation. Many foreign bodies encountered in the ED, including almost all glass, are more dense than soft tissue and can be readily seen on plain radiographs. Plastic and wood foreign bodies are notable exceptions, with many of these objects being radiolucent.

**MECHANISMS OF INJURY AND MANAGEMENT**

**Trauma**

The bones of the hand are the most commonly fractured bones in the body. Radiologic evaluation of significant hand injuries is mandatory. Any hand injury that causes swelling should be evaluated radiographically with a minimum of three views. Although the classification of hand fractures is difficult and at times confusing, it generally is done according to the nature and site of the fracture line and whether the fracture is open or closed (Fig. 50-29).

A fracture is unstable if it cannot be reduced or maintained in an anatomic or near-anatomic position without fixation when the hand is placed in the “safe” or functional position. The four principal determinants of fracture stability or instability are (1) fracture configuration, (2) integrity of the periosteal sleeve and surrounding soft tissues, (3) muscle balance or imbalance, and (4) external forces.

In general, transverse fractures have a stable configuration. Spiral, oblique, and comminuted fractures are unstable. The degree of displacement also is an indicator of potential fracture instability. Fractures of inherently unstable configuration may be stable if they are nondisplaced or only minimally displaced because the periosteum is undamaged or minimally disrupted. Displacement is defined by the deformity it creates and can result in rotation, angulation, shortening, or a combination of these fractures. Although shortening has an adverse effect on muscle tension, the hand accommodates more easily to this component of deformity than to others.

Definitive management of many hand fractures is controversial and beyond the scope of this discussion. The emphasis here is on appropriate initial interventions, including proper splinting techniques to minimize morbidity, and recognition of which fractures may require operative fixation and their potential complications. Most closed injuries may be treated initially in the ED. Most open, intra-articular, periarticular, and unstable fractures require operative management by a hand surgeon.

**Distal Phalanx Fractures**

**Pathophysiology and Clinical Features**

Fractures of the distal phalanx are the most common fractures of the hand. They occur most often as a result of crush or shearing forces, usually as a sports-related injury in children and adolescents, industrial accidents in adults, or accidental falls in elderly persons. Distal phalangeal fractures are classified as extra-articular fractures (longitudinal, transverse, and comminuted) or intra-articular fractures. The most common location for these
fractures is the distal tuft (Fig. 50-30). Because the mechanism of injury is usually direct trauma, tuft fractures often are comminuted and usually are associated with soft tissue injury to the nail, nail bed, and nail matrix. Supporting fibrous septa that radiate from the bone to the skin prevent displacement of fracture fragments and act to contain soft tissue swelling, contributing to the severe pain that can accompany these fractures. Examination typically reveals tenderness and swelling over the distal phalanx, including the pulp.

Fractures at the base of the distal phalanx may be associated with tendon avulsion. The flexor profundus tendon attaches to the volar aspect of the index, middle, ring, and little fingers, and the terminal slip of the extensor tendon attaches on the dorsal surface of the distal phalanx. In the distal phalanx of the thumb, the flexor pollicis longus inserts on the volar base, and the extensor pollicis longus inserts on the dorsal base. These tendons can avulse when subjected to excessive stress. Clinically, loss of function is evident, and small avulsion fractures along the dorsal or volar surface may be seen on radiographs. These fractures are considered intra-articular, and their management is as for other tendon injuries.

Management

Treatment of most fractures of the distal phalanges is directed toward the accompanying soft tissue injury. Closed tuft fractures need only symptomatic treatment with elevation (to reduce swelling) and analgesics. Fracture immobilization is rarely necessary; however, a short volar splint or hairpin splint (Fig. 50-31) is recommended for 2 to 3 days to protect the tip of the finger from further trauma and allow swelling without constriction. Immobilization should not include the PIP joint. Transverse shaft fractures with angulation or displacement may be irreducible because of interposition of soft tissue. Closed reduction may be attempted with dorsal traction on the distal fragment followed by immobilization with a volar splint and repeat radiographs for documentation of position. If this approach is unsuccessful, referral to a hand surgeon is indicated for Kirschner wire fixation.

Distal phalangeal fractures associated with nail bed laceration are considered open fractures. This may be obvious if the nail has been avulsed or torn, but recognition of nail bed laceration is more difficult in closed tuft fractures with an intact nail despite presence of a subungual hematoma. Subungual hematomas often are associated with occult lacerations of the nail bed, and in such cases removal of the nail for accurate assessment and laceration repair uncommonly may be required.

Complications

Distal phalanx fractures generally are uncomplicated; however, distal phalanx fractures that appear innocuous can result in prolonged morbidity, especially if associated with soft tissue crush injury. In a long-term follow-up series, DaCruz and associates showed that at 6 months 31% of tuft fractures had not healed radiographically and 70% of all patients had bothersome symptoms, including numbness, hyperesthesia, and cold sensitivity. Trauma to the nail bed may result in abnormal nail growth despite exact tissue approximation. Failure to recognize and extricate an entrapped nail bed in the fracture site may result in nonunion of the fracture. Osteomyelitis from open fractures is a rare but potentially serious complication.

Proximal and Middle Phalangeal Fractures

Pathophysiology and Clinical Features

Because the anatomy, mechanism of injury, and treatment for proximal and middle phalangeal fractures are similar, these fractures are discussed together. The proximal phalanx has no tendinous attachments. Fractures in this region have a typical volar angulation resulting from forces exerted from the extensors and the interosseous muscles. The middle phalanx has two important insertions. The tendon of the FDS divides and inserts along nearly the entire volar surface of the phalanx, and the extensor tendon inserts on the proximal dorsal base of the middle phalanx. Because of this alignment, fractures at the base of the middle phalanx usually result in dorsal angulation, and fractures at the neck of the
The mechanism of injury often determines the nature of the fracture; a direct blow is more likely to cause a transverse or comminuted fracture, whereas a twisting injury more often results in an oblique or spiral fracture. Associated injuries may include contusion or transection of digital nerves, vascular disruption, and tendon rupture.

Intra-articular fractures include condylar fractures; comminuted fractures; dorsal, volar, or lateral base fractures; fracture-dislocations; and shaft fractures involving the joint. Extra-articular fractures involve the neck, shaft, or base of the phalanx. Although most phalangeal fractures may be easily seen, condylar fractures and displaced neck fractures are not always apparent on antero-posterior radiographs; oblique views may be needed to identify them.\(^{24}\) Rotational deformities are difficult to determine by radiologic study but may appear on the lateral view as discrepancies in the diameter of the shaft at the fracture site.

Skeletal alignment can be assessed radiographically, but rotational alignment should be judged clinically by the relationship of the finger to adjacent normal fingers (Fig. 50-32). Symmetrical flexion of adjacent injured and normal fingers at their MCP and PIP joints is the best possible guide to accurate rotational alignment of the injured segment.\(^{17}\) Normally, all of the fingers of the closed fist except the thumb should point to the scaphoid.

Alternatively, when the fingers are loosely flexed, the nails of opposing digits should lie in the same parallel plane (Fig. 50-33). The uninjured hand should be used for comparison.

**Management**

Similar to metacarpal fractures, phalangeal fractures require precise anatomic alignment to ensure a good result because of the intimate relationship of the flexor and extensor tendons to the phalanx.\(^{23}\) Appropriate treatment selection depends on accurate assessment of fracture stability. The angle of the fracture is an important factor in determining this stability. Transverse fractures usually are stable, whereas oblique fractures are inherently unstable. It also is important to ascertain whether the fracture has been impacted or displaced and what deforming forces are acting on it. If there is any question of the fracture's stability, the digit should be anesthetized, and stress should be applied. Reduction of phalangeal fractures usually is not necessary because most are stable and nondisplaced.\(^{17}\) Patients with such fractures should be started on early protected motion as soon as pain subsides (within the first 3 to 5 days). Protection is provided by taping the injured digit to an adjacent, larger normal finger proximally, a form of dynamic splinting. This technique, known as “buddy-taping,” encourages the patient to move the finger and use the hand as normally as possible while the fracture heals (Fig. 50-34).

If the fracture is displaced or unstable, it is not suitable for dynamic splinting. In general, treatment depends on the type of trauma and the ability to achieve a stable reduction. Phalangeal fractures that are satisfactorily managed by closed reduction can be immobilized by several methods. In such cases it is advisable to immobilize the wrist and the injured finger. Specific types of immobilization include circular cast, the Böhler method of incorporating a cast with an outrigger, gutter splints, and anterior and posterior splints (Fig. 50-35). The period of immobilization of phalangeal fractures should not exceed 3 weeks, to prevent stiffness and to minimize disability. In addition to temporary immobilization, ED management includes ice for comfort, elevation, analgesics, and referral for follow-up care. Repeat radiographs in 7 to 10 days are recommended to ensure that no delayed displacement has occurred.

Unstable fractures that cannot be reduced by closed manipulation and maintained with external splinting require internal fixation. Midshaft transverse fractures tend not to be amenable to closed reduction; similarly, spiral oblique fractures and
intra-articular fractures are inherently unstable and require surgical fixation if a significant portion of the articular surface is involved.\textsuperscript{25} Intra-articular fractures of the proximal metaphysis of the middle phalanx that have extreme comminution may require treatment in static or dynamic traction or external fixation with or without ancillary Kirschner wire fixation.\textsuperscript{25}

Complications

Malunion is the most common bony complication of phalangeal fractures and may result from malrotation, volar or lateral angulation, or shortening. Malrotation usually is seen after oblique or spiral fractures of the proximal and middle phalanges and may require osteotomy through the phalanx or metacarpal for correction. Volar angulation of proximal phalangeal fractures greater than 25 to 30 degrees results in pseudoclawing. This deformity makes use of the hand awkward and is esthetically unacceptable. Other potential complications include diminished motion resulting from tendon adhesions and stiffness of the PIP joint after intra-articular fractures with incongruity.\textsuperscript{23}

Metacarpal Fractures

Metacarpal fractures generally are divided into two groups: fractures involving the thumb metacarpal and fractures involving metacarpals of the index, middle, ring, and little fingers. This distinction is based on the fact that the base of the thumb metacarpal is biomechanically distinct from the remaining metacarpals because of its high degree of mobility. For this reason, these two groups are discussed separately.

Metacarpal Fractures of the Index, Middle, Ring, and Little Fingers

The hand can adjust functionally to dorsal angulation in the metacarpal equal to its motion at the CMC joint, plus 10 to 15 degrees in some patients. Because the index and middle fingers are immobile at their CMC joints, they may accommodate only 10 to 15 degrees of dorsal angulation. The ring finger usually has 20 to 30 degrees of mobility at its CMC joint and may accommodate 40 to 45 degrees of dorsal angulation. The small finger generally has 30 to 50 degrees of motion at its base and may accommodate 50 to 70 degrees of dorsal angulation. Finger metacarpals may tolerate 10 to 15 degrees of lateral angulation and 3 to 4 mm of shortening. Rotational deformity, most commonly seen in spiral and oblique fractures, is poorly tolerated. A small amount of rotational deformity can translate into a substantial digital overlap when the fingers are closed to form a fist. Just 10 degrees of malrotation may cause as much as 2 cm of overlapping (scissoring) of the fingers during flexion.\textsuperscript{22} Surgical intervention is indicated with 2 to 3 mm of shortening, 1 mm of articular surface step-off, greater than 25% articular involvement, or any degree of malrotation.\textsuperscript{23}

Metacarpal Head Fractures

Pathophysiology. Fractures of the metacarpal head are rare. They usually occur as a result of direct trauma or crush injury and typically are comminuted.\textsuperscript{21} These fractures occur distal to the attachment of the collateral ligaments. Physical examination reveals tenderness and swelling over the involved MCP joint. Pain is increased if axial compression is applied along the extended digit. The presence of lacerations over the metacarpal heads is significant and suggests the possibility of an open fracture potentially caused by human bite injury.
Diagnostic Strategies: Radiology. Although routine radiographic imaging of the injured hand reveals most fractures, the metacarpal heads can be difficult to assess because of overlap on the lateral view. In such cases in which clinical suspicion of a fracture exists and the initial radiographic appearance is normal, the Brewerton “ball-catcher’s” view may be helpful.26 This view is obtained with the digits in 65 degrees of flexion at the MCP joints and the x-ray beam angled 15 degrees radially, projecting the metacarpal heads in profile. Occasionally, computed tomography also may be required to evaluate accurately the degree of displacement of intra-articular fractures at the MCP level.

Management. Emergency management of closed metacarpal head fractures consists of elevation, ice for comfort, analgesics, and immobilization of the hand in the “safe” or functional position, which balances the forces of the intrinsic muscles. In this position, shown in Figure 50-36, the wrist is extended 20 degrees, the MCP joints are flexed to 90 degrees, and the PIP and the DIP joints are extended. Referral to a hand surgeon for management and follow-up evaluation is required in all cases. Because these are intra-articular fractures, displacement by more than 1 to 2 mm predisposes the patient to a poor result; however, little consensus has been reached regarding optimal definitive treatment.27

Lacerations or puncture wounds over the dorsum of the MCP joint associated with a metacarpal head fracture should be considered open until proven otherwise. Such injuries often are caused by a clenched-fist injury and are highly contaminated wounds. Emergent consultation with a hand surgeon for operative debridement and irrigation is recommended. Prophylactic coverage with a cephalosporin is routinely recommended, although patients with highly contaminated wounds should receive penicillin with a β-lactamase inhibitor and an aminoglycoside.28 Several studies have found preoperative wound cultures to be of no value in predicting the risk of infection or identifying the likely pathogen, and some clinicians have abandoned their use.29,30

Complications. Metacarpal head fractures may be associated with debilitating hand complications, including avascular necrosis, rotational malalignment, interosseous muscle fibrosis, extensor tendon injury or fibrosis, and chronic stiffness of the MCP joint. Many of these fractures also may require late arthroplasty.31

Metacarpal Neck Fractures

Pathophysiology. Fractures of the metacarpal neck are among the most common fractures in the hand. The mechanism of injury is a direct impaction force (e.g., a punch with a closed fist). A boxer’s fracture is a fracture of the neck of the little finger metacarpal (Fig. 50-37). Most metacarpal neck fractures have a typical apex dorsal angulation. They are inherently unstable because of the deforming muscle forces and frequent comminution of the volar cortex. Management generally is difficult because of this instability and the difficulty in maintaining reduction.

Management. For treatment purposes, metacarpal neck fractures are divided into two groups: fractures involving the ring and little finger metacarpals and fractures involving the index and long finger metacarpals. There is considerably more mobility of the metacarpals of the ring and little fingers compared with the index and long fingers. This greater mobility makes them more prone to fracture, and the relative immobility of the index and long finger metacarpals increases the need for accurate alignment after reduction. In general, less than 15 degrees is allowed in the index and long finger metacarpals; in the ring and little finger metacarpals, 35 degrees and 45 degrees of angulation, respectively, are allowed. Any rotational malalignment should be completely corrected.

Nondisplaced ring and little finger metacarpal fractures without angulation deformity can be treated initially with ice, limb elevation, analgesia, and immobilization in a gutter splint. Nondisplaced, nonangulated metacarpal fractures of the index and long finger metacarpals are treated similarly. The splint should be in standard position of function and extend from below the elbow up to, but not including, the PIP joint. In general, it is recommended to begin PIP and DIP motion without delay. Protected MCP motion can begin in 3 to 4 weeks.31 For isolated fractures of the little finger metacarpal neck, some clinicians advocate immediate mobilization of fractures regardless of the degree of angulation. Results with this approach include excellent function, with only minor cosmetic deformity, and early return to work. Early follow-up evaluation is advised to exclude residual angulation, rotational deformity, and delayed displacement.31

Reduction of ring and little finger metacarpal neck fractures with significant angulation or deformity may be attempted in the
ED. After appropriate anesthesia is obtained, usually with a hema-
toma block or an ulnar nerve block, traction is applied on the
metacarpal to disimpact the fracture. The MCP joints and IP
joints are flexed at 90 degrees, and simultaneous pressure is applied
in a volar direction over the metacarpal shaft and in a dorsal direc-
tion over the flexed PIP joint (Fig. 50-38). This maneuver is termed
the 90-90 method and should complete reduction. A gutter splint
in position of function should be applied. Postreduction radio-
graphs should be obtained immediately and after 1 week to ensure
that reduction has not been lost. If closed reduction cannot be
achieved or maintained, pin fixation by a hand surgeon is neces-
sary, and early referral is indicated.

Displaced or angulated index or long finger metacarpal neck
fractures commonly require anatomic reduction and surgical fixa-
tion. ED management consists of ice, limb elevation, analgesia, and immobilization in a gutter
splint. Prompt referral to a hand surgeon is necessary.

Complications. Metacarpal neck fractures may have an associ-
ated rotational component that can impair function and result
in overlapping of the affected finger over an adjacent finger. If
excessive angulation is not corrected, the patient may experience
forced hyperextension of the MCP joint and flexion of the PIP
joint when extending the finger and pain when tightly grasping
objects. Other complications include extensor tendon injury and
collateral ligament damage. Nonunion is rare after closed meta-
carpal fractures.

Metacarpal Shaft Fractures

Pathophysiology. There are three types of metacarpal shaft frac-
tures: transverse, oblique or spiral, and comminuted. Transverse
and comminuted fractures usually result from a direct blow and
commonly exhibit dorsal angulation (Fig. 50-39). Indirect trauma
or rotational torque applied to the finger may result in a spiral
shaft fracture. These fracture fragments tend to shorten and rotate
rather than angulate.

Management. Metacarpal shaft fractures are treated differently
than fractures involving the neck because rotational deformity and
shortening are more likely and less angular deformity is accept-
able. In general, any rotational deformity should be corrected.
Angulation deformities are unacceptable in the index and long
finger metacarpals, whereas a small amount of angulation may be
compensated for in the ring and little finger metacarpals. Accept-
able reduction is less than 10 degrees of angulation in the former
and less than 20 degrees in the latter, with less than 3 mm of
shortening and normal rotational alignment.21

Most metacarpal shaft fractures can be managed initially with
ice, limb elevation, analgesia, and immobilization in a gutter
splint. The splint should include the wrist and the entire metacar-
pal shaft, but not the MCP joint if the fracture is proximal to the
neck. Repeat radiographic examination and referral to a hand
surgeon are recommended. If manipulative reduction is necessary,
operative fixation usually is indicated. Multiple displaced metacar-
pal shaft fractures, oblique or spiral fractures with rotational
defor emph, irreducible transverse fractures, and displaced open
fractures require internal fixation.21

Complications. Metacarpal Base Fractures

Clinical Features. Fractures of the metacarpal base generally are
stable and occur infrequently. They may result from either a direct
blow over the base of the metacarpal or an axial force or torque
applied along the digit. Examination reveals tenderness and swell-
ing at the base of the involved metacarpal, and a significant degree
of rotational deformity may be evident. Fractures at the base of
the ring or little finger metacarpals may cause injury to the motor
branch of the ulnar nerve, resulting in paralysis of the intrinsic
hand muscles. In addition, they may be associated with a carpal
bone fracture.
Management. Initial management in the ED consists of ice, limb elevation, analgesia, and immobilization in a bulky compressive dressing or volar splint with referral to a hand surgeon for definitive management.

Complications. Metacarpal base fractures may be associated with extensor or flexor tendon damage and significant rotational malalignment. Chronic CMC joint stiffness often is associated with intra-articular fractures and may necessitate arthrodesis or arthroplasty.

Thumb Metacarpal Fractures

Fractures of the thumb metacarpal are relatively uncommon because of its high degree of mobility. Although the shaft occasionally may be involved, most fractures involve the base of the metacarpal. These fractures are classified into two groups: extra-articular and intra-articular. The two common types of intra-articular fractures of the thumb are Bennett’s and Rolando’s fractures.

Extra-articular Fractures. Extra-articular fractures are seen more commonly than intra-articular fractures and usually result from direct trauma or impaction. The three types of extra-articular fractures are transverse, oblique, and, in children, epiphyseal. Examination reveals localized pain and swelling over the fracture site.

Mobility of the thumb metacarpal allows 20 to 30 degrees of angular deformity without functional impairment. Patients with extra-articular fractures with a greater degree of angulation should undergo closed reduction, postreduction radiographic evaluation, and immobilization of the thumb in abduction with its IP joint extended with a thumb spica cast for 4 weeks. Transverse fractures usually are stable and can be managed with closed reduction and immobilization. If the fracture is oblique, it may require Kirschner wire fixation because of instability and a propensity for rotational deformity.22

Intra-articular Fractures

Bennett’s Fracture. Bennett’s fracture is an intra-articular fracture at the base of the thumb metacarpal combined with a dislocation or subluxation of the CMC joint. The ulnar portion of the metacarpal remains in place, and the larger fragment subluxates dorsally because of the pulling force of the abductor pollicis longus and adductor pollicis muscles (Fig. 50-40). There is complete disruption of the ligaments around the CMC joint. Because stability is conferred mostly by the dorsal ligament (posterior oblique CMC ligament), dislocation ensues. The mechanism of injury usually involves an axial force acting on a partially flexed metacarpal (e.g., striking a rigid object with a closed fist). This is the most common fracture of the thumb base.22

Bennett’s fracture requires an anatomic reduction. Treatment goals are to achieve stability of the CMC joint by rejoining the volar lip fragment to the first metacarpal and to restore articular congruity. Initial management consists of immobilization in a thumb spica splint, ice, limb elevation, and analgesia. Early referral to a hand surgeon is warranted because although closed reduction can be achieved, the fragments are difficult to hold in position as a result of the pulling forces of the abductor pollicis longus and adductor pollicis muscles. Definitive treatment consists of conservative management, closed reduction with percutaneous pinning, or, if anatomical reduction fails or the fracture fragment represents more than 20% of the articular surface, open reduction and internal fixation.25

Rolando’s Fracture. Rolando’s fracture is a comminuted fracture of the base of the thumb metacarpal. Various degrees of comminution occur, but the typical configuration is in a Y- or T-shaped pattern. The severity of comminution often is underrepresented on radiographic studies. The mechanism of injury is the same as in Bennett’s fracture, but Rolando’s fracture occurs much less commonly and generally carries a much worse prognosis.

ED management of Rolando’s fracture consists of immobilization in a thumb spica splint, ice, limb elevation, analgesia, and early referral to a hand surgeon for surgical reduction. Definitive treatment is controversial and depends on the severity of comminution at the base of the thumb and the degree of displacement. If open reduction is indicated, a plate often is placed dorsally to maintain the reconstruction; with severe comminution, Kirschner wire fixation, bone graft placement, and external fixation may be used for continued distraction until healing occurs.33

Complications. Complications include joint stiffness, degenerative arthritis, and malunion. Malunion is the most common late complication but usually is well tolerated at the thumb CMC joint.34 Post-traumatic arthritis is more common after Rolando’s fracture and may require arthrodesis or resection hemiarthroplasty. Nonunion is rare.

Pediatric Fractures of the Hand

Pathophysiology and Assessment

The hand is frequently injured in children, with phalanx and metacarpal fractures representing the most commonly fractured bones.35 In young children, the most common hand fracture involves a crush injury of the fingertip with an open fracture of the distal tuft.36 The most distinctive feature of the immature skeleton is the presence of epiphyseal growth centers. Although the cartilaginous epiphysis is believed to be a weak link in the immature skeleton, injuries involving this region reportedly account for only 18% of pediatric fractures.37

The Salter-Harris classification of epiphyseal fractures is used to direct treatment and predict outcome. The injuries are classified...
The proximal phalanx is the most frequently fractured bone among the phalanges. The most common epiphyseal fracture in the hand is a Salter-Harris type II fracture of the proximal phalanx. It usually results from a twisting or hyperextension mechanism and most often involves the ring and little fingers and the thumb. Although lack of cooperation in this age group may make examination difficult, the clinician should look for swelling, ecchymosis, and deformity. In addition, the examiner should palpate for bony tenderness and for tenderness over the collateral ligaments. Persistent limitation of motion in a young child usually implies a significant injury of the bones or joints of the digit.

Radiologic studies should be obtained and should include the same views that are obtained in an adult. In addition, comparison views may be helpful, particularly in subtle fractures. Epiphyseal fractures may be particularly difficult because pediatric growth plates appear differently at different ages, and their varied radiographic appearance may be mistaken for fractures.

Management

Most pediatric hand fractures can be readily treated with either simple splinting or closed reduction, followed by brief immobilization, usually for no longer than 3 weeks. A plaster or fiberglass gutter splint incorporating the adjacent uninjured finger and including the wrist is the best means of immobilizing a child's finger fracture. The previously mentioned safe position still should be used whenever possible. Some clinicians advocate that in children, even stable injuries that ordinarily would be treated by buddy-splinting in an adult should be protected with full splinting for several weeks to prevent further injury. Open reduction and surgical fixation may be necessary for displaced intrarticular fractures, displaced Salter-Harris type III or IV fractures, and unstable fractures that cannot be maintained by closed methods.

Complications

Pediatric hand fractures heal more quickly compared with similar injuries in adults. In addition, remodeling allows correction of some step-offs or angular deformities in younger children but does not correct rotational deformities. The ability of bone to correct angular deformities by remodeling is diminished with age and cannot be relied on for adequate correction in adolescents and adults. Residual deformity is the most commonly reported complication. Other complications, including joint stiffness, tendon adherence, and nonunion, are rarely seen.

Soft Tissue Injuries

Soft tissue injuries of the hand are extremely common ED presentations. Trauma accounts for most of these injuries to the tendons, ligaments, and cartilage. Although such injuries are not life-threatening, they may result in potentially disabling complications, including deep space infection, osteomyelitis, compartment syndrome, joint laxity, loss of motion, chronic pain, swelling, and deformity.

Dislocations and Ligamentous Injuries

Ligamentous injuries to the hand are common and often missed. Injury may range from mild sprain to complete rupture and may produce various degrees of joint instability. Purely ligamentous injuries may be “tears in continuity” (grade I), partial tears (grade II), or complete tears (grade III). The disruption of joints may be complete, with the articular surfaces completely separated (a dislocation), or incomplete, leaving the articular surfaces in partial communication (a subluxation).

Because the goal of treatment is to restore functional stability, it is essential to perform a systematic evaluation of joint stability. Functionally, stability may be determined through use of a two-phase test of the IP and MCP joints of the hand. Because range of motion is heavily influenced by pain, accurate assessment generally requires digital or wrist block anesthesia in even the most cooperative patients. Active stability is tested by allowing the patient to move the digit through the normal range of motion. Completion of a full range without displacement indicates that adequate joint stability remains. Passive stability is assessed by applying gentle radial and ulnar stress to each collateral ligament and posteroanterior stress to assess volar plate integrity. Stress testing should be done in extended and moderately flexed positions to avoid the stabilizing effect of the volar plate. Comparisons with the same joint of the uninjured hand may assist in the diagnosis. Supplemental stress radiographs also may be helpful in evaluating difficult cases.

The diagnosis of incomplete or partial ligamentous injuries is made when the joint is stable to active and passive stress but is significantly swollen, with pain elicited on stress and palpation of the involved ligament systems. The examiner should attempt to ascertain whether the most tender area is over the central slip (dorsal), collateral ligaments (radial and ulnar), or volar plate (volar). Grade I and II injuries exhibit stability with pain on stress testing. Grade III injuries show instability on stress testing. Stability of the joint provides strong evidence that optimal functional recovery would result from short-term immobilization rather than surgical intervention. Because of the three-dimensional boxlike configuration that the collateral ligaments and volar plate form around the joint, wide displacement indicates that at least two components of the ligament box complex are disrupted. Joints with demonstrable instability should be immobilized in a gutter splint and the patient referred to a hand surgeon to determine whether surgical repair is necessary. Immobilization should be done with the IP joints splinted at 30 degrees of flexion and the MCP joints splinted at 45 to 50 degrees of flexion; when the thumb MCP is involved, it should be splinted in 30 degrees of flexion. Because the long-term effects of joint injuries are almost always joint stiffness and loss of flexion rather than persistent instability, the immobilization period usually is brief (2 to 3 weeks) and should be followed by a gradual procession of active range-of-motion exercises.

Interphalangeal Joint Injuries

Distal Interphalangeal Joint. The DIP joint structure is analogous to that of the PIP joint. Additional stability is provided by the adjacent insertions of the flexor and extensor tendons, and dislocations are uncommon. Most dislocations are dorsal and usually are associated with an open wound (Fig. 50-42). The distal phalanx
is said to be “bayonet-apposed”—the shafts of distal and middle phalanges lie adjacent to each other, but no bony contact occurs end-to-end at the articular surfaces. Routine radiographs are used more often to rule out associated fractures than to confirm a suspected diagnosis. Treatment consists of closed reduction performed under digital or wrist block anesthesia, followed by active and passive stability testing. Reduction usually is accomplished easily by longitudinal traction and hyperextension to distract the bayonet-apposed distal phalanx followed by direct application of dorsal pressure to the base of the distal phalanx. Irreducible fractures require surgery for open reduction. The irreducibility may be a result of interposition of an avulsed fracture fragment in the joint, entrapment of the profundus tendon, or buttonhole tear through the volar plate.

If the dislocation is open, the joint is contaminated, and treatment should include débridement and copious wound irrigation. The skin should be sutured and the joint splinted in slight flexion without interposed soft tissue. With complex (complete) dislocations at the PIP joint, there usually are unstable and require surgery. 45

Avulsion fractures involving 33% or more of the articular surface are unstable and require surgery. 45

Most closed dorsal and lateral PIP dislocations are treated nonoperatively. 44 Reduction is facilitated by digital nerve block and usually can be accomplished by longitudinal traction and mild hyperextension followed by firm dorsal pressure on the proximal aspect of the middle phalanx. When reduction has been achieved, active motion is tested. Reduction is stable if no displacement occurs during active range of motion and passive stressing of the joint. More than 20 degrees of deformity and instability with lateral testing indicate a complete ligamentous injury. 46 If stability is maintained during active range of motion, treatment consists of 3 weeks of immobilization in 20 to 30 degrees of flexion, followed by active exercises. Although stiffness, pain, and swelling are likely to persist for months, the long-term prognosis is good, and subluxation usually does not recur unless the finger is hyperextended again. 44 If the dislocation is irreducible or there is evidence of complete ligamentous disruption with dislocation on active range of motion, operative repair is required.

The management of volar dislocations of the PIP joint is controversial. The dislocation has been described as irreducible and requiring open reduction; however, some authorities state that most volar dislocations can be reduced by a closed technique of applying gentle traction with MCP and PIP joints flexed. 44 A stable reduction with repair of the soft tissue structures and transarticular pinning in the fully extended position also has been recommended. 44

Injury to the Metacarpophalangeal Joints of the Fingers

Pathophysiology. MCP dislocations are considerably less common than dislocations of the PIP joint. The MCP joints of the fingers are resistant to ligamentous injury and dislocation because of their inherent ligamentous structure, their surrounding supporting structures, and their protected position at the base of the fingers. Like the DIP and PIP joints, each MCP joint has two collateral ligaments and a volar fibrocartilaginous plate; however, the MCP joints are condylloid joints and permit, in addition to flexion and extension, 30 degrees of lateral motion while the joint is extended. Because of the shape of this articulation, the joint is more stable in flexion when the collateral ligaments are stretched than when they are in extension. They are most vulnerable to injury from forces directed ulnarly and dorsally.

Isolated injury to the collateral ligaments and volar plate of the MCP joint is rare. These injuries usually occur with hyperextension stress applied to the MCP joint with the finger extended. The patient has ecchymosis and swelling of the joint. Examination reveals tenderness along the joint and varying degrees of instability. The radiographic appearance usually is normal on routine views, but some clinicians recommend a Brewerton view to show any evidence of avulsed bone fragments. 47 Treatment for most of these injuries consists of application of a gentle compression dressing with light plaster reinforcement and early orthopedic referral.

Dislocations of the MCP joints of the fingers are relatively rare injuries and usually are dorsal. The most common digit involved is the index finger, followed by the little finger. These dislocations result from hyperextension forces that rupture the proximal volar plate and are divided into simple and complex types. In the simple dislocation (subluxation), the joint appears to be hyperextended to 60 to 90 degrees, and the articular surfaces are in contact without interposed soft tissue. With complex (complete) dislocations, the MCP joint is in moderate hyperextension and angulated, the metacarpal head is prominent in the palm, and the distended palmar skin is dimpled. Complex dislocations have a less striking attachment points and do not indicate the need for open repair.
Injury to the Carpometacarpal Joints of the Fingers

Pathophysiology. The CMC joints of the digit form the base of the transverse metacarpal arch of the hand. The metacarpal bases articulate with one another and with the distal carpal row in a complex interlocking structural arrangement. The joints are supported by strong dorsal, volar, and interosseous ligaments and are reinforced by the broad insertions of the wrist flexors and extensors (Fig. 50-45). Dislocations of the CMC joints are uncommon and often are missed.48 Overall, the most commonly injured CMC joint is the little finger, and most of these injuries are dorsal dislocations. Complex dorsal dislocations do not reduce with closed methods and require operative reduction. Volar dislocations are rare and generally require operative reduction.

Management. Initial treatment consists of ice for comfort, limb elevation, and analgesia. Closed reduction of the dorsal fracture-dislocation may be attempted after adequate regional anesthesia has been obtained. Traction and flexion with simultaneous longitudinal pressure on the metacarpal base, followed by extension of the metacarpal head when length has been restored, generally result in reduction. Even in cases in which reduction is achieved by closed means, early referral to a hand surgeon is needed because Kirschner wire fixation is advisable to ensure adequate stability. The late sequelae of fracture-dislocations include pain and weakness from traumatic arthritis secondary to imprecise alignment or chronic dislocation of the CMC joints.

Injury to the Interphalangeal Joint of the Thumb

The IP joint of the thumb is similar to a finger DIP joint except that the phalanges of the thumb typically are larger and stronger...
Injury to the Metacarpophalangeal Joint of the Thumb

The MCP joint of the thumb is a condyloid joint that allows mainly flexion and extension; however, it also permits some degree of abduction, adduction, and rotation. Its volar plate and collateral ligaments are stronger than in other MCP joints, but its vulnerable position leads to frequent traumatic injury. Overall, injury to the MCP joint of the thumb accounts for five times the number of injuries of all other MCP joints combined.

Most dislocations of thumb MCP joints are dorsal and result from a hyperextension force that ruptures the volar plate, joint capsule, and at least part of the collateral ligament. As with other dorsal MCP dislocations, displacement ranges in extent from subluxation of the phalanx to a complex dislocation with the proximal phalanx resting over the metacarpal head. The complex dislocation is not easily reduced because of volar plate entrapment in the joint. Clinically, the complex dislocation may show a dimple over the thenar eminence. Radiographic studies confirm the dorsal dislocation and reveal the sesamoids in close proximity to the proximal phalanx.

Management. Closed reduction may be attempted after radial and median nerve wrist block anesthesia has been achieved. Pressure is directed distally on the base of the proximal phalanx, with the metacarpal flexed and adducted. If reduction is difficult, the IP joint and wrist can be flexed to relax the entrapped flexor pollicis longus tendon. When restoration of anatomic position has been accomplished, the collateral ligaments should be tested, and reduction should be confirmed by radiographic assessment. Stability to active range of motion and stress testing suggests that immobilization in a thumb spica splint with the MCP joint in 20 degrees of flexion for 4 weeks constitutes adequate treatment. Nonreducible (complex) dislocations or dislocations with significant lateral instability require open reduction and operative repair. Hyperextension, instability, and chronic pain on pinching may occur after these injuries.

Ulnar Collateral Ligament Injuries (Gamekeeper’s Thumb, Skier’s Thumb)

Pathophysiology. Injury to the UCL was first described as an occupational hazard of Scottish gamekeepers, who damaged their thumbs by a repeated maneuver involving twisting the necks of hares. Skiing is now the most common cause of acute and chronic injury to the UCL. Skier’s thumb is the most common upper extremity injury in skiing and results from interference with release of the pole at the moment of impact during a fall. MCP rupture occurs 10 times more often than radial collateral ligament injury. The mechanism of injury is forced radial deviation (abduction), and the subsequent tear usually occurs at the insertion into the proximal phalanx. Stener showed that in nearly two thirds of cases of complete UCL rupture, the adductor pollicis becomes interposed between the superficial proximal portion and the deep distal portion of the ligament. Besides the collateral ligament injury, associated injuries of the dorsal capsule and volar plate are common.

Clinical Features. Physical examination reveals swelling and localized tenderness over the ulnar border of the joint and weakness of pinch. Complete and partial ruptures usually can be differentiated by clinical examination. Valgus stress testing of the UCLs is required and should be performed with the joint in full extension and in 30 degrees of flexion to avoid the stabilizing effect of the volar plate. If the examination elicits pain and guarding, the test should be done after median and radial nerve block at the wrist or with use of local infiltration anesthesia. More than 35 degrees of joint laxity or 15 degrees of laxity beyond that present in the uninjured thumb is consistent with complete UCL rupture. Routine radiographs should be obtained before the joint is stressed and may reveal a bony avulsion from the insertion of the UCL into the proximal phalanx or an associated condylar fracture. Radiographic findings of proximal phalanx volar subluxation and radial deviation may indicate complete UCL rupture. Because of the difficulty in diagnosing complete rupture, it is commonly misdiagnosed as a simple sprain in the ED, potentially resulting in chronic disability.

Management. Acute partial ruptures of the UCL can be treated effectively with a 4-week period of immobilization in a thumb spica cast; full recovery is the rule. Complete ligament tears require surgical repair because a high percentage are associated with soft tissue interposition from the adductor aponeurosis (Stener’s lesion), with limited predicted healing potential. Anatomic repair within 3 weeks of injury achieves good or excellent results in 90% of affected patients. Long-term complications include chronic pain and instability with the loss of pinch strength, which may necessitate arthrodesis.

Radial Collateral Ligament Injuries

Radial collateral ligament injuries of the MCP joint of the thumb are less common but equally debilitating. The usual mechanism is forced adduction with or without hyperextension. Diagnosis and treatment generally are similar to those for UCL injuries. There have been isolated case reports of a Stener-like lesion on the radial side, with some authors advocating for the role of surgical repair.

Injuries to the Carpometacarpal Joint of the Thumb

Injuries of the volar ligament of the thumb CMC joint, similar to those of other joints of the hand, may be complete or partial. Complete rupture permits the entire thumb metacarpal to dislocate dorsally. Controversy exists regarding the ligament most responsible for stability of the thumb CMC joint, although most recent evidence implicates the dorsoradial ligament in dislocations at this joint. These dislocations are reduced easily but are unstable after reduction. Initial management consists of ice, analgesia, limb elevation, and application of a thumb spica splint. The patient should be promptly referred to a hand surgeon for possible operative repair of the ligament. If the capsule is allowed to heal with imperfect metacarpal reduction, joint instability may result, with progressive degenerative changes leading to chronic pain.

Tendon Injuries

Tendon injuries may involve one or more of the extensor or flexor tendons in the hand and encompass a spectrum of abnormalities, ranging from simple stretching of the fibers to complete tendon rupture with or without an associated avulsion fracture. The most common mechanisms of injury of tendons are lacerations, avulsions, and crush injuries. In a normal resting position, the fingers are flexed, with the little finger having the greatest degree of flexion and the index finger having the least. In the resting hand, a finger with a greater or lesser degree of flexion than that of the opposite hand often indicates a tendon injury. This observation may be especially useful in an uncooperative or pediatric patient. If the patient can move a joint, but active flexion or extension is limited
or painful, a partial tendon laceration may be present. To assess the tendons adequately, motion should be tested against resistance. This testing may cause a partially ruptured tendon to rupture but identifies a lesion that needs surgical repair. The tendon should be placed in maximal stretch before testing to provide for the greatest strength during contraction. As a general rule, extensor injury causes greater impairment of motion than a similar flexor injury. Vessels and nerves travel closely with flexor tendons, particularly in the fingers. Damage to one of these structures is likely to be associated with damage to the other two.

The position the hand was in when the injury occurred is important. When trauma occurs while the hand is held in flexion, the flexor tendons may be transected, and the distal tendon stump would retract distal to the overlying skin wound. If the hand is in the extended position, however, the tendon stumps would lie at the wound edges. When the tendons are injured by a direct blow to the hand or the fingers, the closed injury may hide significant tissue damage. Partial tendon lacerations may be associated with small surface wounds. To help exclude injury, wounds and visible tendon edges. When the tendons are injured by a direct blow or painful, a partial tendon laceration may be present. To assess the tendons adequately, motion should be tested against resistance. This testing may cause a partially ruptured tendon to rupture but identifies a lesion that needs surgical repair. The tendon should be placed in maximal stretch before testing to provide for the greatest strength during contraction. As a general rule, extensor injury causes greater impairment of motion than a similar flexor injury. Vessels and nerves travel closely with flexor tendons, particularly in the fingers. Damage to one of these structures is likely to be associated with damage to the other two.

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**Extensor Tendon Injuries**

The most common site of tendon injury is the extensors over the dorsum of the hand. The extensors are predisposed to laceration because of their superficial location on the dorsum of the hand and the minimal amount of subcutaneous tissue between the tendon and overlying skin. This anatomic arrangement also predisposes the extensor mechanism to more complex tendon injuries, including abrasion, crush, and avulsion. Because the extensor tendons are not constrained in tight fibro-osseous canals except in the wrist, they also are easily located and repaired.

Injuries to the extensor tendons have been grouped into anatomic zones for easy understanding and classification. Different systems for assigning zones have been described, but the most widely accepted is that of Verdan (Fig. 50-46). This system defines eight zones, from zone I at the DIP joint level to zone VIII at the distal forearm level. The use of zones is convenient for assessing injury patterns, repair techniques, and rehabilitation.

**Zone I Injuries**

Pathophysiology. Zone I is the area over the distal phalanx and DIP joint. In this region, the conjoint extensor tendon is well defined and dorsally positioned. Injuries that occur here disrupt the terminal extensor tendon; they may be open or closed and may occur with or without a fracture. Complete laceration of the conjoint tendon results in a flexed posture of approximately 40 degrees at the DIP joint. Partial transaction results in a lesser extension lag and a decrease in the strength of extension against resistance from a flexed position. The extension lag may increase if the partial injury is not treated appropriately. For this reason, exploration of dorsal lacerations near the DIP joint is important.

**Mallet finger** is the most common injury in zone I and refers to a closed disruption of the distal extensor apparatus. As a result of loss of extensor tendon continuity to the distal phalanx, there is a flexion deformity of the DIP joint. The injury can be seen in any finger but is most common in the long, ring, and little fingers. Overall, mallet finger represents the most common tendon injury in the hand seen in athletes. The mechanism of injury often is sudden forceful flexion of an extended finger when an object, such as a ball, strikes the tip of the finger. This mechanism is commonly encountered in athletes and often is described as “jamming” the finger. Other mechanisms include hyperextension with axial compression and direct crush injury at the DIP joint. Four types of injury patterns are recognized, with type I injuries being the most common (Fig. 50-47 and Box 50-2). Fracture fragments of

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**Figure 50-47.** Mallet finger occurs with loss of extensor function to the distal phalanx. This may be caused by a tear of the tendon itself or an avulsion fracture of the dorsal base of the distal phalanx.

**Box 50-2 Classification of Mallet Fingers (Doyle)**

<table>
<thead>
<tr>
<th>Type I</th>
<th>Closed tendon rupture, with or without small dorsal avulsion fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type II</td>
<td>Open tendon laceration</td>
</tr>
<tr>
<td>Type III</td>
<td>Open tendon injury with skin and subcutaneous tissue loss</td>
</tr>
<tr>
<td>Type IV</td>
<td>Mallet fracture</td>
</tr>
<tr>
<td>A. Transepiphyseal plate fracture in children</td>
<td></td>
</tr>
<tr>
<td>B. Hyperflexion injury with fracture of articular surface of 20 to 50%</td>
<td></td>
</tr>
<tr>
<td>C. Hyperextension injury with fracture of the articular surface &gt;50% and with early or late volar subluxation of distal phalanx</td>
<td></td>
</tr>
</tbody>
</table>

variable size are seen in one fourth to one third of cases (Fig. 50-48). Small avulsion fractures usually are the result of hyperflexion injuries, whereas large fracture fragments usually result from a hyperextension mechanism.62

**Clinical Features.** In the acute injury, clinical findings include swelling, pain, and tenderness over the DIP joint. The distal phalanx is flexed because of the unopposed action of the FDP. There is usually complete passive but incomplete active extension at the DIP joint. Although the diagnosis is easily made, the patient often seeks treatment late because the functional disability is not great.

**Management.** Although various treatment protocols have been proposed, splinting of the IP joint for 6 to 8 weeks has yielded good results while minimizing morbidity in a majority of patients. The primary goal of treatment is the maintenance of continuous DIP joint extension until tendon healing occurs. Treatment of closed (type I) injuries is nonoperative. Immobilization can be accomplished with either a volar or a dorsal splint made from a variety of materials, including aluminum and plastic (Fig. 50-49). The DIP joint is immobilized in slight hyperextension for 6 to 8 weeks, but the PIP and MCP joints are allowed to move freely.21 An excessive degree of hyperextension should be avoided because this can lead to skin necrosis on the dorsal surface of the DIP joint.63

Open zone I injuries that divide the extensor tendon (mallet finger types II and III) are treated by suturing the cut ends (Fig. 50-50). Partial and complete lacerations are repaired with either a roll suture or figure-of-eight stitch with 5-0 nonabsorbable sutures. This repair should be followed by continuous splinting of the DIP joint in full extension for a minimum of 6 weeks.60

**Prognosis.** More than 80% of patients who receive conservative treatment for mallet finger report successful outcomes; however, most patients do not regain full mobility at the DIP joint.60 Possible delayed complications include dorsal deformity, cold intolerance, pain, and the so-called swan neck deformity (Fig. 50-51). This abnormality develops when the lateral bands displace proximally and dorsally, resulting in increased extension forces on the PIP joint. Secondarily, the extensor lag at the DIP joint increases because the force of the FDP tendon is unopposed. The swan neck deformity is not seen acutely unless the injured finger has a normally hyperextended PIP joint. Classically, this deformity occurs as a complication of a chronic untreated mallet finger.60
Zone II Injuries. Zone II is the area over the middle phalanx. As the lateral bands blend dorsally to form the conjoint tendon, they are thin and oriented around the dorsal half of the middle phalanx. Injuries here usually are the result of a simple laceration, which seldom transects all of the dorsal apparatus. Examination reveals a typical mallet deformity. The treatment is identical to that for open zone I injuries.

Zone III Injuries

Pathophysiology. Zone III is the area over the PIP joint. The central tendon is the most commonly injured structure in this zone; such injuries are the second most common closed tendon injury in athletes. The mechanisms for closed rupture include forced flexion of an actively extended finger, a direct blow to the dorsum of the PIP joint, and hyperextension with volar dislocation of the PIP joint. It often results from a “jamming” injury. Lacerations that occur just distal to the PIP joint also may divide the central tendon and readily extend into the joint. Wounds are carefully explored to define the status of the PIP joint capsule.

Disruption of the central tendon causes an imbalance in the extensor mechanism. The FDS is now unopposed and flexes the PIP joint. The lateral bands displace volarly to the axis of the PIP joint and become flexors of the joint. In addition, the extensor hood retracts proximally, causing extension of the MCP and DIP joints. The resulting tendon imbalance leads to the so-called boutonnieré (buttonhole) deformity, with flexion of the PIP joint and hyperextension of the DIP and MP joints (Fig. 50-52). Although open injuries of the central tendon may cause an acute boutonnieré deformity, this usually is delayed several weeks after a closed athletic injury.

Clinical Features. Early diagnosis of a closed central tendon rupture or avulsion is difficult before the boutonnieré deformity has developed. The patient typically has a history of trauma to the involved digit and a painful, swollen PIP joint. The finger is held in slight flexion at the PIP joint and slight extension at the DIP joint. Rupture of the central tendon may be differentiated from the more common injury to the collateral ligament by the location of the maximal area of tenderness on the dorsum rather than on the sides of the joint, and by the patient’s inability to extend the PIP joint actively. PIP joint extension can be tested by having the patient attempt to extend the fingers against slight resistance with the hand flat on the table and the PIP joint flexed 90 degrees over an edge of a table (Elson’s test). A positive Elson’s test result, indicative of rupture of the central tendon slip, occurs when the DIP joint is held in fixed extension or hyperextension, with the absence of PIP joint extension. During the acute phase of an injury, a digital block may be necessary to facilitate performance of the Elson test. The radiographic appearance of a central tendon rupture typically is normal but may be diagnostic if an avulsion fracture of the volar base of the middle phalanx is visualized on the lateral view.

Management. Patients with suspected closed central tendon injuries should be managed with splinting of the PIP joint in full extension for 5 to 6 weeks. Only the PIP joint should be immobilized, and passive and active DIP joint flexion is encouraged from the outset. Operative repair may be required for an acute closed boutonnieré injury associated with a displaced avulsion fracture and injury with volar PIP joint dislocation. Early referral to a hand surgeon is advised.

When an acute boutonnieré deformity is caused by an open injury, exploration of the central slip is mandatory and a hand surgeon should be consulted immediately. Primary repair of the tendon and Kirschner wire fixation of the PIP joint often are performed. If the joint capsule has been violated, the joint should be thoroughly debrided and irrigated, and the use of prophylactic antibiotics is recommended.

Zone IV Injuries. Zone IV includes the area over the proximal phalanx. The clinical findings are similar to those with zone III injury but are less severe because the PIP joint and lateral bands are intact. The resulting injury usually is partial, and the tendon ends usually do not retract appreciably. These injuries are treated with primary or delayed primary repair and appropriate splinting for 3 to 6 weeks. Simple injuries in this zone can be well approximated with 5-0 nonabsorbable sutures with buried knots. Immobilization should be done with maintenance of the wrist in extension and the MCP joints in approximately 15 degrees of...
Flexor Tendon Injuries

Pathophysiology. Flexor tendon injuries are not as common as injuries to the extensor complex and often have a subtle clinical presentation. The most common mechanism of injury is laceration, but closed traumatic disruption also may occur. FDP avulsion is the third most common tendon rupture in the hand in athletes. This injury usually is sports-related and involves a hyperextension force applied to an actively flexing digit; the classic example is that of an injured digit in a football player who grabs the clothing of an opponent who is breaking free from a tackle. Most of these injuries involve the ring finger, possibly because the ring finger becomes the most prominent finger with the fingers held in a partially flexed position. Because of the closed nature of these injuries, the patient may not seek immediate care, or the condition initially may be misdiagnosed.

Clinical Features. Careful assessment is necessary to diagnose flexor tendon disruption and associated neurovascular injury. With the normal hand at rest, there is a cascade of flexion of the digits, beginning with less flexion at the index finger and progressing to more flexion toward the little finger. An injury to a flexor tendon may be evident if the involved finger does not assume a naturally flexed position. Complete disruption of the profundus tendon results in an extended position of the DIP joint as a result of unopposed extensor forces. If the FDS is completely severed, or a partial tendon injury has occurred, the digit rests in less flexion than normal. An abnormal posture of the injured digit may suggest a flexor tendon injury; this usually is confirmed by a functional examination. The FDP and the FDS should be tested separately as previously described. This examination requires careful observation: The patient may flex the distal tip with an intact profundus, but an injury to the FDS precludes flexion at the PIP joint. Disruption of the FDP tendon leads to loss of flexion at the DIP joint, instability in pinch, and loss of grip strength. FDP avulsions can be classified into three types. Type I injuries involve retraction of the avulsed FDP tendon into the palm, damaging the blood supply to the tendon and causing hematoma formation in the process. Because of the damaged vasculature, these injuries should be repaired urgently to prevent ischemic tendon damage. Types II and III injuries cause lesser degrees of retraction of the FDP tendon. Accordingly, these injuries result in less compromise of the tendon’s blood supply and have more favorable outcomes. FDP injuries may be present if the patient complains of subjective weakness or if an abnormal position of the hand is observed at rest. Clinically, injuries are associated with pain and weakness with flexion against resistance. Despite these findings, it may not be possible to arrive at a complete and accurate diagnosis until the wound is surgically explored. The palmaris longus, which is not present in approximately 15% of people, is not a functionally significant wrist flexor. Palmaris longus lacerations have tremendous diagnostic significance, however, because most of these injuries (80 to 90%) are associated with concomitant partial or complete median nerve lacerations. For this reason, all patients with palmaris longus lacerations should be assumed to have median nerve laceration until such injury has been ruled out clinically or by direct examination. Management. Flexor tendon repairs require the expertise of a hand surgeon and generally are not repaired by emergency physicians. Immediate or delayed primary repair is now advocated for most acute flexor tendon injuries, including avulsions of the FDP and injuries involving the so-called “no man’s land,” which extends from the distal palmar crease to the midportion of the middle phalanx. The term “no man’s land” refers to the high frequency of tendon adhesion after injury in this area. The advantages of primary repair with surgical reaproximation over secondary grafting for treatment of acute injuries have been well described in the literature. Emergent repair of lacerated flexor tendons is indicated in the setting of diminished circulation to the digit requiring vascular repair. Otherwise, early definitive repair can be undertaken within days of the injury. Secondary repair of flexor tendons may be performed 4 weeks after injury, but repair is considered late after that. In general, the results of primary, delayed primary, and early secondary repair are approximately equal. Treatment of partial flexor tendon lacerations is controversial, but referral to a hand surgeon for further exploration and possible repair is prudent.

If a hand surgeon is not immediately available, open wounds should be copiously irrigated and closed with 5-0 nylon and the hand splinted with the wrist in 30 degrees of flexion—the MCP joints flexed approximately 70 degrees and the IP joint flexed 10 to 15 degrees. This flexion ensures that no further damage occurs to the tendon and that the tendon will not contract further on movement. The patient also should receive tetanus immunization as indicated, and most authorities recommend empirical use of broad-spectrum antibiotics. Most closed tendon injuries require referral to a hand surgeon because of the risk of long-term disability.
Complications. With optimal management, most patients with flexor tendon injuries have good to excellent outcomes. With injuries involving the no man’s land, results may be poor, and tendon grafting occasionally is required. Overall, adhesions remain the most significant problem after operative repair. Other complications include triggering, bowstringing, and intratendinous epidermoid cyst formation.

Mutilating Injuries

Mutilating injuries to the hand are encountered frequently in the ED. These are severe multisurgical injuries that destroy the anatomy and functional integrity of the hand. Initial evaluation should focus on preservation of vital structures, analgesics, early consultation, wound care with débridement of devitalized tissue, and antibiotics. Evolving over recent years is a more aggressive push with respect to procedure timing, whether a single-stage or multistage strategy is used. Successful long-term clinical and socioeconomic outcomes have brought focused attention on procedure timing. The concept of early primary reconstruction with fast rehabilitation should be pursued based on case profile.

One such type is snowblower-, wood chipper–, or lawnmower–associated hand injuries, which can result in substantial deformity and disability. Snowblower injuries typically occur in clusters and are responsible for approximately 1000 amputations and 5000 ED visits annually. The dominant hand is involved approximately 68% of the time, with middle and index fingers most commonly injured. Phalangeal fractures are the most common type of injury. Snowblower injuries often are managed as open fractures with intravenous antibiotics, irrigation, and débridement and repair of bone, soft tissue, and nail bed structures. Irreparable devascularization currently is considered the only absolute indication for immediate or early digital amputation after injury. The concept and techniques for reimplantation and revascularization in mutilating injuries in children are similar to those in adults.

Fingertip Injuries

Fingertip injuries may involve any structures distal to the DIP joint, including the skin, volar pulp tissue, distal phalanx, nail, nail bed, and related structures. These are among the most common injuries of the upper extremity and, although usually minor, may have significant long-term consequences. The goals of management are to maintain finger length and to achieve good tissue coverage, near-normal sensibility, and early functional recovery.

Fingertip Amputations

Classification. Fingertip amputations are the most common type of amputation of the upper extremity. In zone I injuries (Fig. 50-53), the proximal two thirds of the nail bed is preserved. In zone II injuries, bone is exposed, and in zone III injuries, the entire nail bed is lost. Radiographic studies are indicated if bony avulsion injury or fracture cannot be excluded. Most of these fingertip injuries can be managed on an outpatient basis.

Management. Treatment of distal fingertip injuries is controversial; consequently, management should be individualized, and few guidelines are available. In general, most hand surgeons try to maintain length of the thumb by whatever means possible. The index finger is considered next before the other fingers. An intact pulp-to-pulp pinch mechanism is the principal goal. Other factors to consider include the patient’s age, health, occupation, and handedness.

In most fingertip amputations distal to the DIP joint, adequate care can be provided with conservative wound management. The simplest and often best method for managing a fingertip amputation is allowing the wound to heal by secondary intention. This method generally is effective and produces good results if the wound is less than 1 cm. Large dorsal wounds also heal well by this method. It is the treatment of choice in childhood fingertip amputations, particularly when no bone is exposed. In cases in which a small protuberance of phalangeal bone (extending no more than 0.5 cm) is exposed, it may be trimmed back with a rongeur to just below skin level and the wound allowed to heal by secondary intention; if the bone is left exposed without soft tissue coverage, the patient will need an operative procedure. In most cases the wound heals through a process of granulation, wound contracture, and reepithelialization within a few weeks. Initial management should include careful and meticulous wound cleansing, a nonadherent dressing, appropriate tetanus prophylaxis, and splinting to protect the tip. Amputations that involve the distal phalanx usually are treated as contaminated open fractures with an initial intravenous dose of a cephalosporin followed by an oral course. Patients should have appropriate follow-up care to ensure adequate healing and recovery.

Management of fingertip injuries involving significant soft tissue (especially volar) or bone loss usually requires the expertise of a hand surgeon. Surgical management may include primary closure, full-thickness or partial-thickness skin grafts, composite grafts, adjacent flaps, regional flaps from the hand, distant flaps, and reimplantation. With most of these operative techniques, repair is best performed as a primary procedure under ideal circumstances or as a delayed procedure when necessary. A flap may be used to cover exposed bone or soft tissue avulsion and to add bulk to the tip. The nail bed tissues should be preserved because the presence of a nail affects the cosmetic result. At least 5 mm of healthy nail bed distal to the lunula is needed for nail adherence. Skin grafting is a common method for treating fingertip amputations with significant avulsed tissue and can provide a functional and anesthetic reconstruction.

Complications. These injuries commonly leave the patient with a painful, cold-intolerant fingertip; this complication has been described after primary closure, coverage with grafts or flaps, and healing by secondary intention. Skin grafting may result in induration, fissuring, and diminished sensibility. Nail deformity is common, particularly with considerable volar loss of tissue.

Acute Nail Bed Injuries

Injuries of the nail bed most commonly result from localized trauma to the nail with subsequent compression of the nail bed. The most common type of injury is simple laceration followed by stellate laceration, crush, and avulsion. The middle and distal thirds of the nail bed are the most common sites of injury, and 50% of these injuries involve fractures of the distal phalanx or tuft. Radiographs are required in most cases to show occult fractures and foreign bodies.

Subungual Hematoma. Subungual hematomas result from crush injury or blunt trauma to the nail bed with bleeding from...
the rich vascular bed. The nail bed is predisposed to injury because it is interposed between the firm nail and the distal phalanx. The injury is manifested by pain and dark red to black discoloration of the nail bed and is classified by the percentage of area beneath the nail that is involved. When the fingertip is unstable or the mechanism of injury suggests a significant distal phalanx fracture, a radiograph should be obtained to identify associated fracture.

Management. Small subungual hematomas do not require drainage; the blood is incorporated into the nail and eventually removed with the free edge. Large (>50% of the nail) hematomas cause significant discomfort and should be removed by nail trephination with a heated paper clip or a hot microcautery unit. Some clinicians recommend a surgical scrub of the finger before perforation of the nail to prevent contamination of the subungual area and the subsequent risk of infection and potential osteomyelitis, but this generally is unnecessary. Anesthesia is not necessary, and pain relief is immediate with decompression. If a significant fracture is present, the digit should be splinted. Although a distal phalangeal fracture with a subungual hematoma is technically an open fracture, such injuries usually heal without problems. Ungual tuft fractures are not associated with osteomyelitis. The risk of infection with an open fracture of the phalanx proper should be considered, and a broad-spectrum antibiotic and close follow-up monitoring are recommended. Otherwise, antibiotics are not necessary. Patients with significant hematomas should be informed that they may lose the nail.

Some authorities recommend nail removal and nail bed repair if the size of the subungual hematoma is greater than 50% of the nail area. Simon and Wolgin attempted to correlate the association between subungual hematoma size, digital phalanx fractures, and occult nail bed lacerations. In their series, patients with a subungual hematoma greater than half the size of the nail had a 60% incidence of nail bed laceration requiring repair, and if an associated fracture of the distal phalanx was present, the incidence was 95%. If more than 50% of the visible portion of the nail is undermined by hematoma, some clinicians recommend removal of the nail, inspection of the nail bed, and repair of injuries. However, several studies have found no notable differences in outcome between nail trephination alone and formal nail bed repair regardless of hematoma size in cases with an intact nail and nail margins. As a result, many authorities now recommend nail removal and repair of the nail bed only if the nail is broken or the nail edges are disrupted.

Nail Bed Lacerations. Lacerations of the nail bed should be repaired to minimize esthetic deformity and the duration of functional impairment. These injuries generally do well after primary repair, but late reconstruction of the nail bed is unpredictable, and usually little improvement is obtained.

Simple and crushing lacerations should be repaired accurately with 5-0 or 6-0 absorbable suture, ideally under loupe magnification. The results with both injuries should be satisfactory in the majority of cases. After the nail bed is accurately approximated, a hole is burned through the nail to allow drainage of blood from the subungual area after the nail is reinserted into the nail fold. The avulsed nail may be sutured in place or secured with tape. A single thickness of nail-shaped Adaptic or other nonadherent gauze may be placed in the nail fold if the nail is unavailable. The replaced nail or gauze is used as a temporary splint to help protect the integrity of the underlying nail bed and maintain the fold for new nail growth and to help prevent synchiae and subsequent nail deformity. Complete nail growth takes 70 to 160 days, but after the injury the growth pattern often is changed.

Nail bed avulsion commonly leaves fragments of nail bed attached to the undersurface of the avulsed nail. In these cases it is advisable to replace the nail as accurately as possible onto the avulsion site. Repair should be done with mattress sutures without attempting to separate the nail from the nail bed. If the tissue is not available and the defect is small, effective healing occurs by secondary intention.

Clipped-Fist Injuries
All human bites should be considered serious in nature and at risk for significant complications. Clipped-fist injuries, also called “fight bites,” are notorious for being the worst human bites. Inadequate initial management leads to significant morbidity. Misleading history, innocuous wound appearance, intoxication and lack of cooperation of the patient leading to inadequate examination, patient reluctance to admit the nature of the injury, delayed presentation, and inadequate exploration all may lead to mismanagement. Clipped-fist injuries are associated with the highest incidence of complications of any closed-fist injury and of any type of bite wound.

Clinical Features
The classic injury is a bite wound over the third MCP joint, but injury can occur over any joint. Soft tissue injury is apparent with possible extensor tendon injury and violation of the joint capsule. When the fist is subsequently opened, the bacterial inoculum is dragged with the extensor tendon and soft tissue proximally into the dorsum of the hand. Presentation may be acute or delayed. Swelling, limited range of motion, erythema, and pain out of proportion to the apparent severity of injury are typical findings. Pain is more severe with range of motion.

Management
Aggressive management is indicated with these injuries. Immediate consultation with a hand surgeon is advised. Analgesics, irrigation, tetanus, cultures, intravenous antibiotics; appropriate wound care, elevation of the affected limb, and hospital admission should be considered for all patients. Foreign bodies are excluded with radiologic studies and possibly exploration. Tendon injuries are ruled out with careful exploration. The hand should be splinted in the position of function. Pathogens usually are polymicrobial, with Staphylococcus aureus, streptococci, and anaerobes the predominant species. Multiple-drug regimens are recommended; amoxicillin-clavulanic acid or penicillin with a first-generation cephalosporin is commonly used.

High-Pressure Injection Injuries
Epidemiology
High-pressure injection injuries to the hand are uncommon, and most are occupation related. The usual cause is an accident involving industrial equipment, with machinery such as grease guns, spray guns, and diesel engine injectors accounting for most of these injuries. A wide variety of materials, including paint, paint thinner, grease, oil, hydraulic fluid, plastic, wax, water, and semi-fluid cement, have been reported to be injected. In general, substances that are highly viscous (e.g., grease) require higher forces to produce injury than do paint, oil, and solvents. The high pressures involved are sufficient to penetrate skin from a distance, and contact of the device with the hand is not a prerequisite for injury to occur. High-pressure injection injuries have been associated with amputation rates as high as 48%. Recent data suggest amputation rates of 30%, which may be a result of higher vigilance and early recognition of tissue injury. Early recognition and intervention are essential. Even with early intervention, the injury leads to significant impairment, with delays in debridement associated with higher rates of amputation.
Pathophysiology

Patient characteristics and injury circumstances often are similar in high-pressure injection injuries. The patient generally has a history of coming into close proximity to the jet stream during cleaning of the nozzle or testing or operation of the equipment. The patient usually is an inexperienced worker, and the nondominant hand most commonly is involved, with the index finger the most common site.

Tissue injury from high-pressure injection generally depends on physical, chemical, and biologic factors. Of particular importance are the type, amount, and velocity of injected material and the anatomic location of the injury. The most important factor is the type of material injected, which determines the likely tissue inflammatory response and the resulting fibrosis that develops during healing. Paint and paint thinner produce a large, early inflammatory response, resulting in a high percentage of amputations. By contrast, grease injuries cause a small inflammatory response and carry a lower amputation rate but are associated with oleogranuloma and fistula formation, scarring, and loss of digit function. The amount of material injected into the confined space of the digits or palm determines the degree of mechanical distention and the potential for vascular compromise. The velocity of the injected material and the site of tissue penetration determine dispersion, which may include the digit, hand, and forearm. Injection injuries at distal sites (e.g., tips of fingers) carry a worse prognosis than proximal injections.

Clinical Features

The patient who seeks treatment early after injury may have minimal symptoms with either an innocuous entrance wound or no visible break in the skin. Fusiform swelling resulting from mechanical distention of the tissue by the injectant may not be apparent. Several hours later, the involved digit or palm becomes extremely painful, swollen, and pale because of vascular compromise and tissue necrosis. Careful examination is necessary to document the extent of injury and associated neurovascular function. Radiographs of the involved hand can help determine the spread of material and the amount of débridement necessary, because certain injected materials are radiopaque. In addition, they may reveal subcutaneous emphysema.

Management

Initial ED management includes splinting, elevation of the affected limb, tetanus prophylaxis, analgesia, and broad-spectrum antibiotics. Digital blocks are contraindicated because of the potential for increased tissue pressure, which may aggravate vascular compromise. The keystone in treatment of these injuries is prompt recognition of the severe nature of the injury despite the often innocuous appearance of the wound. Emergent hand surgery consultation is warranted because most cases require early extensive surgical decompression and débridement.

Complications

Early recognition and treatment, including operative débridement and débridement, greatly influence outcome. Early surgical amputation should be considered in cases in which the affected digit is initially cool or poorly perfused. In most other cases, joint stiffness is a late sequela.

Amputations and Ring Avulsion Injuries

Few epidemiologic studies have been done on amputation injuries. Traumatic amputations have been reported to constitute 0.1 to 1% of all hand injuries. Amputation may be complete or partial. Injuries with interconnecting tissue between the distal and the proximal portions are considered incomplete, or partial, amputations. Complete amputations will necessitate replantation, whereas with partial amputations, revascularization is attempted. Traumatic amputations most commonly result from local crush injuries and occur infrequently from a sharp guillotine mechanism. Partial and complete amputations reportedly occur with equal frequency. The former are often related to the use of power saws and lawn mowers.

Ring avulsions include a spectrum of injuries from partial degloving of the skin of a finger to loss of the entire digit and entire length of a flexor tendon. These injuries usually occur when a ring on a finger catches on an object during a fall. In addition to neurologic and arterial injuries, there may be complete disruption of the venous return of the finger. In general, these injuries represent complex management problems, and treatment may range from primary amputation to microvascular repair with replantation and free tissue transfer in addition to local flap, pedicle flap, or graft coverage.

The initial care and treatment for the patient who has had a body part amputated are the same as for any trauma patient. After the initial primary assessment and stabilization of the patient, the injured extremity should be examined carefully with documentation of neurologic, vascular, and musculotendinous function. Subsequent care should be directed toward preservation of the limb and its components. General management goals include the following: (1) provide supportive care, such as control of hemorrhage with direct pressure and elevation; (2) prolong the time that the amputated tissues remain viable; (3) protect wounds from further injury; and (4) arrange expeditious consultation by a surgical subspecialist. With few exceptions, all completely amputated parts should be considered for replantation, and all partially amputated parts should be considered for revascularization.

In complete amputations, the proximal stump and the amputated part should be examined for degree of tissue injury, contamination, and associated injuries. Gross contaminants can be removed by irrigation with normal saline. Local antiseptics, especially hydrogen peroxide or alcohol, should not be used because they may damage viable tissues. The wound should not be manipulated, clamped, tagged, or traumatized further in any way. The stump should be covered with a saline-moistened sterile dressing to prevent further contamination and desiccation, and the limb should be elevated to help reduce edema and control bleeding. The amputated part requires minimal handling and should be cooled as soon as possible. After being wrapped in saline-moistened gauze, the part is sealed in a dry plastic bag, which is placed in ice water. Ice should not come in direct contact with the tissue because this can cause tissue freezing. Amputated parts should not be discarded or sent to the pathology department because even if they cannot be replanted, they may serve as a donor source for skin, bone, or vessel grafts. Radiographs of the amputated part and proximal stump should be obtained. The use of analgesic medications will likely be necessary, and appropriate tetanus prophylaxis can be administered. The use of prophylactic antibiotics is indicated in amputation injuries because significant devitalized tissue often is present. Most authorities recommend empirical coverage for S. aureus with a combination of penicillin G and an antistaphyllococcal antibiotic or first-generation cephalosporin.

Treatment for partial amputations with vascular compromise is the same as that just described. The wound should be cleaned with normal saline irrigation, and the injured part wrapped in a sterile moist dressing and splinted to protect it from further injury. Cold packs are applied to the dressings to prevent warm ischemia.

The time for which an amputated part can survive before replantation has not been determined. As a general rule, the more proximal the amputation, the less ischemia time the amputated
part can tolerate. Attempts to extend viability during ischemia have shown that the most important controllable factor is the temperature of the amputated part. Warm ischemia may be tolerated for 6 to 8 hours; cooling the part to 4°C extends this time to approximately 12 to 24 hours with distal amputations. Successful replantation of digits after 40 hours of warm ischemia has been reported.

The decision of whether to attempt replantation should be made by the surgeon who is responsible for performing the procedure. On occasion, final judgment regarding replantation may be delayed until after microscopic inspection of vessels and nerves has been completed. Patient selection generally is based on the nature and level of the injury and patient age and health-related factors. The classic indications for and contraindications to replantation are listed in Box 50-3. The thumb is needed to preserve the function of opposition, and all such traumatic amputations should be considered for microvascular salvage regardless of the level of amputation or mechanism of injury. Loss of the thumb is equivalent to a 40% loss of function of the hand. Similarly, all amputations should be considered for replantation in children. The classic indications for and contraindications to replantation of digits are listed in Box 50-3. The thumb is needed to preserve the function of opposition, and all such traumatic amputations should be considered for microvascular salvage regardless of the level of amputation or mechanism of injury. Loss of the thumb is equivalent to a 40% loss of function of the hand. Similarly, all amputations in children should be considered for replantation. In replantation of digits amputated distal to the insertion of the FDS to the wrist, assessment of capillary refill, and the use of Allen’s test. Ischemic pain is the most common initial complaint of patients with vascular insufficiency, along with physical manifestations of pallor and gangrene. The presence of a mass, with or without pain and tenderness, is the second most common initial complaint.

Complications

Replanted fingers and hands never regain premorbid function. Replanted and revascularized parts may develop cold intolerance, stiffness, loss of sensation, pain, malunions, and nonunions. Even successful replantations may require repeated operative procedures and involve prolonged disability. Necrosis is an obvious sign of failure.

Vascular Injuries

Significant vascular disorders of the hand are uncommon compared with other problems of the hand. The vascular supply to the hand and digits is duplicated so that isolated arterial injuries to either side seldom result in ischemia. Lacerations of the arteries of the hand may stop bleeding by the time the patient is evaluated; in these situations, a history of pulsatile bleeding is highly suggestive of an arterial injury. Although most arterial injuries are the result of penetrating trauma, blunt trauma to the hand occasionally can result in arterial thrombosis or a false aneurysm. In addition, associated injuries should not be overlooked. Because digital nerves invariably cross with and are superficial to the digital artery, an arterial lesion should raise the possibility of an accompanying nerve injury.

Circulatory status is assessed as previously described by observation for cyanosis or pallor, palpation of radial or ulnar pulses at the wrist, assessment of capillary refill, and the use of Allen’s test. Ischemic pain is the most common initial complaint of patients with vascular insufficiency, along with physical manifestations of pallor and gangrene. The presence of a mass, with or without pain and tenderness, is the second most common initial complaint.

Management

Lacerations or amputations of the upper limb rarely cause life-threatening hemorrhage. Even a major vessel that is completely transected usually retracts, constricts, and clots. Major vessels often continue to bleed briskly, however, from partial transections with life-threatening hemorrhage. Usually hemorrhage can be adequately controlled with direct pressure and limb elevation. If necessary, a proximally placed blood pressure cuff inflated to 30 mm Hg above systolic pressure can be used for short periods (<30 minutes) to control severe bleeding. Vascular clamps and hemostats should not be used in the ED to control bleeding in the hand because of the danger of inadvertently crushing nerves and tendons. Lacerated arteries should be repaired if symptoms of ischemia or an associated nerve injury are present. Arterial repair is not mandatory in isolated arterial injuries with good distal vascularity because there is a high rate of thrombosis after reanastomosis. If the decision is made not to repair a lacerated artery, both stumps should be ligated to prevent further bleeding. Palmar arch lacerations may be difficult to visualize in the ED and usually require surgical exploration to control bleeding.

Compartment Syndrome in the Hand

A compartment syndrome develops when elevated pressure within a closed fascial space reduces perfusion to the point of muscle and nerve dysfunction. In the hand, 10 compartments are evident on cross section through the palm (Fig. 50-54). In addition, the
fingers are compartmentalized by fascia and skin at flexor creases. Because these compartments are not interconnected, each additional compartment should be surgically decompressed if muscle ischemia is suspected.\textsuperscript{13,95}

**Nerve Injuries**

Nerve injuries may result from a direct blow, puncture or laceration, crush injury, injection injury, or amputation. These injuries are divided into three main groups: neurapraxia, axonotmesis, and neurotmesis. In neurapraxia, there is loss of function of the nerve, but the axon, Schwann’s sheath, and endoneurium remain intact. Recovery in these cases is usually complete within days. In axonotmesis, the axon is severed within an intact endoneurial tube. The distal axon degenerates and is absorbed after disruption. The proximal portion of the severed axonal stump can regenerate along the intact endoneurial tube at a rate of approximately 1 to 3 mm/day with ultimate return of function. Neurotmesis refers to complete disruption of all nerve elements. Regrowth of the proximal axonal endings does not occur along the endoneurial tubes, unless the severed nerve endings are reapproximated.\textsuperscript{96}

Peripheral nerve injuries are diagnosed by physical examination showing loss of motor or sensory function. Specific nerves at risk should be examined as previously outlined. Injury most commonly involves one of the digital nerves but also may be localized to the median, radial, or ulnar nerve.

**Management**

Identification of the injury and appropriate referral are important aspects in the initial management of patients with nerve injuries in the hand. Patients with closed nerve injuries not associated with compartment syndromes should be referred to a hand specialist for serial examinations. All digits that have lost function as a result of a nerve injury should be splinted to prevent further inadvertent injury. If function does not return within 3 weeks, electromyograms and nerve conduction studies can help differentiate neurotmesis from axonotmesis and determine the need for surgical exploration.\textsuperscript{96}

Lacerated nerves require reapproximation by hand surgeons. In general, all motor branches of the ulnar and median nerves should be repaired. In addition, digital nerve injuries proximal to the DIP crease on the radial aspect of the index finger, the ulnar aspect of the little finger, and both sides of the thumb should be considered for repair.\textsuperscript{97} Clean, single-nerve lacerations should be repaired primarily when feasible. Complex nerve injuries may involve wound contamination or extensive tissue damage and usually are managed by delayed repair to allow for improved soft tissue conditions. Although the functional recovery is never complete, a good outcome can result from primary and delayed repair. In general, sensory recovery returns more often than does motor function.

**Complications**

Complications of nerve injuries include motor and sensory loss, atrophy from denervation, chronic paresthesias, regrowth of painful neuromas, and sympathetic dystrophy.

**Infections of the Hand**

The unique anatomic structures of the hand affect the nature of infections in this region of the body. In general, hand infections can be divided into infections involving the skin, subcutaneous tissues, fascial spaces, tendon, joint, and bone. Fibrous compartments of the distal fingertips contain the spread of infection, whereas flexor tendon sheaths allow infection to travel considerable distances along the lengths of the tendons from the original site. Infections in the deep spaces of the palm usually manifest on the dorsal surface of the hand.

**Paronychia**

**Pathophysiology.** A paronychia is a localized superficial infection or abscess involving the lateral nail fold. It is the most common infection in the hand and is thought to be caused by frequent trauma to the delicate skin around the fingernail and cuticle. Clinically, swelling and tenderness of the soft tissue along one or both sides of the lateral nail fold are evident. A paronychia begins as a cellulitis, but a frank abscess may form, and occasional extension to the overlying proximal nail (termed an eponychia) may be seen. \textit{S. aureus} is the most common isolate, followed by streptococci.\textsuperscript{98} Paronychias in children often are caused by anaerobes, presumably because of finger sucking and nail biting common in this age group.\textsuperscript{99} Atypical mycobacteria, \textit{Candida albicans}, and other fungi should be considered as causative agents in chronic cases unresponsive to standard treatment.\textsuperscript{100}

**Management.** In the early cellulitis phase, management consists of frequent warm soaks, elevation of the affected limb, and administration of an oral antistaphylococcal antibiotic, such as dicloxacillin or cephalaxin. When the area becomes fluctuant, drainage is necessary and usually is curative. Adequate drainage often can be obtained by lifting the skin edge off the nail to allow the pus to drain (Fig. 50-55). This can be accomplished without anesthesia in selected patients, but drainage for more extensive lesions is best carried out under digital block anesthesia. After the eponychium has been softened by soaking, a No. 11 blade scalpel or an 18-gauge needle may be advanced parallel to the nail and under the eponychium to the site of maximal swelling.\textsuperscript{98} If the infection is more extensive, the lateral one fourth of the nail may be bluntly dissected from the underlying nail bed and germinal matrix, and the lateral nail plate excised. After the cavity is irrigated, a small piece of packing gauze may be slipped under the eponychium for 24 hours to provide continual drainage. Cultures are not indicated. Antibiotics are commonly prescribed, although this is not necessary if drainage is complete or if the surrounding area of cellulitis is minimal. Most paronychias resolve in 5 to 10 days, and patients are advised to obtain primary care follow-up evaluation. A well-known complication of even a properly drained paronychia is osteomyelitis of the distal phalanx. Patients with a chronic,

![Figure 50-55. Drainage of paronychia. A, Eponychial fold is elevated from the nail for a simple paronychia. B, Lateral nail is removed if pus tracks under it. A small eponychial incision may be necessary. C, Proximal nail is removed if pus tracks under it. Two incisions are needed to remove the proximal nail. (From Moran GJ, Talan DA: Hand infections. Emerg Med Clin North Am 11:601, 1993.](image-url)
indolent infection of the perionychium seldom respond to ED intervention. These patients should be referred to a dermatologist or hand surgeon because of the prolonged treatment required.

Felon

Pathophysiology. A felon is an infection of the pulp of the distal finger or thumb. It differs from other types of subcutaneous abscesses because of the presence of multiple vertical septa that divide the pulp into small fascial compartments. The usual cause is penetrating trauma with secondary bacterial invasion. The most common pathogen is S. aureus, although gram-negative organisms and polymicrobial infections also have been described.100 Although the septa may facilitate an infection in the pulp and inhibit drainage after incomplete surgical decompression, they provide a barrier that protects the joint space and the tendon sheath by limiting the proximal spread of infection. Clinically, a felon begins as an area of cellulitis and inflammation that progresses rapidly to severe throbbing, pain, swelling, and increased pressure in the distal pulp space.

Management. Traditional management of felons emphasizes the need for early and complete incision through the septa to provide adequate drainage and to relieve pressure in septal compartments. Most felons can be drained by a single lateral incision.100 The incision should be made along the ulnar aspect of the index, middle, and ring fingers and the radial aspects of the thumb and little finger, avoiding pincher surfaces. The incision is begun approximately 0.5 cm distal to the DIP joint crease and dorsal to the neurovascular bundle of the fingertip. The incision is extended to the free edge of the nail (Fig. 50-56). The wound should be irrigated and loosely packed with gauze, and the affected finger splinted. The packing is removed in 48 to 72 hours, and the wound is left to close secondarily. Most felons are treated empirically with an antistaphylococcal oral antibiotic for at least 5 days pending culture results. Some authorities recommend draining this abscess where it “points,” with use of a volar midline incision that does not cross the distal flexion crease.101

Complications. If untreated, the expanding abscess can extend toward the phalanx, producing an osteitis or osteomyelitis, or toward the skin, resulting in necrosis and formation of a sinus tract on the palmar surface of the digital pulp. Other complications include soft tissue and bony tuft necrosis, osteomyelitis, septic arthritis of the DIP joint, and flexor tenosynovitis from proximal extension. The lateral incision used to drain felon commonly leaves unstable finger pads or may result in painful neuromas or anesthetic fingertips. “Fishmouth” incisions may destroy the blood supply to the fingertip.100 Longitudinal midline incisions on the volar surface may leave scars over an important area for sensation but do not have the other disadvantages of lateral incisions. Any incision that is made too deeply and proximally can injure the flexor tendon sheath, initiating a tenosynovitis.

Herpetic Whitlow

Epidemiology and Pathophysiology. Herpetic whitlow is a self-limited herpes simplex viral infection of the distal finger. It is the most common viral infection of the hand. Infection by human herpes simplex virus type 1 or 2 is clinically indistinguishable.102 Direct inoculation of the virus into an open wound or broken skin is the usual mechanism of primary infection. Herpetic whitlow commonly is found in adult women with genital herpes and children with coexistent herpetic gingivostomatitis. Health care workers are at increased risk for development of this infection as an occupational hazard secondary to exposure to orotracheal secretions; however, a review of herpes infection in the hand found that only 14% of adult cases occur in health care workers.103 The overall incidence has decreased, probably as a result of heightened awareness of the condition and strict infection control precautions.

Clinical Features. The infection usually involves a single finger and begins with localized pain, pruritus, and swelling, followed by the appearance of clear vesicles. Systemic symptoms usually are absent; however, secondary infection of the vesicles can occur. More typically, the vesicles coalesce over 2 weeks to form an ulcer, which may develop a hemorrhagic base. At this stage, it may be difficult to distinguish herpes simplex infection of the hand from more common bacterial infections, such as felon or paronychia. The distinction is important because drainage of the herpetic lesions is contraindicated and may lead to viral dissemination and secondary bacterial infection. A careful history is important to determine risk of a possible herpetic cause. On examination, tenderness is present but is noticeably less than that typical for bacterial infections. In addition, the pulp space remains soft and does not become tense, as it does in a bacterial felon.104

Diagnostic Strategies. The diagnosis usually is made clinically on the basis of the appearance of the lesion and the history of recurrence or potential sources of inoculation. The diagnosis may be confirmed by polymerase chain reaction (PCR), viral culture, or a Tzanck smear showing multinucleated giant cells in a scraping taken from the base of an unroofed vesicle.102,105

Management. Herpetic whitlow usually resolves spontaneously in 3 to 4 weeks, although recurrence is common, occurring in up to 20% of cases. The main goals of treatment are to prevent oral inoculation or transmission of the infection and to provide symptomatic relief. The involved digit should be kept covered with a dry dressing. Oral acyclovir has a role in treatment for immunocompromised patients and patients with frequently recurring infections, but its role in immunocompetent patients is less clear.105 Topical acyclovir has not been shown to be effective in either the treatment of or the prophylaxis for this disorder.

Tenosynovitis

Pathophysiology. Acute synovial space infections in the hand usually involve the flexor tendon sheaths and the radial and ulnar bursae. The tendon sheaths are double-walled, with a visceral layer adherent to the tendon and a parietal layer extending from the midpalmar crease to just proximal to the DIP joint. The flexor tendon sheath of the thumb is continuous with the radial bursa of the palm, and the small finger sheath is continuous with the
ulnar palmar bursae. The ulnar bursa surrounds the superficial and deep flexor tendons, and the radial bursa surrounds the flexor pollicis longus. These two bursae communicate in 80% of persons; in most instances, however, the tenosynovial coverings of the index, middle, and ring fingers do not communicate. Infections in the synovial spaces in the hand tend to spread along the course of the flexor tendon sheaths and may spread to the midpalmar, thenar, and lumbrical compartments. Infections usually are caused by penetrating trauma to the sheath, but they occasionally result from hematogenous spread. The most commonly isolated organisms are *S. aureus* and streptococci, followed by gram-negative organisms and enterococci.

Clinical Features. Four cardinal signs of acute flexor tenosynovitis usually are present and help differentiate tenosynovitis from other soft tissue infections in the hand: (1) tenderness along the course of the flexor tendon, (2) symmetrical swelling of the finger, (3) pain on passive extension, and (4) a flexed posture of the finger. All four signs may not be present early in the course of infection. The third sign may be the most important. Early recognition and treatment are essential because elevated pressure within the enclosure of the flexor tendon sheath can occlude the already tenuous circulation to the tendon, resulting in necrosis and proximal spread.

Management. All patients with flexor tenosynovitis require hospital admission and prompt consultation with a hand surgeon to determine whether open drainage or closed tendon sheath irrigation is indicated. In early cases or uncertain diagnoses, the hand should be splinted in a bulky dressing and elevated, and intravenous antibiotics should be initiated. Infections secondary to penetrating trauma should be treated with a penicillinase-resistant antistaphylococcal penicillin or first-generation cephalosporin. Disseminated gonorrhea should be considered in all sexually active persons, especially if a traumatic cause for the infection is not apparent. In such cases, some authorities recommend empirical treatment with ceftriaxone until results of final cultures (including mucosal sites) are available. Surgical treatment is indicated for established cases or when improvement is not evident within 24 hours.

### Deep Space Infections

Anatomy and Pathophysiology. The deep fascial or palmar spaces of the hand include the midpalmar space, the hypothenar space, and the thenar space. Three additional, more superficial spaces of the hand are the dorsal subcutaneous space, the dorsal subaponeurotic space, and the interdigital web space (Fig. 50-57).


Although anatomically distinct from the deep spaces owing to their lack of well-defined anatomic borders, superficial spaces can harbor infections that manifest similarly to deep space infections. The fascial spaces are potential rather than actual spaces in a normal hand. These closed compartments are susceptible to infection from direct penetrating trauma, infection in contiguous compartments, or hematogenous seeding. The most commonly isolated pathogens are *S. aureus*, streptococci, and coliforms.

Clinical Features. The unique anatomic features of the deep fascial spaces lead to characteristic clinical findings when these regions are involved with pyogenic infection. The dorsal subaponeurotic abscess causes swelling and erythema on the dorsum of the hand. Pain with passive movement of the extensor tendons often is present, but it may be difficult to distinguish clinically from simple cellulitis on the dorsum of the hand. Subfascial web space infections commonly result when palmar blisters become secondarily infected. The infection tends to spread dorsally into the interdigital space and produce a characteristic hourglass configuration, or the so-called “collar-button abscess” (Fig. 50-58). Thenar space infections are characterized by pain and swelling of the thenar eminence and the first web space; the thumb is held in abducted and flexed position. In midpalmar infections, clinical features include loss of the normal hand concavity and tenderness of the central palm; movement of the middle and ring fingers is painful. Suppurative tenosynovitis of the second digit can rupture proximally into the thenar space, with subsequent abscess formation. Tenosynovitis of digits III, IV, and V may be responsible for a midpalmar space infection.

Management. Treatment of all deep fascial space infections involves intravenous antibiotics and operative exploration and drainage by experienced surgeons. The most common practice is to use broad-spectrum empirical coverage with a β-lactamase-resistant penicillin or a first-generation cephalosporin. Based on local bacteriologic data, it may be necessary to begin empirical coverage against methicillin-resistant *S. aureus* (MRSA).
Septic Arthritis

Pathophysiology. Septic arthritis in the hand may involve the IP, MCP, CMC, or radiocarpal joints. These joints usually are infected by direct inoculation of bacteria from penetrating trauma or by spread from a contiguous infective process, such as a felon or tenosynovitis. Hematogenous spread may occur but is less common than in other joints of the body. *S. aureus* is the most common cause; *streptococci, Haemophilus influenzae, Pseudomonas aeruginosa*, and *coliforms* are involved much less commonly. A survey at a large county hospital found that the most commonly isolated organisms were *staphylococci* and *streptococci* in nearly equal numbers, with *enterococci, corynebacteria*, and anaerobes encountered rarely. Monarticular nontraumatic septic arthritis also may be caused by *Neisseria gonorrhoeae*.

Clinical Features. Clinically the involved joint appears red and swollen and is extremely tender; an overlying puncture wound may be visible. The joint is held in a position that maximizes its volume (slight flexion for MCP and IP joints), and passive motion of the joint, however slight, is painful. In contrast with flexor tenosynovitis, tenderness is localized to the involved joint. Pain also may be elicited by axial compression of the joint. The diagnosis is made by arthrocentesis.

Management. Treatment includes parenteral antibiotics with a semisynthetic antistaphylococcal penicillin and emergent drainage of the joint. Most infected joints require open drainage, but some hand surgeons may choose to manage certain cases with closed joint catheter irrigation and repeated aspiration.

Osteomyelitis

Osteomyelitis in the hand occurs most commonly with open fractures or with secondary involvement of bone from soft tissue infections. The incidence of infection in open fractures of the hand is much lower than in open long bone fractures and is reported to be 1 to 11%. McLain and colleagues found that injuries with severe skeletal trauma, gross contamination, and significant soft tissue injury have the highest risks for infection. The presentation of osteomyelitis is seldom rapid and fulminant, unless associated with septic arthritis or other deep space infection of the hand. Physical signs may include fever, localized redness, swelling, warmth, and tenderness. Children with osteomyelitis may have pseudoparalysis, manifesting as refusal to use the affected limb. Radiographs may show bone destruction or periosteal elevation. Treatment includes débridement of infected bone and sequestra and parenteral antibiotics.

Nontraumatic Disorders of the Hand

Stenosing Tenosynovitis

The most common type of stenosing tenosynovitis in the hand involves the flexor tendons at the level of the MCP joint where the tendon passes through the pulley systems. Repetitive strain can result in tendon and pulley hypertrophy with localized tenderness. When painful blocking of flexion and extension is noted at the involved joint, the condition is called trigger finger, as noted earlier. The ring and long fingers are the most commonly involved digits. Injection therapy is recommended and works well in most patients. A mixture of 1% lidocaine and steroid suspension (for a total volume of 0.5-1 mL) is given over the nodule and into the tendon sheath. After the injection, extension of the finger usually is possible. The finger should be splinted in extension, and referral to a hand surgeon is advised because multiple injections or surgical release may be required.

Ganglion

A ganglion is the most common soft tissue tumor of the hand and consists of a synovial cyst from either a joint or the synovial lining of a tendon that has herniated. Ganglia contain a gelatinous fluid that is secreted by the synovial tissue. They are common in the wrist and the flexor tendon sheaths of the fingers and usually have an insidious onset. Patients rarely recall a specific inciting traumatic event. Patients commonly complain of a dull ache or mild pain over the ganglion. Reassurance is important, and the patient should be informed of the benign nature of the lesion. A large or troublesome ganglion can be aspirated. Because of the high rate of recurrence, definitive treatment is operative excision, which is done on an elective basis.

Foreign Bodies in the Hand

Penetrating trauma to the hand may result in a foreign body becoming lodged in the soft tissues. The presence of a foreign body should be considered in any wound regardless of its size. A detailed and accurate history of the injury should be obtained because the mechanism often gives clues to the possibility of a foreign body. The most common foreign bodies are pieces of wood, glass, or metal. Useful signs of occult foreign bodies include sharp pain with deep palpation over a puncture wound, pain associated with a mass, and failure of a wound to heal or persistence of pain with movement.

Initial examination of hand wounds should include local exploration with sterile technique in a bloodless field. After exploration and removal of easily accessible foreign bodies, radiographs should be taken using soft tissue technique with multiple views. Radiographs are the best method for detecting radiopaque foreign bodies and detect metals, most glass, many plastics, gravel, and sand. Wooden foreign bodies are difficult to visualize radiographically. Whether an object shows on plain radiographs depends on its composition, configuration, size, and orientation. When a foreign body is clinically suspected and the initial radiographic appearance is normal, other imaging methods should be considered. The identification of nonmetallic objects such as splinters may be improved by the use of modalities including computed tomography, magnetic resonance imaging, and ultrasound studies.

Management

Removal of embedded foreign bodies can be difficult and time-consuming, and potential damage to tissues caused by the procedure is weighed against the risk posed by the specific foreign body. Generally, if a foreign body contaminating a wound is clearly visible and likely to be easily extractable during local exploration, it should be removed in the ED. In some cases, the entrance wound may need to be enlarged with a small skin incision. In general, foreign bodies should be removed only under direct vision. When the object is buried within the intricate anatomy of the hand, this procedure should be deferred to a hand specialist.

Decisions regarding the necessity and timeliness of removal of a foreign body are based on the size and the reactivity of the foreign body, proximity to vital structures, degree of wound contamination, and presence or absence of symptoms. Foreign bodies that cause continued pain, interfere with hand function because of their size or their position, or cause local or systemic toxicity (e.g., paints or mercury) should be removed. In removing foreign bodies, traction should be applied along the long axis of the foreign body in order to allow easier extraction, as well as to avoid breakage into two or more pieces. With foreign bodies
associated with fractures, prompt surgical débridement is necessary to prevent osteomyelitis. Wounds that are grossly contaminated with soil or organic material require immediate removal of the foreign body, débridement, and irrigation. Foreign bodies near tendons, nerves, and vessels and foreign bodies causing ischemia or hemorrhage require cautious removal under optimal conditions.

Patients who do not require immediate removal of the foreign body may be referred to a hand surgeon for delayed surgical exploration. If the hand specialist plans to remove the object within 3 to 4 days after injury, and if bacterial contamination is minimal, the wound may be closed primarily. Initial treatment also should include tetanus prophylaxis and an appropriate wound dressing. The patient should be informed about the presence of the foreign body and the reason for delayed removal. If no removal is planned, the physician should explain to the patient that the dangers of removal outweigh the benefits.

Complications.

Foreign bodies can damage soft tissues, provoke excessive inflammation with granuloma formation, predispose the patient to infection, and cause systemic toxicity. Iatrogenic damage to tissue can result from blind probing or excessively aggressive searches for foreign bodies; such maneuvers should be avoided, particularly in the hand.