6 Phalangeal and Metacarpal Fractures of the Digits

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Introduction

The metacarpals and phalanges are among the most commonly observed sites of fracture of the upper extremity in adults in the United States with an incidence of 20.9 fractures per 10,000 annually [1]. Together, metacarpal and phalangeal fractures comprise an estimated 41% of fractures below the elbow in the general population [1, 2]. Injuries of the hand and wrist account for 3–9% of all traumatic athletic injuries, with rates as high as 25% observed in adolescent athletes [3, 4]. Fractures of the metacarpals and phalanges account for over 40% of fractures among professional athletics injuries observed both in the United States and abroad [5, 6]. Male athletes have a particular predilection toward sustaining fractures of metacarpals (87:13, male/female athletes) and phalanges (80:20, male/female athletes) [5].

Fractures of the hand pose a particular challenge in baseball players due to the unique demands of fielding, throwing, and batting coupled with the limited ability to play wearing splints or casts. Fractures of the metacarpals and phalanges are observed at all levels of baseball; therefore, the treating surgeon must possess a sound understanding of the unique demands of their patient's tier of competition. The hand and fingers account for 8.5% of all baseball-related injuries, and over 30% of all fractures observed at the high school level [7]. Comparable rates of injury have been observed at the professional level with hand and finger injuries representing 10% of all baseball-related injuries, and 32.5% of all fractures [8, 9]. Of the observed hand and finger injuries, metacarpal fractures account for 2.6–4.7% of injuries, while phalangeal fractures account for 1.3–3.7% [8, 9]. Injuries of the upper extremity are of particular concern to players, coaches, trainers, and treating physicians as they account for significantly longer time lost to the Injured List relative to that observed in lower extremity and axial skeleton injuries, with average time out of competition in some series ranging from 51 to 59 days for metacarpal fractures and 31 to 61 days for phalangeal fractures [8, 9].

Optimal treatment of metacarpal and phalangeal fractures in baseball athletes is multifactorial in nature. Prompt diagnosis provides for appropriate early care and counseling of the athlete. The treating surgeon must acknowledge the unique needs and circumstances of athletes at different levels of competition from amateur to elite while remaining continually grounded in sound evidence-based medical practices. Strickland has cited the vocal, and occasionally unreasonable, external pressure often encountered by treating physicians from multiple stakeholders including

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parents, coaches, fans, and sometimes even the athletes themselves [10]. His commentary provides an invaluable perspective and serves as a reminder that the treatment of athletes must remain grounded in solid orthopedic principles to provide for the best short- and long-term treatment outcomes for the patient.

Anatomy

The architecture of the palm and digits lends itself well to the unique motions required for fielding, throwing, and batting. The carpometacarpal (CMC) joints serve as a stout transition from the distal row of the carpus to the metacarpals [11]. This is particularly true on the radial side of the hand where the index and long finger CMC joints exhibit particularly rigid ligamentous complexes. On the ulnar side of the hand, the ring and small finger CMC joints display increased mobility, allowing for 15–20° of flexion and supination which results in deepening of the palm [12]. This unique motion about the ulnar CMC joints, coupled with reciprocal flexion and pronation of the thumb CMC joint, allows for the palm deepening required for accommodation of objects such as grasping a baseball or bat handle.

The coronal and sagittal plane alignment of the metacarpals compliments the anatomy and function of the CMC joints. When viewed in the coronal plane, the long axes of the metacarpals are slightly divergent in nature, with the most radial portions of the index and most ulnar portion of the small finger metacarpal heads lying further from midline than their associated CMC joints. This orientation serves to increase the overall surface area of the palm relative to the width of the carpus. When viewed in the sagittal plane, the metacarpals appear in near parallel alignment. However, when viewed in the axial plane, the metacarpals appear to align in a concave arch configuration [13]. The depth provided by the carpal arch compliments the supination of the fourth and fifth CMC joints to allow for more effective object acceptance into the palm.

The diaphysis of the metacarpal is quite stable, and frequently displays relatively little displacement with low-energy injuries as a result of the attachments of the adjacent dorsal and palmar interossei [14]. Distally, the finger metacarpals are attached via the deep transverse intermetacarpal ligaments, which further stabilizes the metacarpal arch and allows for relative preservation of the bony architecture of the palm even in the setting of fractures. While the interossei origins can serve as partial stabilizers of the metacarpal diaphysis, their distal tendinous expansions impart a deforming force in the sagittal plane as a result of their course volar to the axis of rotation of the metacarpal head. The characteristic apex dorsal angulation of metacarpal fractures is in part attributed to this deforming force imparted by the interossei, along with a similar force from the lumbrical as it passes volar to the deep transverse intermetacarpal ligament. Varus and valgus stability of the metacarpophalangeal joints is conferred by a robust collateral ligament complex consisting of proper and accessory fibers which run in 30° and 90° angles, respectively, from the collateral recess of the metacarpal to the base of the proximal phalanx and volar plate.

The general bony morphology of the phalanges consists of a base, narrow diaphysis, and head [15]. The specific architecture of the proximal and middle phalanges is relatively similar and distinct from that observed in the distal phalanx. Radiographically, the proximal and middle phalanges exhibit a 2:1 size ratio [13]. The proximal phalanx is unique in that it does not have any direct extrinsic tendinous insertions, resulting in a predictable apex volar deformity secondary to the deforming forces of the central slip distally and interossei proximally when extraarticular fractures of the diaphysis occur. The insertions of the central slip of the extensor apparatus dorsally and flexor digitorum superficialis (FDS) palmarly contribute to unique fracture morphology in extraarticular fractures of the middle phalanx. Middle phalangeal fractures occurring proximal to the FDS insertion generally result in apex dorsal angulation as a result of the vector of pull of the FDS slips. Conversely, apex volar angulation is observed in middle phalangeal fractures occurring distal to the FDS insertion. The anatomy of the distal phalanx is distinct from that of the proximal and middle phalanges, consisting of a wide base which narrows through the diaphysis

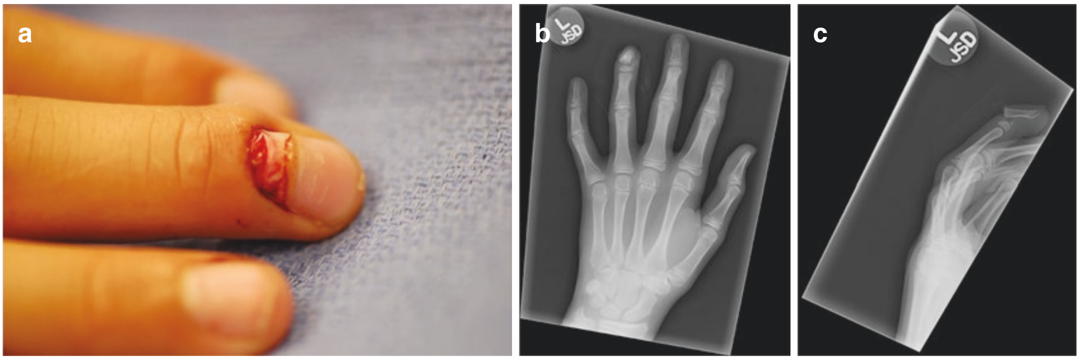

Fig. 6.1 Clinical image of the ring finger demonstrating a visible nail plate deformity concerning for injury to the underlying nail bed and distal phalanx (**a**) PA and lateral radiographs of the ring finger distal phalanx demonstrate a displaced physeal fracture in the same patient who was observed to have interposed nail bed at the time of fracture fixation consistent with a Seymour fracture (**b** and **c**)

and distal tip (often referred to as the "tuft"). Tendinous insertions on the distal phalanx include the terminal tendon of the dorsal apparatus and the flexor digitorum profundus tendon more volarly and distal, both of which may act as deforming forces in fractures of the distal phalanx. The nail plate and underlying nail matrix must also be taken into consideration when treating fractures of the distal phalanx as this tissue may become interposed in fracture sites in both children and adults. In skeletally immature patients, the classic "Seymour" fracture has been described as a physeal fracture associated with entrapment of the nail matrix between the epiphyseal and metaphyseal fracture fragments resulting in non-anatomic alignment (Fig. 6.1a–c). Lacerations of the nail matrix require prompt attention and repair in order to avoid future nail deformity which may impair function of the finger and result in an unacceptable cosmetic deformity in some patients.

Mechanism of Injury

Metacarpal fractures have been observed to occur more frequently than phalangeal fractures in baseball at the minor and major league levels [9, 16]. Fractures of the metacarpal commonly occur as a result of a direct blow from the baseball to the dorsum of the band in batters [17]. This typically affects the lead hand (bottom hand) as the dorsum of the hand faces toward the pitcher and is in line with the trajectory of the incoming pitch. Metacarpal fractures may also occur as a result of direct impact with another player (e.g., collisions at home plate, tagging an opposing player, unintended collision between outfielders, etc.), impact of the hand on a solid object such as a base or with the outfield wall, or a fall onto an outstretched hand.

Phalangeal fractures have a lower incidence than metacarpal fractures but are at risk during similar activities to those which place the metacarpals at risk. Proximal and middle phalangeal fractures occur less frequently than do fractures of the distal phalanx. Due to the relatively unprotected position of the distal phalanx at the tip of the finger, it is at particular risk from events such as fielding a ground ball, sliding into a base, or collisions with players or objects [18].

Differential Diagnosis

Athletes reporting pain about the hand or digits warrant evaluation with a thorough history and physical examination. Particular attention should be paid to the mechanism of injury, reported areas of pain, and associated symptoms. In addition to fractures of the metacarpals and phalanges, care should be taken to rule out alternate or associated diagnoses of the affected extremity. Pain and swelling about the dorsum of the hand may be indicative of a metacarpal fracture, or fractures, but may also be suggestive of injury to the extensor tendons over the dorsum of the hand. Carpal fractures may also present with pain referred distally to the hand and fingers, and care should be taken to rule out any associated carpal pathology such as a fracture of the scaphoid. More distally, pain about the metacarpal head and neck should prompt careful evaluation of the MCP collateral ligament complex as well as the sagittal bands. Distally in the finger, careful attention should be turned to exclusion of associated injuries of the flexor tendons, flexor pulley system, and injuries to the dorsal apparatus (i.e., central slip, lateral bands, terminal tendon).

Physical Examination

When fractures of either the metacarpals or phalanges are suspected, physical examination should begin at the carpus and proceed distally. The hand and fingers should be carefully inspected and compared to the contralateral extremity to note any areas of asymmetry. Particular attention should be paid to areas of swelling, skin changes (erythema, induration, ecchymosis, pallor), skin turgor, open wounds (lacerations, abrasions), loss of normal metacarpal arch contour, altered MCP joint contour, malrotation of the digits, and temperature change. Open metacarpal and phalangeal fractures are relatively uncommon in baseball but should be formally ruled out as this may indicate the athlete for urgent operative intervention for irrigation and debridement of the fracture site. The carpus should be palpated for any focal areas of tenderness suggesting underlying bony or soft tissue injury. Formal examination of the distal radioulnar joint (DRUJ) should be conducted including assessment of the ulnar styloid, triangular fibrocartilage (TFC), extensor carpi ulnar (ECU), and integrity dorsal and volar radioulnar ligaments.

Examination of the hand and fingers should include formal assessment of the digital extensor tendons, sagittal bands, dorsal apparatus of the digit, and flexor tendon system. Range of motion of the MCP, PIP, and DIP joints should be assessed for pain with motion or differences in mobility relative to the contralateral extremity. A detailed neurovascular examination should be performed including sensation in the distal median, ulnar, and radial nerve distributions. Peripheral pulses and capillary refill should be assessed, especially in catchers, and if concern for vascular injury exists, further evaluation with handheld Doppler ultrasound should be conducted promptly.

Imaging

If sufficient concern exists for fracture of either the metacarpals or phalanges, imaging with plain radiographs should be conducted. Posteroanterior (PA), lateral, and oblique radiograph of the hand should be obtained for evaluation of metacarpal fractures. Obtaining oblique radiographs in both pronation and supination is occasionally indicated to provide added detail with respect to the metacarpal anatomy. Oblique radiographs also provide added detail regarding the integrity of the CMC joints, and may detect subtle injuries not readily apparent on standard PA and lateral radiographs [19]. A 30° pronated view is especially helpful for evaluating the fourth and fifth CMC joints. The Brewerton PA view may also be indicated when concern for metacarpophalangeal joint injury exists. This view is obtained by capturing a PA image of the hand with the MCP joints flexed to 60°, and the X-ray beam directed 75° relative to the plate [14]. PA, lateral, and oblique radiographs of the finger should be obtained for suspected phalangeal fractures. Advanced imaging with computed tomography (CT) scans of the hand and/or digit may be obtained if concern for intraarticular fracture exists and radiographic examination alone is deemed insufficient in fully characterizing the injury pattern. CT may be particularly helpful for injuries about the CMC and MCP joints where significant overlap of adjacent structures may obscure visualization on plain radiographs.

Conservative Treatment

Nondisplaced and minimally displaced metacarpal fractures with preserved length, rotation, and alignment are often amenable to nonsurgical treatment though many non-biologic factors such as level of the athlete, time remaining in season, and hand dominance may influence the decision. Angulation of 30–40° of the ring and small finger metacarpals, and 15–20° of index and long finger metacarpals, is generally well-tolerated. While these parameters are often acceptable for the general population, this may not be acceptable for optimum hand function for hitting, fielding, and throwing due to the discomfort associated with a prominent metacarpal head in the palm [17]. Principles of conservative treatment including edema control and maintenance of active and passive range of motion (ROM) of the MCP, PIP, and DIP joints are strictly adhered to in the early post-injury period to allow for timely return to sport. A removable radial gutter orthosis for index and long finger metacarpal fractures, and ulnar gutter orthosis for ring and small finger metacarpal fractures generally, provides adequate support for the player to continue with other daily activities in the early post-injury period. The addition of buddy taping may be considered to discourage malrotation, particularly in more unstable fracture patterns such as long oblique or spiral fractures. Initiation of active ROM with the MCP joints immobilized and IP joints free is initiated on the first 2–3 days following injury to prevent joint stiffness and facilitate return to a baseball-specific rehabilitation program. Follow-up radiographs should be obtained at 2 and 4 weeks post-injury to assess for evidence of radiographic healing. The player is usually converted to a removable orthosis with the MCP joint free at 3 weeks post-injury. Return to play is generally allowed at 6 weeks post-injury provided the player demonstrates at least 75% MCP, PIP, and DIP range of motion (or has returned to their baseline if preexisting deficits were present) and radiographs demonstrate callous formation at the fracture site. Protective dorsal hand splints can be fabricated for players who desire extra protection of the dorsal hand while batting, but formal orthosis wear is otherwise not strictly recommended or tolerated for pitching and fielding.

Similar guidelines are followed for conservative treatment of phalangeal fractures. Nondisplaced or minimally displaced, extraarticular, length-stable fractures are generally considered amenable to nonoperative treatment. Initial treatment for stable fracture patterns generally consists of buddy taping for a period of 2–3 weeks, with an active ROM program beginning no later than 3 weeks after injury. Return to baseball-specific activities is generally allowed between 4 and 6 weeks after injury once painless active ROM of the MCP, PIP, and DIP joints has been achieved. Return to gameplay is allowed between 4 and 6 weeks as well as pending the player's progress with a baseball-specific rehabilitation program under the direction of their trainer.

Surgical Treatment

Surgical treatment of metacarpal fractures is indicated for injuries resulting in malrotation of the digits, open fractures, fractures with shortening >4–5 mm, intraarticular fractures of the metacarpal head, CMC fracture dislocations, and fractures with associated neurovascular or tendon injuries requiring repair. Relative indications for treatment of metacarpal fractures include angulation greater than 20–30° of index and long finger metacarpal shaft fractures, or 30–40° of angulation of ring and small finger metacarpal fractures, prominent metacarpal head in the palm, and multiple metacarpal fractures. Furthermore, elite athletes (we consider professional, college players with aspirations of professional play, and occasionally high school athletes with opportunities for scholarships) may elect surgical management for nondisplaced and minimally displaced fractures in an effort to return to sport sooner. Athletes should be carefully examined for prominence of the metacarpal head in the palm at the level they would grip a bat or the baseball. If athletes are sufficiently bothered by the position of the metacarpal head in the palm, then consideration may be given to operative fixation following a thorough discussion of risks and benefits with the player and the team. Multiple fixation constructs are available for treatment of metacarpal fractures, and the optimal treatment strategy is the one which will allow for stable fixation and early range of motion. Achievement of stable fixation allows for early range of motion, and expeditious progression toward return to play.

Metacarpal Head Fractures

Most metacarpal head fractures are approached via either a longitudinal split of the extensor tendon or a parasagittal approach through the sagittal bands. The authors' preference is to approach the long and ring finger metacarpal head by dividing the ulnar sagittal band and retracting the extensor tendon to expose the fracture site and the metacarpophalangeal joint. The sagittal band is repaired at the time of closure with 3-0 or 4-0 nonabsorbable suture to prevent postoperative extensor tendon subluxation. The index and small finger metacarpal heads are preferentially approached via a longitudinal split in the interval between the common extensor tendon and accessory digital extensor (extensor indicis proprius for the index finger, extensor digiti quinti for the small finger). At the time of closure, the longitudinal split is repaired with 3-0 or 4-0 absorbable suture in a figure-of-eight fashion. Intraarticular fractures of the metacarpal head are treated with anatomic reduction and fixation with either headless interfragmentary compression screws, plate and screw constructs, or smooth Kirschner wires. Plate and screw constructs may be left in place permanently if they do not result in any discomfort in the hand upon return to play. If removal is ultimately desired by the athlete, this is generally performed at least 6 months from the time of fixation and only if the fracture has gone on to clinical and radiographic union. Kirschner wires used for fracture fixation are generally removed between 3 and 4 weeks after surgery; however, these may be left in place for up to 6 weeks if required for achievement of fracture union prior to removal. Rarely, volar shear fractures of the metacarpal head can be encountered. These are best approached with a palmar approach, releasing the A1 pulley, and releasing the volar plate distally. The fracture is then fixed with headless compression screws when possible and the volar plate repaired at the time of closure.

Metacarpal Shaft Fractures

Fractures of the metacarpal shaft are approached via a longitudinal dorsal approach due to the relatively subcutaneous nature of the metacarpal shaft. The common digital extensor tendon is mobilized in line with the incision and retracted radially or ulnarly at the discretion of the treating surgeon. Fixation can be achieved with either interfragmentary screws, plate and screw constructs, or intramedullary fixation using smooth Kirschner wires or a cannulated screw. The fixation construct utilized should be tailored to the fracture pattern present. Provisional reduction is achieved using a combination of longitudinal traction and rotation of the digit. Reduction is maintained with either smooth wires or a small, pointed reduction clamp. Care should be taken to ensure provisional fixation allows for placement of the desired fixation construct and does not result in fracture comminution or displacement.

Interfragmentary lag screw fixation of spiral and long oblique fractures is preferred when the fracture length is at least twice that of the diameter of the bone at the length of the fracture. Fixation generally requires two to four interfragmentary screws depending on the fracture pattern (Fig. 6.2a, b). Screws are placed in a lag-by-technique fashion by over-drilling the near cortex such that the screw glides through the near cortex to engage and compress via the distal cortical hole. The first screw placed should allow for compression perpendicular to the fracture site, with subsequent screws placed proximally and/or distally for added torsional stability.

Metacarpal plating is suitable for treatment of short oblique, transverse, and comminuted fractures of the metacarpal shaft. Plate and screw constructs can be applied to either the dorsal or lateral aspects of the metacarpal depending on the fracture morphology. The plate selected

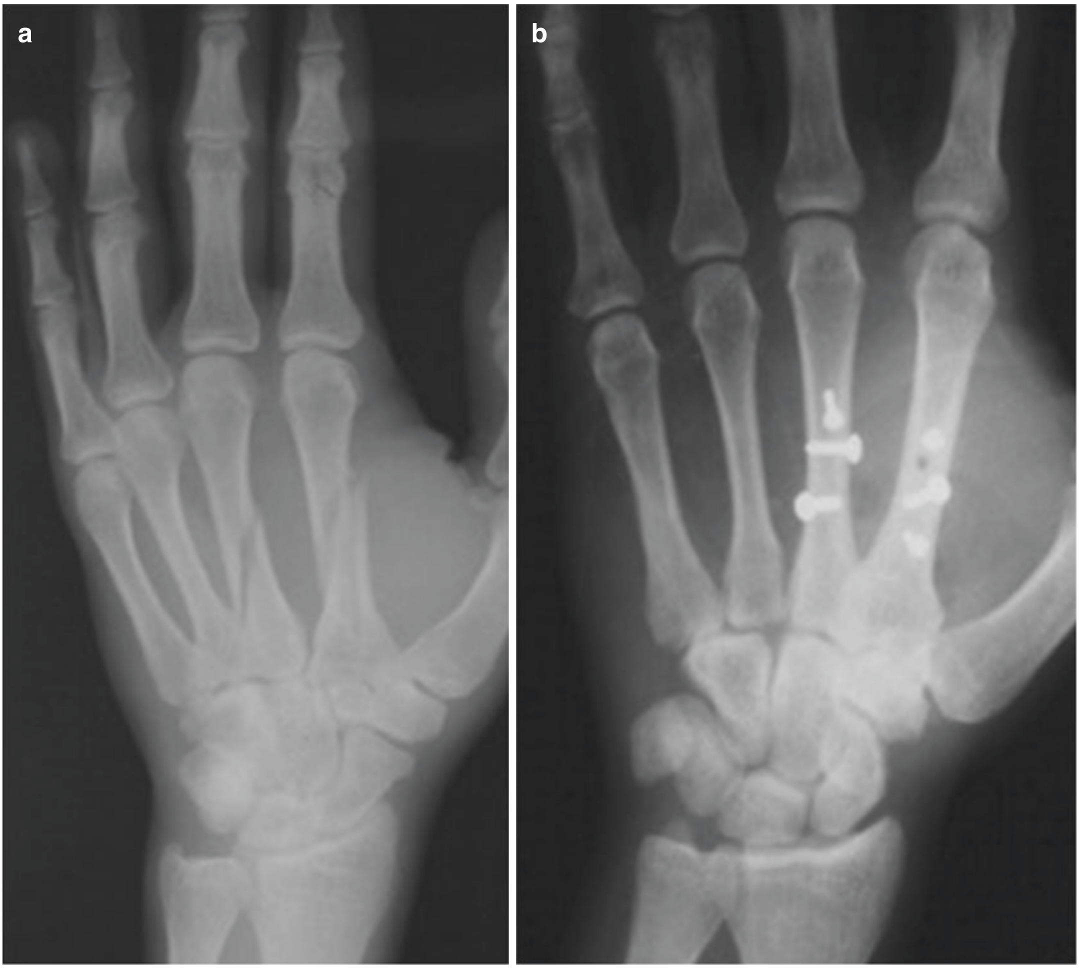

Fig. 6.2 Oblique fractures of the index and long finger metacarpal shaft (**a**) treated with interfragmentary lag screw fixation (**b**)

should allow for fixation of six to eight cortices on both sides of the fracture to ensure adequate stability will be present to allow for early active motion (Fig. 6.3a–d). Plate contouring may be required to accommodate the dorsal bow of the metacarpal shaft to ensure that fixation does not result in fracture malreduction. Care must also be taken to ensure that screw heads are sufficiently recessed within the plate, and no prominent plate edges are present in order to avoid mechanical abrasion of the extensor tendons which may result in pain or tendon rupture. Following completion of fixation, closure of the interosseous fascia over the plate construct should be undertaken when possible to minimize hardware prominence which may be bothersome while wearing either a fielding glove or batting glove.

Intramedullary pinning may be selected for the treatment of transverse, short oblique, and comminuted fractures of the metacarpal shaft. Intramedullary fixation provides sufficient stability to allow for mobilization of the athlete while minimizing trauma to the surrounding soft tissues. Pinning can be performed in an antegrade, retrograde, or transverse fashion depending on the fracture morphology present. Antegrade pinning is best suited for proximal and mid-diaphyseal metacarpal shaft fractures (Fig. 6.4a–i). A longitudinal incision is made centered over the base of the metacarpal. The extensor tendon and travers-

Fig. 6.3 (**a**–**d**) Oblique fractures of the long and ring finger metacarpal shafts (**a** and **b**) treated with open reduction and internal fixation with a plate and screw construct (**c** and **d**)

ing dorsal sensory nerve branches are identified and carefully protected. A starting awl or small diameter drill (1.2–1.8 mm) is used to create a small window in the dorsal metacarpal base. Depending on the size of the patient and fracture morphology, either 0.035″ or 0.045″ smooth wires may be selected for fixation. Wires are prebent to match the native bow of the metacarpal for which they are to be used and then advanced in an antegrade fashion into the medullary canal using the previously created pilot hole. Generally, either two 0.045″ wires or three 0.035″ wires are

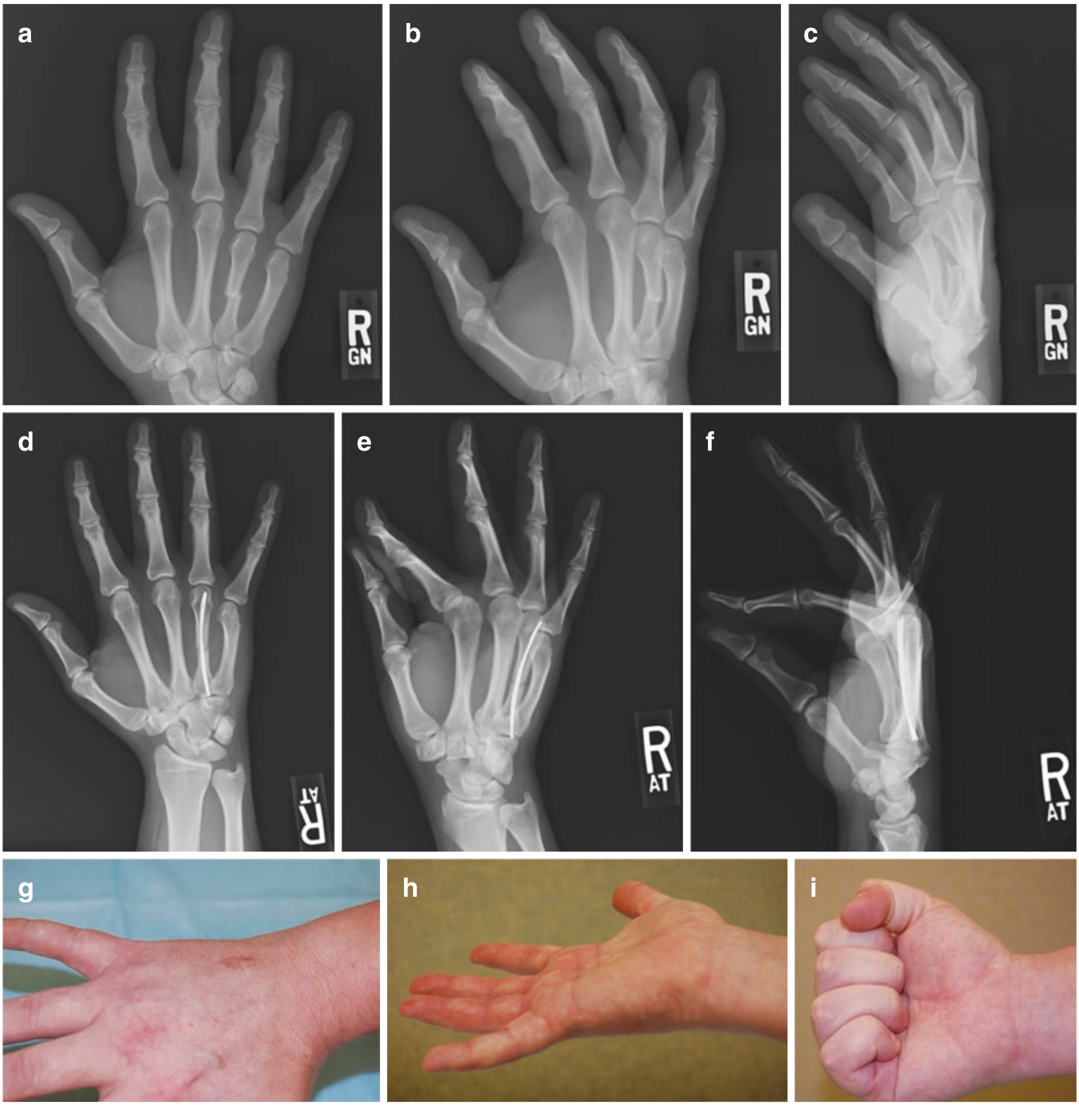

Fig. 6.4 (**a–i**) Transverse fracture of the ring finger metacarpal shaft (**a–c**) treated with antegrade intramedullary wire fixation (**d–f**). At 6-week postoperative follow-up, the patient demonstrated a well-healed wound and full active digital motion (**h–i**)

inserted to achieve stable fixation. Wires may be cut flush with the dorsal cortex of the metacarpal and left in place permanently or left slightly proud for later retrieval following fracture union. Retrograde pinning of the metacarpal is performed percutaneously by passing two 0.035″ or 0.045″ smooth wires from the radial and ulnar collateral recesses into the medullary canal of the metacarpal. Care must be taken to avoid inadvertent penetration of the articular surface of the metacarpal head when obtaining the starting point of the wire as hardware placed in this position may be a source of pain, limited motion, and chondral loss which could be deleterious to the athlete's future return to sport in both the short and long term. The authors' preference is to cut the wires below the skin to decrease the risk of pin tract infection and allow for early range of motion without irritation from wire prominence when this fixation is used. Wires are generally retrieved between 3 and 6 weeks following fixation provided evidence of clinical and radiographic healing is present. Retrieval may be performed with the athlete wide-awake under local anesthetic block to avoid the need for formal return to the operating room. Transverse pinning is useful for maintenance of length, rotation, and alignment of comminuted or significantly length-unstable fracture patterns. This fixation construct is most frequently utilized for the border digits, where the intact long and ring finger metacarpals are used to maintain the desired reduction of the index and small fingers, respectively. Generally, one to two 0.045″ smooth wires are placed both proximal and distal to the fracture site in a transverse, quadricortical fashion across the diaphysis of adjacent metacarpals. Wires are cut below the skin to avoid irritation and decrease the risk of superficial soft tissue infection. Similar to retrograde wire fixation, transverse wires are generally retrieved between 3 and 6 weeks following fixation provided evidence of clinical and radiographic healing is present. Retrieval of transverse wires may also be performed with the athlete wide-awake under local anesthetic block. In general, we try and avoid the use of K-wires for athletes during the season given the risk of refracture once the pins are removed and return to sport commences.

The use of intramedullary screw fixation for the treatment of metacarpal fractures has become our treatment of choice for transverse and short oblique metacarpal shaft fractures (Fig. 6.5a–f). Similar to intramedullary nail fixation of other long bones, the ability to provide rigid, length-stable, diaphyseal fit fixation of the metacarpal with minimal soft tissue trauma allows for earlier mobilization and return to weightbearing activities compared to smooth wire or plate and screw constructs [20]. A provisional closed reduction is first achieved via either closed or limited percutaneous means. After reduction has been achieved, the proximal phalanx is flexed 90°, and a 1 cm incision is made over the dorsal aspect of the MCP joint allowing for creation of a small longitudinal split in the common digital extensor tendon. Under fluoroscopic guidance, the starting guidewire is placed slightly dorsal in the metacarpal head such that it is in-line with the center of the diaphysis on a lateral projection of the metacarpal. The guidewire is advanced across the fracture site to the subchondral bone of the metacarpal base. Using the appropriate sizing guides for the intramedullary fixation system selected, the appropriate screw length and diameter is selected. The appropriate screw length should account for recession of the screw at least 2 mm below the chondral surface of the metacarpal head. Careful attention should be paid to the inner diameter of the metacarpal isthmus, particularly in the ring finger metacarpal which often has the most narrow coronal plane intracortical diameter at the isthmus, and small finger which has the most narrow sagittal plane intracortical diameter at the isthmus [21, 22]. We prefer to template the screw over the skin under fluoroscopic guidance prior to implanting it to ensure appropriate canal fit.

Operative treatment of proximal and middle phalangeal fractures is accomplished by similar means to those described for the metacarpal. Fractures about the proximal phalangeal head or middle phalangeal base warrant careful scrutiny on radiographs to determine the congruency of the PIP joint, as fracture dislocations of the PIP sometimes require alternate treatment methods to those described here for fractures without associated joint dislocation [23]. Unicondylar and bicondylar fractures of the phalangeal head may be treated with smooth 0.035″ wires in either a parallel or crossing pattern, interfragmentary screw fixation, plate and screw constructs, or a combination of these strategies. Transverse and short oblique fractures of the proximal and middle phalanx can be treated with either retrograde or antegrade pinning with smooth 0.035″ or 0.045″ wires (Fig. 6.6a–d). Similar to that of the metacarpal, the authors' preference is to cut the wires below the skin and plan for removal in 3–6 weeks depending on the degree of healing present and fracture morphology. Plate and screw constructs may be employed for transverse, short oblique, or comminuted fractures (Fig. 6.7a, b). Plates may be placed on either the dorsal or lateral surfaces of the phalanx, with care taken to avoid irritation to the central slip or lateral bands

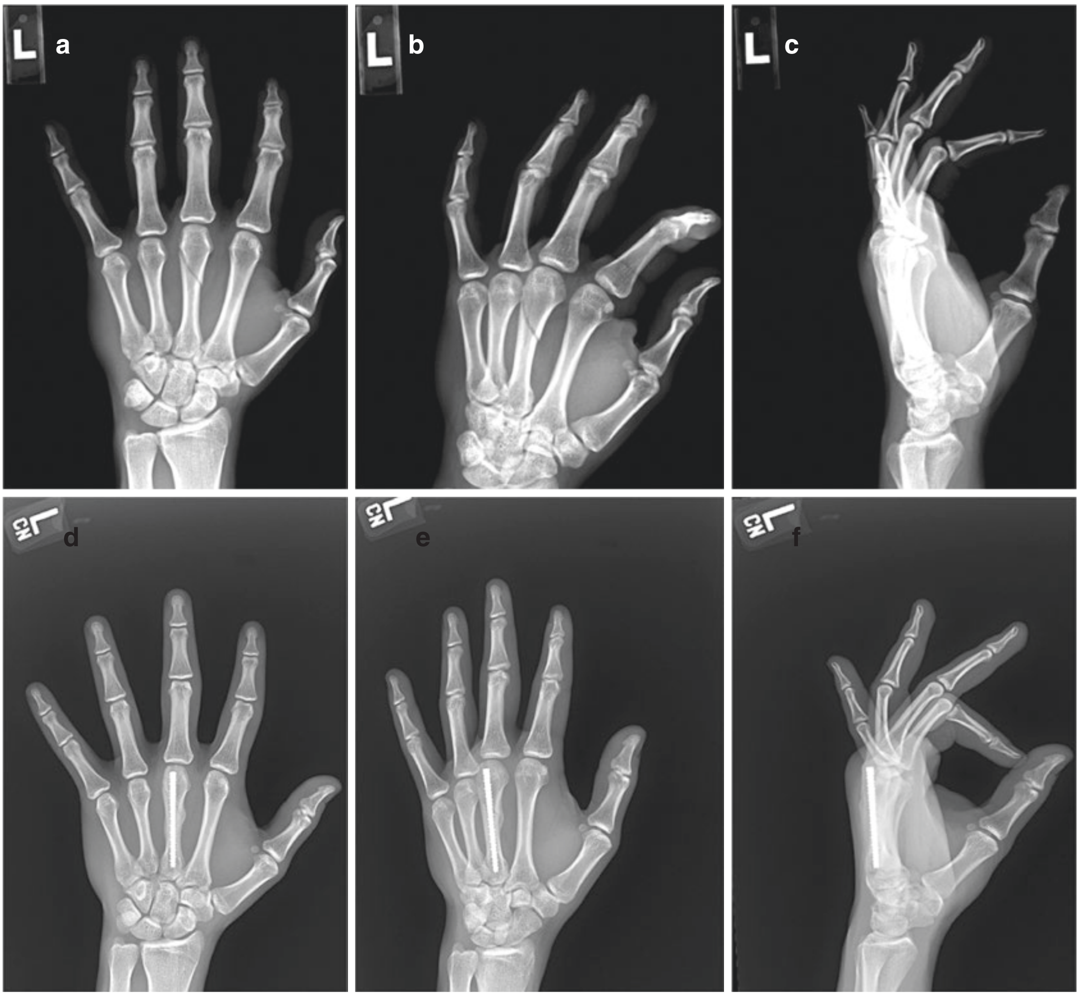

Fig. 6.5 (**a**–**f**) PA, oblique, and lateral radiographs of a left long finger distal metacarpal shaft fracture with significant clinical malrotation of the finger on examination (**a**–**c**). Six-week postoperative PA, oblique, and lateral radiographs demonstrate robust callous formation at the fracture site following intramedullary screw fixation (**d**–**f**)

of the dorsal apparatus. Retrograde or antegrade intramedullary screw fixation may also be considered for transverse and short oblique fractures of the proximal and middle phalanx and may allow for earlier return to activities (Fig. 6.8a–e). Spiral and long oblique fractures whose length measures at least two times the cortical diameter at the shaft are amenable to fixation with two or three interfragmentary lag screws. Occasionally, fractures of the proximal or middle phalangeal bases will require supplementary transarticular pinning of the PIP or MCP joints, or dorsal extension block pinning of either joint in order to maintain stable fracture reduction. Use of these modalities should be done with caution as this may result in a greater degree of motion loss that would be observed with non-transarticular fracture fixation.

Post-treatment Rehabilitation

Following most surgical treatment of metacarpal fractures, the athlete is immobilized in a radial gutter splint for the index and long finger metacarpals or an ulnar gutter splint for the ring and

Fig. 6.6 (**a**–**d**) PA and lateral radiographs of transverse fractures of the right ring and small finger proximal phalangeal bases (**a**, **b**) treated with closed reduction and percutaneous pinning with 0.045″ smooth wire fixation (**c**, **d**)

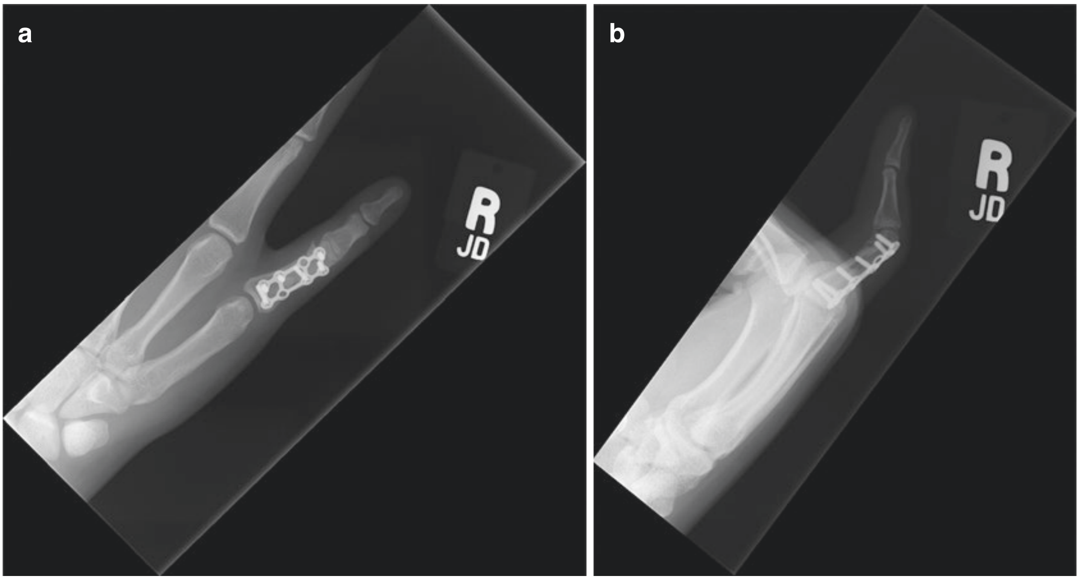

Fig. 6.7 (**a**, **b**) PA and lateral radiographs of a right small finger proximal phalanx fracture treated with open reduction and internal fixation with a plate and screw construct

small finger metacarpals. Active range of motion of the IP joints should be encouraged during the initial period of immobilization. Two weeks postoperatively, the patient is converted to a removable orthosis which blocks MCP motion but allows for continued free PIP and DIP motion. At 4 weeks, the player is converted to a hand-based radial or ulnar gutter splint for comfort and allowed to begin MCP range of motion. The immediate postoperative splint for those treated with intramedullary or transverse pinning should include the MCP joint in an intrinsic plus position with IP joints free. The player is subsequently converted to a removable orthosis to be worn as needed for comfort following suture removal at 2 weeks postoperatively. Following suture removal, the player is encouraged to return to conditioning activities as tolerated while adhering to the restrictions set forth for the operative hand. Players are allowed to begin full weightbearing activities once clinical and radiographic union are observed, generally at 6–8 weeks postoperatively. Athletes treated with rigid fixation including intramedullary screw, interfragmentary lag screw, or plate and screw constructs are allowed to return to early range of motion at the discretion of the treating surgeon, sometimes as early as 3–5 days postoperatively.

Rehabilitation following fixation of phalangeal fractures includes immobilization in a radial gutter splint with the digits in intrinsic plus position with the DIP joint free for proximal phalanx fractures of the index and long finger, or a similarly fashioned ulnar gutter splint for proximal phalanx fractures of the ring and small finger. Fractures of the middle phalanx are immobilized in a digital gutter splint incorporating the adjacent digit, with the MCP joint left free for range of motion. At 2 weeks, sutures (if present) are removed and the athlete is converted to removable orthosis similar to their immediate postoperative splint. The player is allowed to begin removing their splint for gentle ROM of all joints beginning at 3–4 weeks postoperatively if the fracture remains stable on follow-up radiographs. The removable orthosis is generally discontinued between 4 and 6 weeks postoperatively once the player has achieved pain-free range of motion. Players are allowed to begin full weightbearing activities once clinical and radiographic union are observed, generally at 6–8 weeks postoperatively.

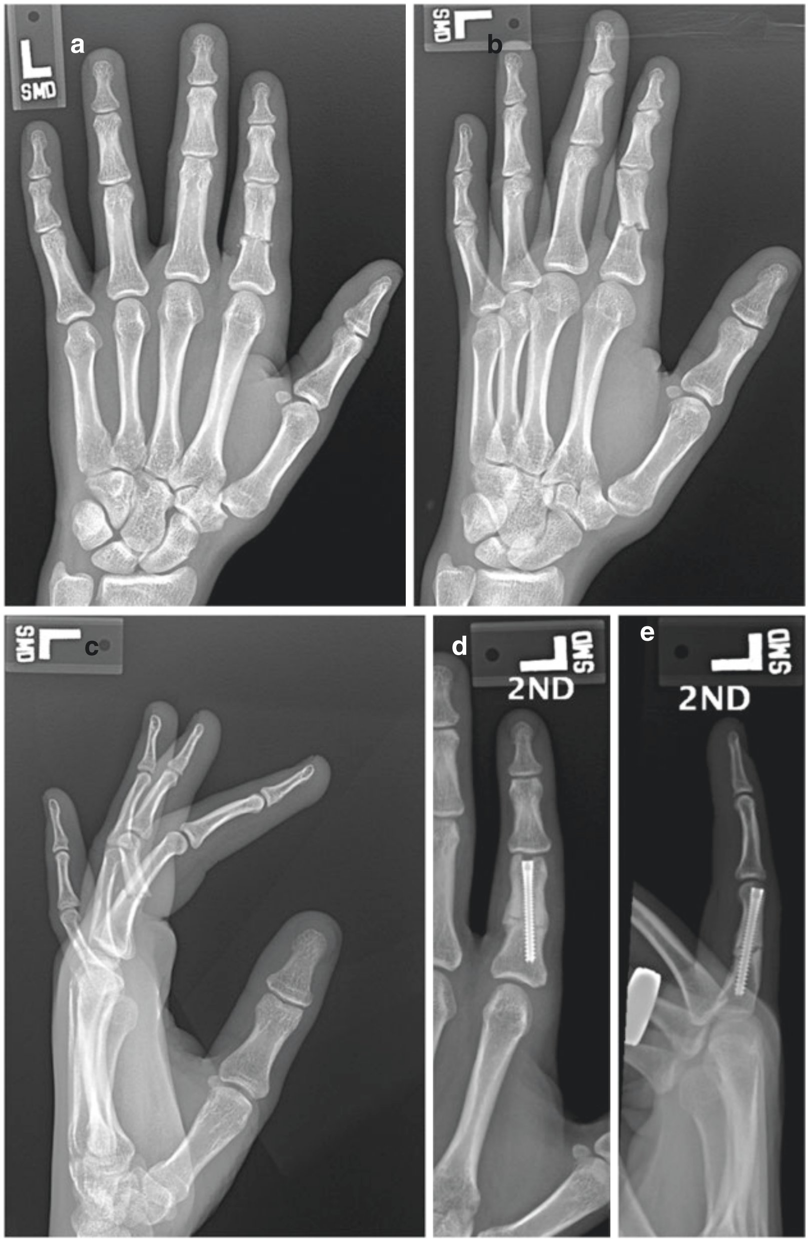

Fig. 6.8 (**a**–**e**) PA, oblique, and lateral radiographs of a transverse fracture of the index proximal phalanx (**a**–**c**) treated with retrograde intramedullary screw fixation (**d**, **e**)

Complications

Complications may occur as a result of both nonoperative and operative treatment of metacarpal and phalangeal fractures. Patients treated with smooth wire fixation are at risk for pin-site irritation or pin-site infection. Superficial pin-site infections should be treated with 7–10 days of oral antibiotics, with close monitoring by the training room staff and treating surgeon to ensure resolution of the infection. Deep infection is rare with the described operative treatment modalities, but if present should be treated with prompt surgical debridement of the infection, removal or exchange of the hardware if possible, and appropriate antimicrobial therapy.

Smooth wire fixation may also result in wire breakage, which may complicate wire retrieval at the time of union or contribute to delayed union, nonunion, or malunion if occurring in the early postoperative period. Similarly, hardware failure has been observed with both interfragmentary screw and plate and screw constructs which may contribute to delayed union, nonunion, or malunion of the fracture. Malrotation of the digit following surgical fixation can be observed if careful attention is not directed to restoration of the normal digital flexion cascade intraoperatively. As little as 5° of malrotation can cause clinically significant digital overlap and may result in player dissatisfaction with the operation and limitations in performance. Shortening of the metacarpal may be poorly tolerated, as an extensor lag of 7° has previously been observed to result from every 2 mm of metacarpal shortening.

Postoperative stiffness is frequently observed following operative treatment of metacarpal and phalangeal fractures. Loss of motion may occur as a result of extensor tendon adhesion over the metacarpal, dorsal apparatus adhesions over the digit, collateral ligament contracture or tethering by fixation hardware, and capsular contracture. The degree to which stiffness occurs is often dependent upon the ability to effectively mobilize the athlete following surgery. The importance of edema control and early range of motion of the uninvolved joints cannot be overemphasized to the training staff and the athlete. Clinical examination by the treating surgeon at regular intervals postoperatively may allow for identification and early intervention for impending stiffness resulting in minimal lost time from competition. While removal of hardware for plate and screw constructs is not routinely indicated, this may be considered in players with postoperative stiffness and suspected tendinous adhesions undergoing an extensor tenolysis with or without concomitant dorsal capsulectomy.

Early Return to Play

The goal of both operative and nonoperative treatment of metacarpal and phalangeal fractures is to achieve clinical and radiographic fracture union and allow the athlete to return to competition as quickly and as safely as possible. In a survey of professional sports franchise hand consultants, it was noted that 38% favored immediate return to protected play for nondisplaced metacarpal fractures, while another 56.8% recommended return to protected play at 3–4 weeks (approximately the time of clinical union) [24]. In this same survey, unprotected play was allowed at 4–8 weeks by 73% of hand consultants. For players undergoing nonoperative treatment, we advocate for early edema, control, and initiation of range of motion of the unaffected adjacent joints to allow for early return to play. For patients with nondisplaced or minimally displaced metacarpal fractures amenable to nonoperative treatment, return to positional drills and batting practice may be allowed as early as 2 weeks if the patient is pain-free and has the requisite range of motion for each of these activities. Provided the player continues to progress with a focused return to play program under the supervision of the team's trainer, return to full competition may be allowed as early as 3 weeks (though it can take up to 6–8 weeks) without the need for formal orthosis wear. If early return to play is critically important due to any number of factors (scholarships, contractual implications, postseason, or championship competition), athletes may be counseled on the risks and benefits of intramedullary screw fixation of nondisplaced and minimally displaced fractures of the metacarpals and phalanges if it is felt this will allow for earlier return of range of motion and subsequent return to play. Players undergoing rigid intramedullary fixation of these fractures are often allowed to begin an early active range of motion as early as day 3 postoperatively, including MCP and PIP joint motion for metacarpal and proximal phalangeal joints, respectively. It is recommended that if players are to return to early baseball-related activities, the finger of the affected ray should be buddy taped to an adjacent digit to allow for assistance with range of motion and discourage malrotation of the involved digit.

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