# Fractures of the Digits and Metacarpals: When to Splint and When to Repair?

*Noah D. Shaftel, MD and John T. Capo, MD*

**Abstract:** Fractures of the digits and the metacarpals are common injuries in athletes. The majority of these can be treated nonoperatively with careful attention to alignment, rotation, and shortening. Those requiring operative fixation are usually amenable to either K-wire, interfragmentary screw, or plate fixation. Whichever treatment pathway is chosen, the goal should be to provide adequate stability for healing while attempting to maintain mobility of the joints and digits. Dedicated rehabilitation is essential to optimizing functional outcomes, patient satisfaction, and return to sport.

**Key Words:** metacarpal fracture, phalanx fracture, hand fracture, fracture fixation, athlete, sports injury

(*Sports Med Arthrosc Rev* 2014;22:2–11)

Injuries to the hand and the forearm are a frequent occurrence and account for approximately 1.5% of all US emergency department visits a year. Of these, approximately 41% are fractures of the metacarpals and phalanges.[1] Grouped by etiology, sports are the leading cause of phalangeal fractures in the 10 to 19 years age group (43%), as well as in the 20 to 29 (27.8%) and 30 to 39 (21.6%) years age groups.[2] These injuries can lead not only to a significant time away from sport but can have long-term morbidity, which inhibits performance for lengthy periods long after the acute injury has healed. As a result, great importance has been placed on timely diagnosis, treatment, and rehabilitation of phalangeal and metacarpal fractures. The focus of this article is appropriate indication and treatment of these injuries, with special attention to which can be treated in a closed manner and which requires operative fixation for optimal outcome.

## EVALUATION

The decision to treat a fracture by closed means, or to indicate it for operative fixation, is often based on the initial evaluation and radiographs. As with any injury, a thorough history should be elicited that can provide details on the mechanism of injury and magnitude of the force involved. The physician should inquire about prior injuries and deformity in the hand. Signs of previous trauma may be readily observed on examination and radiographs and could be confused with acute pathology.

The initial examination, whether it is on the sidelines or in the office, should be comprehensive and complete. The skin should be examined for abrasions or lacerations, which, when indicative of open fracture, may have implications in proper and timely care. Open fractures are frequently associated with higher rates of infection and complications. In the hand, open fractures have been shown to have low rates of infection and nonunion, provided the soft tissue envelope is not significantly disrupted. In a large prospective series of open digital fractures, the infection rate was approximately 2% and the rate of nonunion was approximately 2.5%.[3] As the soft tissue involvement increased (tendon injuries, nerve injury, skin loss, combination of these), the resultant outcomes worsened. Recently, a retrospective review of 145 open fractures managed in the emergency department with irrigation and debridement showed similar results with infection occurring in 1.4% of the population.[4] Those that did become infected were all with Modified Gustilo and Anderson grade III injuries. Special attention should be paid in athletes, however, as the propensity for gross contamination from playing surfaces and equipment is theoretically higher than usual.

Neurovascular status and associated tendinous injury should be assessed in all digits. Associated tendinous injury can be determined by assessing the resting cascade of the digits, checking for tenodesis effect with the wrist extended and flexed, and isolating active movement of individual tendons.

The last important part of the examination involves evaluation of malrotation and/or scissoring of digits. Often times, it is difficult to assess for these with the fingers in an extended posture. The patient should be asked to make a composite fist. In this position, all of the finger tips should point to the scaphoid tubercle without scissoring or overlap. If the patient cannot actively make a fist because of pain, a local block can be given or flexion through tenodesis effect can be used. Another method of assessing rotation involves observing the fingers on end and using the fingernail alignment as a proxy of rotation. With any of these techniques, findings should always be compared with the contralateral extremity as variation does exist from person to person.

## RADIOGRAPHIC EXAMINATION

Proper, high-quality radiographs are essential for diagnostic and treatment purposes. Three views of the affected hand or digit should be obtained including a posteroanterior (PA), oblique, and lateral view. If phalangeal injury is suspected, dedicated finger films should be completed.

Obtaining true lateral views of individual metacarpals requires adjustment in the technique as a lateral view of the hand will not provide true laterals of all metacarpals. A lateral view of the hand usually provides an adequate lateral view of the middle metacarpal. An appropriate lateral radiograph of the index metacarpal involves 20 to 30

From the Division of Hand Surgery at the NYU-Hospital for Joint Diseases, New York, NY.
J.T.C. is a paid consultant for Depuy-Synthes". Some of the plates in the pictures are made by Synthes.
Disclosure: The authors declare no conflict of interest.
Reprints: John T. Capo, MD, Division of Hand Surgery at the NYU-Hospital for Joint Diseases, New York, NY.

degrees of supination of the hand, whereas the ring and small fingers require approximately 30 degrees of pronation.

Advanced imaging for metacarpal and digital fractures is not usually indicated or routine in the acute stage of injury. It can, however, be useful in diagnosing injuries that are difficult to recognize such as carpometacarpal (CMC) fracture dislocations and can be helpful in assessing articular fractures of the phalangeal joints. The use of judicious 3-dimensional reconstructions can be particularly helpful in preoperative planning for complex articular injuries, as it may aide in better understanding the fracture "character."

## TREATMENT PRINCIPLES

Standard orthopedic treatment principles are applied to fractures of the metacarpals and phalanges. Many of these injuries can be managed nonoperatively with appropriate immobilization. Often times, immobilization can be accomplished in such ways that the athlete can either continue participation or return to play in a more rapid manner. Padded casts, splints, or taping is permitted in many sports, although this is based on the individual rules and regulations of that activity. In those injuries requiring operative treatment, careful attention to surgical technique and fixation are mandatory. Equally important are postoperative protocols in returning the athlete to play as quickly and safely as possible. In either instance, dedicated rehabilitation and hand therapy play extremely important roles in optimizing clinical results and patient function.

When considering nonoperative treatment of metacarpal and phalangeal fractures, choice of immobilization (if any), position of immobilization, and duration are all necessary and important considerations. These factors are all dictated by the type of injury, inherent stability, and associated soft tissue injury, which are discussed later in this paper.

Operative fixation requires careful planning with consideration to the type of fixation and its placement. The primary modes in the hand include K-wire (both percutaneous and open), interfragmentary screw, tension band, plate and screw (in compression, position, or bridging configurations), and external fixation (wire-based or standard) constructs. With pinning, the surgeon should avoid transfixing surrounding tendinous or ligamentous structures. K-wires are best placed in mid-axial positions, avoiding tethering of the flexors and extensor/extensor mechanism. Typically 0.054- or 0.045-inch wires are used in the metacarpals, whereas 0.045- or 0.035-inch wires are used in the phalanges. Plates and screws now come in a variety of sizes and configurations. Newer implants are thinner and more low profile, limiting prominence and secondary hardware complications. Metacarpal fractures in an average-sized patient can generally accept a 2.0 or 2.4 mm plates or screws. More distally, the proximal and middle phalanges generally are large enough for 1.3, 1.5, or 2.0 mm constructs.

## METACARPAL FRACTURES

The metacarpals form the longitudinal and the medial-lateral arches of the hand. The metacarpals are inherently stable bones with much soft tissue support provided by the intrinsic muscles of the hand and deep intermetacarpal ligaments. Intuitively, the middle and the ring metacarpal fractures are more stable because of the supporting soft tissue structures on both sides of the affected bone. The border digits do not have this advantage and are therefore more prone to instability and deformity. The dorsal-volar mobility of the metacarpals increases in a radial to ulnar direction. This is largely because of increased motion at the CMC joint, with the metacarpal-hamate articulation providing the ring and small metacarpals with the most mobility. This has significant implications when deciding which fractures can be treated closed and which require fixation. The index and middle metacarpals are much less tolerant of angulation because of its relatively minimal motion at the CMC joint, providing less accommodation of deformity. The small finger metacarpal, however, is much more able to accommodate deformity.

Although some volar-dorsal angulation can be accepted, rotation in the axial plane is not well tolerated. Even relatively small amounts of malrotation within the metacarpal can lead to significant scissoring of the digit with flexion. This emphasizes the need to examine the hand in full extension and complete composite flexion. If this cannot be accomplished because of pain, one should examine the nail plates "head on" by looking at the tips of the fingers in an axial direction. There is great variation from person to person, and the finger alignment should always be compared with the contralateral hand.

A third important consideration in fracture management is shortening of the metacarpal. As mentioned above, the central metacarpals are relatively resistant to axial shortening because of soft tissue attachments. The border digits are more apt to this deformity. A recent biomechanical study evaluating the effect of metacarpal shortening on digital flexion force demonstrated a significant decrease in flexion force at 50% full finger flexion when the metacarpal was shortened 7.5 mm or more. Significantly decreased flexion force at full composite flexion was found with 5 mm or more of shortening.[5] When looking at compromised extensor function, biomechanical data have shown approximately 7 degrees of extensor lag with every 2 mm of shortening.[6] This may not manifest, however, because of hyper extensibility of the metacarpophalangeal (MP) joint in some individuals. Similar studies have predicted 50% decreased interosseous force with 10 mm of shortening.[7] Although no absolute value that compromises function can be given, many would agree that approximately 3 to 5 mm can be tolerated in most individuals.

### Metacarpal Base Fractures

Metacarpal base fractures occur more frequently in the small and ring fingers because of increased mobility of the ulnar digits at the CMC joints. A majority of these fractures are inherently stable and minimally displaced because of surrounding soft tissue structures. In case of all hand fractures, rotational alignment should be assessed. Significant malrotation with subsequent scissoring of the digits is an indication for operative management that does not correct after closed reduction.

Diagnosing these fractures, particularly fracture dislocations of the ulnar digits, can prove difficult because of difficulty in imaging this region. Recently, McDonald and colleagues described the use of the intermetacarpal angle to screen for subtle injury. They found that if the index-small or middle-small intermetacarpal angle on a lateral radiograph exceeded 10 degrees, there was a high likelihood of small finger CMC fracture/dislocation.[8]

Intra-articular fractures and fracture/dislocations should be assessed for congruity of the articular surface and subluxation of the CMC joint. Computed tomography (CT) scans may be useful in these situations. No parameters dictating the treatment type have been well established with regard to fractures necessitating fixation. Most of the available data comes from small case series. When taken as a whole, the studies seem to suggest that approximately 40% of patients will experience some degree of long-term pain, irrespective of operative or nonoperative treatment.[9] It is typically accepted that fractures with significant displacement, comminution, joint subluxation, and tendinous avulsion should be treated operatively.[9] One of the goals of operative treatment is to minimize posttraumatic arthrosis and subsequent pain at the CMC joint.

Nonoperative treatment typically consists of short arm cast or splint immobilization with the wrist extended 30 degrees and the MP flexed. The interphalangeal (IP) joints should not be included to allow for full motion. Operative fixation is usually accomplished with closed reduction and pinning in noncomminuted fractures/dislocations. In most of these instances, the intact metacarpal shaft can be pinned to the carpus or adjacent intact metacarpal in a reduced position.

## Metacarpal Shaft Fractures

Appropriate management of metacarpal shaft fractures is largely dependent on which metacarpal is involved (border digit vs. central digit), the fracture configuration (transverse, oblique/spiral, comminuted), displacement (rotation and shortening), and number of metacarpals involved (single vs. multiple).

Transverse fractures are usually angulated in an apex dorsal configuration because of pull from the intrinsic muscles of the hand. There is no consensus on the amount of angulation that can be accepted without affecting function. Operative fixation is usually indicated in the index/middle metacarpal with angulation > 10 degrees, > 20 degrees in the ring metacarpal, and > 30 degrees in the small metacarpal.[10] The ulnar digits are better able to accommodate deformity because of the increasing motion at the CMC joints on the ulnar aspect of the hand. The radial digits have much less motion at the CMC joint and are therefore less tolerant to angular deformity. Rotation is not well tolerated and is an indication for operative fixation if appropriate reduction cannot be achieved and maintained.

In fractures that are nondisplaced and within these angulation limits, closed treatment can be attempted. In a study by Rettig et al,[11] the authors found 82% of all metacarpal fractures in athletes to be stable and minimally displaced and that they can be treated nonoperatively. Closed treatment usually involves any necessary closed reduction and application of a forearm-based dorsal-volar clamshell splint in the safe position with the MP joints flexed and the IP joints free to move. This is removed 2 to 3 weeks later and a thermoplast splint is fabricated including the injured ray and 1 adjacent ray. Removal of the splint and active range of motion (ROM) with buddy taping can be started at 4 weeks.

Fractures not meeting the aforementioned criteria should be managed operatively. Various methods can be used for transverse shaft fractures. Common methods involve pinning of the injured metacarpal to adjacent uninjured metacarpals, cross pinning at the fracture site, and intramedullary wiring. Pinning to the adjacent uninjured metacarpal can be accomplished using 0.045-inch K-wires with 2 wires distal to the fracture site and 1 proximal. These pins can then be removed at 4 weeks. Galanakis et al[12] used this technique for 25 consecutive metacarpal neck and shaft fractures and noted excellent functional outcomes and patient satisfaction. In patients with transverse metacarpal shaft fractures with significant comminution, multiple metacarpal fractures, and ones that cannot be reduced in a closed manner, open reduction and internal fixation (ORIF) is indicated (Figs. 1, 2). A dorsal plate has been shown to be a more rigid construct than wire constructs.[13] Fixation with a 2.4 or 2.0 mm plate allows for early motion and can obviate the need for splinting except during sport and during sleeping.[14]

Oblique or spiral fractures, especially in border digits, have the propensity to shorten in addition to angulate and rotate. Central digits are less likely to shorten because of attachment of the deep intermetacarpal ligaments to the distal fragment on both sides of the injured metacarpal. With regard to acceptable shortening, as discussed above, no absolute criteria have been established. Many authors would agree that up to 5 mm is acceptable without significant deficit.[5–7] Fractures that meet the aforementioned parameters can be treated in a closed manner as described above. Those requiring operative fixation are commonly

**FIGURE 1.** Multiple metacarpal shaft fractures requiring operative fixation.

 

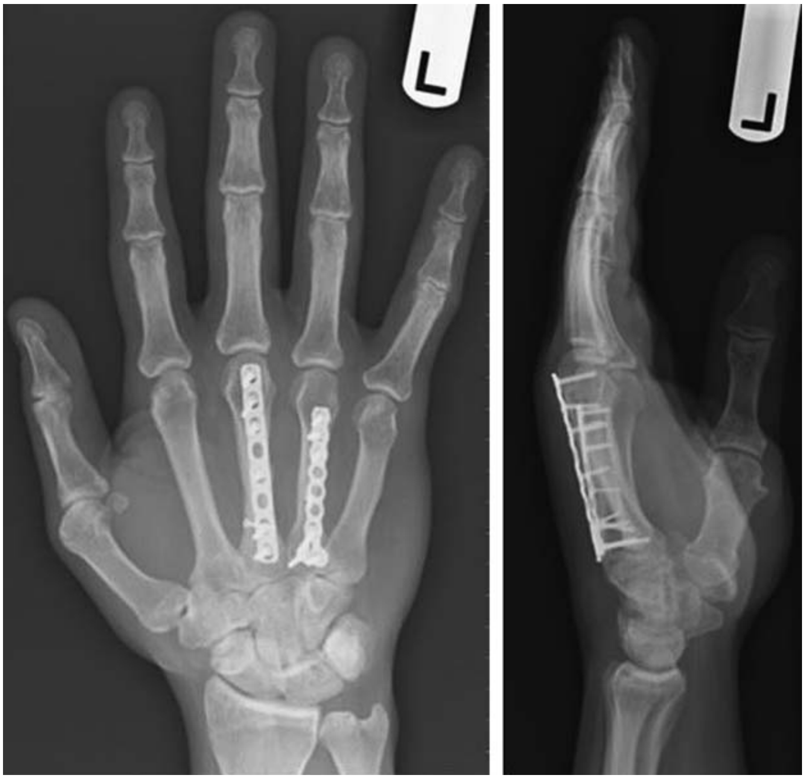

**FIGURE 2.** Postoperative radiographs after fixation of unstable middle and ring metacarpal fractures with plate and lag screw construct.

stabilized with K-wires, interfragmentary (IF) screws, and plate/screw constructs. If closed reduction can be obtained, interfragmentary K-wire fixation can, at times, be utilized. Wire fixation can be difficult as the oblique or spiral nature of the fracture can have a tendency to shorten. If open reduction is required, fixation with either interfragmentary screws or plate/screw constructs is a viable option. Oblique or spiral fractures that are greater than three times the length of the metacarpal shaft width can be treated with multiple 1.3, 1.5, or 2.0 mm interfragmentary screws alone. The shorter oblique fractures should be treated with a lag screw and dorsal neutralization plate construct. As above, those fractures treated with rigid internal fixation can begin early active motion and require protective splinting while participating in sport.

Comminuted or open fractures of the metacarpal shaft are usually high energy injuries and are often associated with significant soft tissue damage. As a result, these are very unstable and require internal or external fixation depending on the soft tissue envelope. In those with comminution greater than one third of the shaft diameter, bone grafting may be indicated to assist in union.[14]

## Metacarpal Neck Fractures

The metacarpal neck is a region of frequent fracture in the hand. These injuries usually occur from striking a solid object with a clenched fist. In the orthopedic literature, this is often referred to as a "boxer's fracture" when occurring in the small metacarpal. The deformity is usually apex dorsal with or without a rotational component. Because of the mechanism of injury, a large proportion of these are unstable with volar comminution of the neck and the deforming forces of the intrinsic muscles. This clinically appears as a "dropped knuckle" with loss of the dorsal MP contour and prominence of the metacarpal head in the palm.

As discussed previously, acceptable dorsal-volar angulation at the metacarpal neck increases from radial to ulnar. Once again, there is little consensus on what degree of angulation can be tolerated without significant functional deficit. The more distal nature of the metacarpal neck fracture does allow more deformity to be accepted than in a more proximal metacarpal shaft fracture. There is general agreement that the index and the middle metacarpals can accept up to 10 degrees of deformity before they could be treated surgically. When dealing with the ring and small finger metacarpals, some authors have tolerated up to 70 degrees of apex dorsal angulation without significant disability,[15] whereas others have advocated up to 40 degrees.[16] Malrotation is poorly tolerated in all digits and should be addressed with closed reduction or through surgical fixation if unable to be maintained closed.

Many metacarpal neck fractures in athletes can be treated in a closed manner as a result of the significant deformity that can be tolerated. Closed reduction is accomplished using the Jahss maneuver first described in 1938. Traction is first applied to the digit to disimpact the fracture. The MP and proximal interphalangeal (PIP) joints are then maximally flexed, thereby placing the MP collateral ligaments under tension and stabilizing the metacarpal head fragment. A dorsally directed force is then applied to the proximal phalanx and a volarly directed force is applied over the apex of the fracture. Once reduction is accomplished, the hand is placed in a forearm-based ulnar or radial gutter splint incorporating the injured metacarpal and at least one neighboring uninjured metacarpal. The fingers can be buddy taped to assist with rotational deformity. The splint is removed at 2 weeks and can be changed to a gutter cast or splint for an additional 2 weeks. A ROM with buddy taping is begun 3-4 weeks after injury.[14] Athletes can usually return to play at approximately 6 weeks after injury. Some loss of reduction is not unusual but is generally well tolerated in the ulnar digits if within the limits proposed above.

Metacarpal neck fractures that have failed nonoperative management and cannot be maintained in appropriate alignment should be indicated for surgical fixation. If the fracture is mobile at the time of surgery, closed reduction and percutaneous pinning can be attempted utilizing three 0.045-inch K-wires. Two wires are placed in the head fragment, proximal to the collateral insertions, and are driven into an adjacent intact metacarpal. One K-wire is placed proximal to the fracture site and driven into the adjacent metacarpal shaft. Crossed K-wire fixation can also be used by inserting K-wires in a retrograde manner from the collateral recesses into the shaft. These wires should not be left in for a prolonged period, and motion should be initiated while the pins are in to avoid excessive MP joint stiffness. Some authors have advocated using multiple small wires inserted in an intramedullary manner to treat unstable metacarpal neck fractures with excellent outcomes.[17] ORIF is indicated when the fracture cannot be adequately reduced using the closed approach. In these cases, K-wires, tension band wiring, and plate fixation are all viable options. Newer low-profile and dedicated plates for this particular fracture, with multiple screw placement options, have made fixation with this method more popular in recent years and theoretically decrease the hardware complications seen in prior iterations.

## PROXIMAL PHALANX FRACTURES

The phalanges are surrounded by multiple ligamentous and soft tissue structures including the extensor mechanism dorsally, the lateral bands on the medial and lateral aspects, the flexor sheath and flexor tendon on the volar surface, and the ligaments of Grayson and Cleland anchoring the phalanx to the overlying skin. These overlying structures provide significant stability to the digit but can also act as strong deforming forces in the event of fracture. The adjacent tissues can also become adherent and limit ROM and excursion after injury. Treatment is focused on a balance of adequately treating the fracture while attempting to limit adhesions and promote gliding of the tendons.

### Proximal Phalanx Base Fractures

Fractures occurring at the proximal phalangeal base are usually extra-articular and have a characteristic apex volar angulation. In the adolescent athlete with physes that are still open, this may occur as a Salter-Harris II fracture through the proximal phalangeal physis. Some frontal plane deformity may be present, but significant malrotation is rare. This may give a "pseudoclawing" appearance to the digit with hyperextension through the fracture site and loss of extrinsic extensor tension leading to lag at the PIP joint. Approximately 25 degrees of apex volar angulation can be tolerated. With angulation greater than this, loss of flexion and extensor lag may affect daily activities. As with all hand and digital fractures, malrotation cannot be accepted.

Closed reduction and splinting may be attempted in these fractures but instability is frequent. A hand-based dorsal blocking splint to the level of the PIP joint with the MP in full flexion and the IP joints free to move is utilized. Active flexion of the PIP joint allows the extensor hood to act as a tension band in this instance. It also helps to prevent extensor adhesion to the phalanx.[18] Immobilization in this position is continued for 3 to 4 weeks, after which the splint can be removed and more aggressive therapy initiated. The splint is discontinued at approximately 6 weeks or when the fracture becomes completely nontender.

In base fractures in which acceptable alignment cannot be achieved or maintained, internal fixation is indicated. Closed reduction and percutaneous fixation should be attempted before any attempts at open reduction. Either crossed K-wires or intramedullary K-wire fixation through the dorsal metacarpal head into the proximal phalangeal shaft with the MP joint maximally flexed can be utilized. Pins are removed at 3 to 4 weeks and active PIP motion is encouraged immediately after surgery. It should be noted that no matter what treatment is provided, significant issues with ROM appear to be frequent. A recent retrospective study compared these 2 techniques and noted loss of $>20$ degrees of PIP flexion in over half of the patients in each group. Approximately, one third of the patients in each group had fixed flexion contractures of $>15$ degrees at the PIP as well. The authors cautioned that overall outcomes were not as good as previously reported.[19]

### Diaphyseal Proximal Phalanx Fractures

Like metacarpal fractures, diaphyseal proximal phalanx fractures are usually transverse or oblique in nature. Many transverse fractures are nondisplaced and can be managed with buddy taping and early motion. Displaced transverse fractures typically display apex volar angulation. Acceptable parameters are the same as listed previously for proximal phalangeal base fractures. Closed reduction occurs with traction and flexion of the distal fragment to bring it to align with the proximal fragment. Nonoperative management proceeds as described in the previous section using splinting, with the MP joint flexed and the IP joints free to move for 3 to 4 weeks. Active PIP flexion is encouraged immediately. Unstable transverse fractures that cannot be held by closed means can be managed with closed reduction and with either retrograde crossed pinning or intramedullary pinning through the MP joint as described above.

Long oblique fractures of the proximal phalangeal shaft are subject to shortening and malrotation, albeit to a lesser degree than metacarpal shaft fractures. Those requiring operative fixation are amenable to either closed reduction and percutaneous pinning or open reduction and IF screw fixation with 1.5 or 2 mm screws. Open approaches can be made either in a mid-axial manner or dorsal extensor tendon splitting. In pin fixation, at least 2 pins should be approximately perpendicular to the fracture line with slight divergence. Screws can be placed as in position or lag mode and should be perpendicular to the fracture line. Rotation should be carefully examined before completion of the case.

Occasionally, unstable transverse or short-oblique fractures may require ORIF with plates and screws. The plates are typically 1.3 or 1.5 mm in size and can be applied to the lateral phalanx through a lateral approach or dorsally though a tendon splitting or sparing surgical technique. If possible, a tendon-sparing approach is preferred as it permits early active motion postoperatively. Often times, the plate can be combined with IF screws to achieve provisional reduction of separate fragments and also to increase overall construct stability (Figs. 3, 4). This type of construct allows nearly immediate ROM for light activities but does require bony healing before return to sport activities.

### Phalangeal Neck (Subcondylar) Fractures

These fractures occur at the phalangeal neck of the proximal phalanx, just proximal to the condylar flare. They also take on the characteristic apex volar angulation and can also be rotated 90 degrees with the distal fragment resting on the dorsum of the proximal shaft fragment. These fractures are difficult to reduce and hold in a closed manner. Most displaced phalangeal neck fractures require operative reduction and pinning. The distal fragment is often small and difficult to control, necessitating open reduction through a mid-axial approach. Retrograde crossed K-wires from the margin of the condylar fragment or retrograde crossed wires crossing the PIP joint may be utilized.[14] If the wires cross the PIP joint, the joint should be immobilized in full extension to prevent volar plate contracture. Wires should be removed at approximately 4 to 5 weeks.

## MIDDLE PHALANX FRACTURES

Fractures of the middle phalanx are usually because of direct blows or crushing-type injuries. As a result, many of these are transverse or short oblique in nature. The deforming forces at this level include the central slip insertion on base at the dorsal lip and the broader insertion of the flexor digitorum superficialis on the middle two thirds of the bone volarly. Angulation and deformity are dependent on where along the length of the bone the fracture occurs. Approximately 15 to 30 degrees of angulation can be accepted. As with all phalangeal fracture, rotation is not well tolerated.

### Extra-articular Middle Phalangeal Base Fractures

Most nondisplaced middle phalangeal base fractures can be managed nonoperatively with either buddy taping or splinting. Displaced fractures tend to display apex dorsal angulation with extension of the proximal fragment because of the central slip insertion and flexion of the distal fragment from the pull of the FDS. Displaced fractures that can be reduced and are stable can be treated with splinting for 3 to 4 weeks, followed by mobilization and buddy taping. Those fractures which cannot be maintained in appropriate alignment after reduction should be managed operatively. Most are amenable to either interfragmentary screw fixation in long oblique patterns or pinning in short-oblique or transverse patterns.

### Middle Phalangeal Shaft and Neck Fractures

Fractures occurring at the level of the FDS insertion can angulate into apex dorsal or apex volar alignment. Those that occur distal to the FDS insertion tend to display apex volar angulation. Shaft fractures are managed with the same principles as those described above for base fractures. Middle phalangeal neck fractures generally produce apex volar angulation, of which approximately 30 degrees can be tolerated.[14] Beyond this, an extensor lag can develop, as well as a swan neck attitude. If these fractures cannot be manipulated into a stable configuration, closed reduction and percutaneous pinning should be attempted. Two methods of pinning are currently used for treating these specific injuries. Cross-pinning[20] and longitudinal pinning through the distal interphalangeal (DIP) joint are both utilized with success. Often times, because of the size of the distal fragment, attempting to hold the fracture reduced while pinning can be difficult. Paksima et al[21] recommended

**FIGURE 3.** Displaced and angulated index proximal phalanx fracture requiring reduction and fixation.

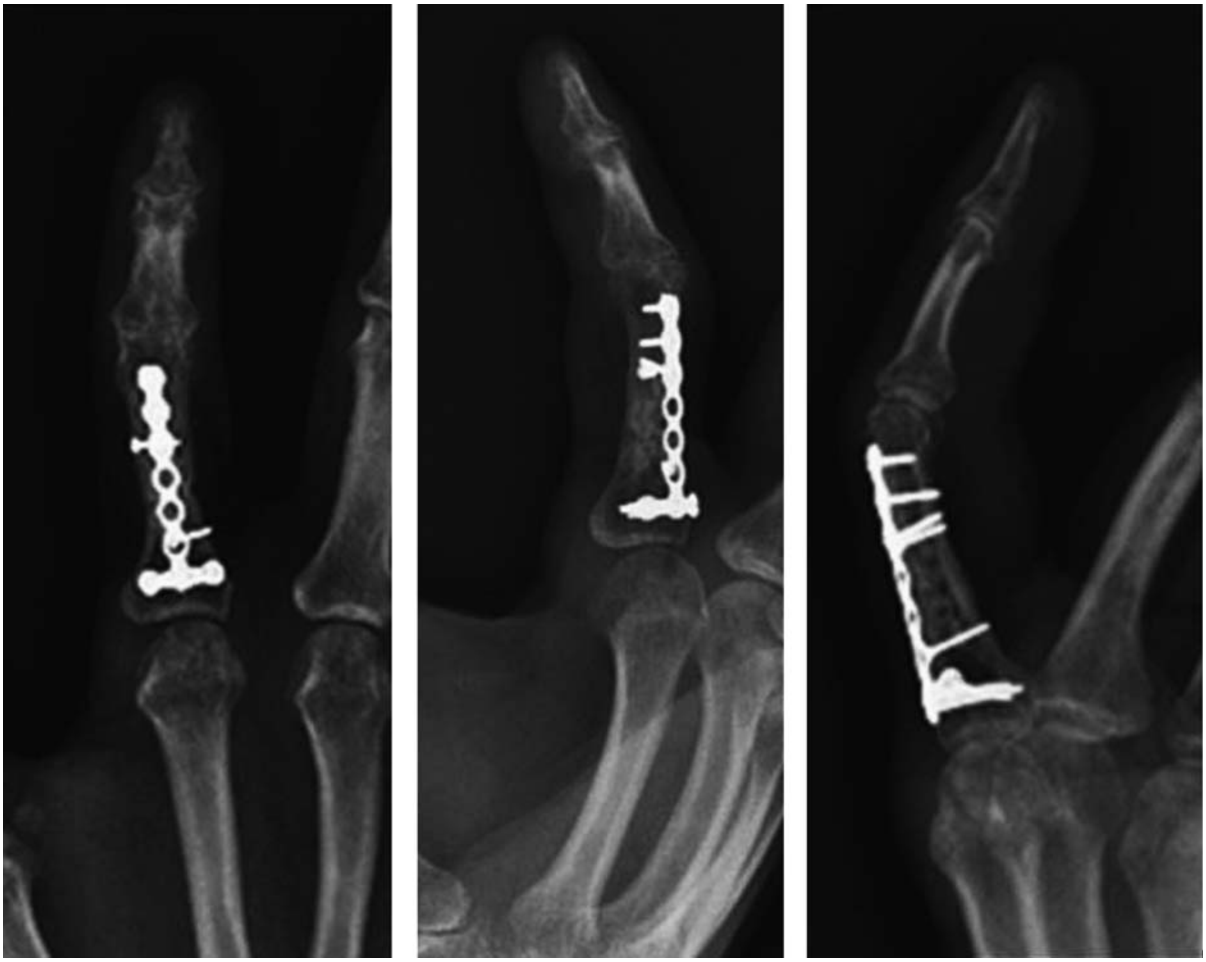

**FIGURE 4.** Postoperative radiographs after fixation with plate and lag screw construct.

a technique utilizing retrograde pin insertion though the DIP joint, followed by withdrawal of the wire proximally through the middle phalangeal base, followed by antegrade drilling of the wire across the DIP joint with good success. By using this technique, the surgeon does not have to hold the DIP joint and small phalangeal head fragment reduced while simultaneously driving the K-wire retrograde. The pins should be left in for 3 to 4 weeks, at which point they are removed and ROM is begun.

## DISTAL PHALANX FRACTURES

The distal phalanx is frequently injured in sporting events, largely because of the distal position on the digit. Fractures in this bone are usually due to crushing or direct blow type injuries. As a result, the fracture patterns most seen are transverse and comminuted tuft types. In assessing injuries to this phalanx, careful attention must be directed to the overlying nail bed and nail plate. Fractures with significant displacement often times damage the nail bed or eponychium, resulting in an open fracture of the distal phalanx requiring irrigation, debridement, reduction, nail bed repair, and sometimes fixation. These injuries may have a large degree of contamination from the surrounding athletic environment, making careful irrigation and debridement important in preventing infectious sequelae. While nail bed repair was traditionally accomplished using suture, reapproximation with 2-octylcyanoacrylate glue, commonly known as Dermabond (Ethicon Inc., Sommerville, NJ), yields faster and equally cosmetic and functional results.[22]

### Transverse Fractures of the Base/Shaft

Nondisplaced or minimally displaced fractures can usually be treated nonoperatively with small alumafoam, thermoplast, or "tip protector" type splints. Immobilization should only include the DIP joint, leaving the PIP joint free to move.

Significantly displaced fractures, often times with eponychial or nail bed injury, may require fixation because of their unstable nature. Physeal fractures in children can have interposition of the nail bed in the physis and need to have appropriate reduction to avoid nail bed and bony deformity. Fixation can occur with a single axial 0.045- or 0.035-K-wire spanning the DIP joint. This is usually left for 3 weeks, at which point it is removed, and DIP motion is initiated. Active PIP motion should be encouraged while the pin is in place.

### Tuft Fracture

Tuft fractures are usually the result of crush injuries, with comminution being common. They are frequently accompanied by nail bed hematomas. Although previous

 

**FIGURE 5.** Displaced, angulated extra-articular thumb metacarpal fracture requiring reduction and fixation.

authors have advocated removal of the nail plate and nail bed laceration repair in subungual hematomas $>50\%$,[23] other authors have recommended simple trephination of the nail with retention of the nail plate.[24] The majority of these injuries remain well aligned because of the splinting effect of the nail plate and dense septae within the finger pulp. A protective splint, not including the PIP joint, is usually worn for approximately 3 weeks.

## THUMB FRACTURES

### Extra-articular Metacarpal Fracture

Fractures of the metacarpal shaft, often in the proximal third, usually display a characteristic apex dorsal deformity. Because of the significant motion in multiple planes at the CMC joint, up to 30 degrees of angulation can be tolerated without dysfunction. Most of these fractures can be managed nonoperatively with closed reduction and thumb spica immobilization. Those with more displacement/angulation may require closed reduction and percutaneous pinning. Pins are left in place for 4 weeks, followed by mobilization. If the fracture is unable to be closed reduced and pinned, then ORIF is necessary. A volar-radial approach at the glabrous and nonglaborous skin junction allows excellent exposure while preventing exposure of most branches of the superficial radial nerve. Smaller locking plates have recently been developed that provide sufficient rigidity while being low profile in this high-contact area. These plates are often combined with IF screws to provide a very rigid construct, permitting early ROM (Figs. 5, 6).

### Thumb Proximal Phalanx and Distal Phalanx Fractures

Fractures of the proximal and distal phalanges of the thumb are managed according to the principles described above for the other digits. Most stable injuries can be treated with splint or cast immobilization. Unstable injuries can be treated using the multiple modes of fixation described previously as the individual fracture dictates.

## SPECIFIC CONCERNS IN ATHLETES

The question of when a patient can return to play after metacarpal and phalangeal fracture is a controversial one. Unlike other sports injuries in which treatment can be delayed until the end of the season to minimize time away from participation, fractures of the metacarpals and phalanges are most appropriately treated acutely. In the instance where an athlete presents with a malunion, or possibly even nonunion, select individuals can be treated in a delayed manner on a case-by-case basis.

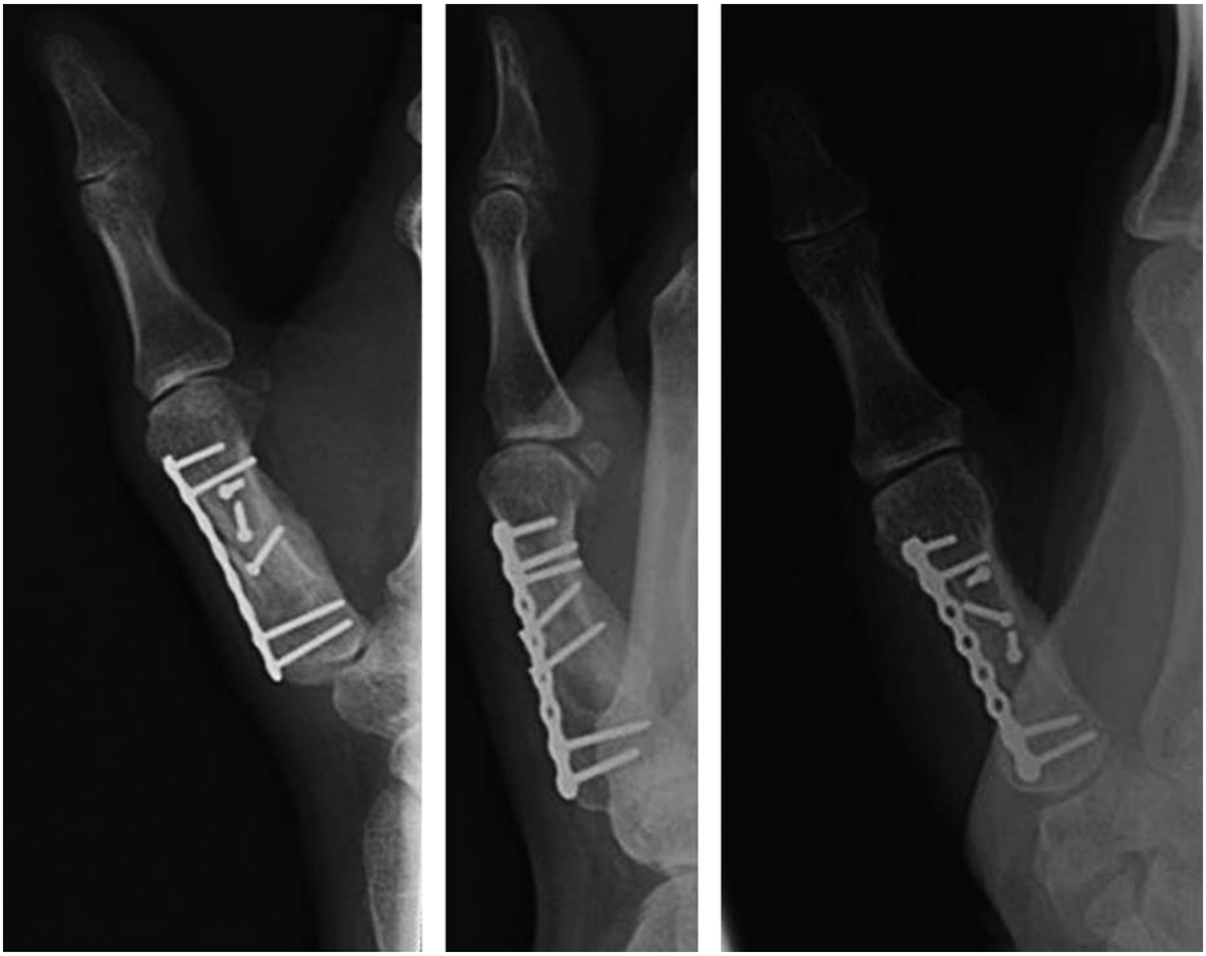

**FIGURE 6.** Postoperative radiographs after fixation with a 1.5 mm locking plate and lag screw construct.

There are no universal guidelines for return to sport following operative or nonoperative treatment of metacarpal or phalanx fractures. Much of this decision involves the rules governing specific sports with regards to the acceptability of rigid orthoses. These are highly variable from sport to sport and one level of competition to another. The decision also involves the level, sport, and position of the athlete being treated. While a college level football lineman might be allowed to play with a well-padded ulnar gutter cast, this might not be allowed in a high school soccer player.

In general, the authors of this paper allow players to return to sport when evidence of healing is seen clinically and on radiographs. If the patient had rigid plate fixation of a metacarpal fracture, the player is usually allowed to return to sport with a rigid orthosis at 4 weeks as long as healing is noted on radiographs. Metacarpal fractures treated with pin fixation are not usually returned to sport before evidence of healing on radiographs and the pins are removed. Metacarpal fractures treated nonoperatively are treated similarly, with athletes permitted to return in a rigid orthosis after bony healing is observed.

The same basic principles apply to phalangeal fractures. Because most of these fractures are treated nonoperatively or utilize operative pin fixation, players are allowed to return to sport with a protective splint once bony healing is observed on radiographs and the pins have been removed. A protective orthosis is then usually used for an additional few weeks until complete union is observed.

## CONCLUSIONS

Extra-articular fractures in the hand are common in athletic activities. The management of these injuries is largely dictated by the location, stability, and displacement. By utilizing the appropriate treatment and rehabilitation principles, the athlete can be returned to sport as quickly and safely as possible with good functional results. As with all patients, good communication of goals and expectations before undergoing any treatment course is vital to achieving an optimal result.

## REFERENCES

1. Chung KC, Spilson SV. The frequency and epidemiology of hand and forearm fractures in the United States. *J Hand Surg [Am]*. 2001;26A:908–915.
2. De Jonge JJ, Kingma J, Van Der Lei B, et al. Phalangeal fractures of the hand: an analysis of gender and age-related incidence and aetiology. *J Hand Surg (Br)*. 1994;19B:168–170.
3. Chow SP, Pun WK, So YC, et al. A prospective study of 245 open digital fractures of the hand. *J Hand Surg Br*. 1991;16B: 137–140.

4. Capo JT, Hall M, Nourbakhsh A, et al. Initial management of open hand fractures in an emergency department. *Am J Orthop*. 2011;40:E243–E248.
5. Wills BP, Crum JA, McCabe RP, et al. The effect of metacarpal shortening on digital flexion force. *J Hand Surg Eur*. 2013;38:667–672.
6. Strauch RJ, Rosenwasser MP, Lunt JG. Metacarpal shaft fractures: the effect of shortening on the extensor tendon mechanism. *J Hand Surg Am*. 1998;23:519–523.
7. Meunier MJ, Hentzen E, Ryan M, et al. Predicted effects of metacarpal shortening on interosseous muscle function. *J Hand Surg Am*. 2004;29:689–693.
8. McDonald LS, Shupe PG, Hammel N, et al. The Intermetacarpal angle screening test for ulnar-sided carpometacarpal fracture-dislocations. *J Hand Surg Am*. 2012;37A:1839–1844.
9. Bushnell BD, Draeger RW, Crosby CG, et al. Management of intra-articular metacarpal base fractures of the second through fifth metacarpals. *J Hand Surg Am*. 2008;33:573–583.
10. Henry MH. Fractures of the proximal phalanx and metacarpals in the hand: preferred methods of stabilization. *J Am Acad Orthop Surg* . 2008;16:586–595.
11. Rettig AC, Ryan R, Shelbourne D, et al. Metacarpal fractures in the athlete. *Am J Sports Med*. 1989;17:567–572.
12. Galanakis I, Aligizakis A, Katonis P, et al. Treatment of closed unstable metacarpal fractures using percutaneous transverse fixation with kirschner wires. *J Trauma*. 2003;55:509–513.
13. Black D, Mann RJ, Constine R, et al. Comparison of internal fixation techniques in metacarpal fractures. *J Hand Surg Am*. 1985;10:466–472.
14. Capo JT, Hastings H II. Matacarpal and phalangeal fractures in athletes. *Clin Sports Medicine*. 1998;17:491–511.
15. Hunter JM, Cowen NJ. Fifth metacarpal fractures in a compensation clinic population. A report of one hundred and thirty-three cases. *J Bone Joint Surg*. 1970;52:1159–1165.
16. Birndorf MS, Daley R, Greenwald DP. Metacarpal fracture angulation decreases flexor mechanical efficiency in human hands. *Plast Reconstr Surg*. 1997;99:1079–1083.
17. Winter M, Balaguer T, Bessiere C, et al. Surgical treatment of the boxer's fracture: transverse pinning versus intramedullary pinning. *J Hand Surg Eur*. 2007;32:709–713.
18. Burkhalter WE. Closed treatment of hand fractures. *J Hand Surg Am*. 1989;14A:390–393.
19. Faruqui S, Stern PJ, Kiefhaber TR. Percutaneous pinning of fractures in the proximal third of the proximal phalanx: complications and outcomes. *J Hand Surg Am*. 2010;37: 1342–1348.
20. Edwards GS, O'Brien ET, Heckman MM. Retrograde cross-pinning of transverse metacarpal and phalangeal fractures. *Hand*. 1982;14:141–148.
21. Paksima N, Johnson H, Brown A, et al. Percutaneous pinning of middle phalangeal neck fractures: surgical technique. *J Hand Surg Am*. 2012;37:1913–1916.
22. Strauss EJ, Weil WM, Jordan C, et al. A prospective, randomized, controlled trial of 2-octylcyanoacrylate versus suture repair for nail bed injuries. *J Hand Surg Am*. 2008; 33:250–253.
23. Simon RR, Wolgin M. Subungual hematoma: association with occult laceration requiring repair. *Am J Emerg Med*. 1987;5: 302–304.
24. Dean B, Becker G, Little C. The management of the acute traumatic subungual haematoma: a systematic review. *Hand Surg*. 2012;17:151–154.


 