Phalanx fractures and dislocations in athletes

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Abstract

Purpose of review Phalangeal fractures, dislocations, and fracture-dislocations in the hand are common injuries. We review the current literature on the diagnosis and treatment of these injuries in the athlete. An understanding of the anatomy and its relationship to the mechanism of injury may help to direct appropriate management. Return to play remains an important concern to the patient-athlete.

Recent findings Findings from recently published articles reinforce previously established treatment methods in the management of finger phalangeal fractures, dislocations, and fracture-dislocations. The majority of these injuries can be treated non-operatively. Technological advances in implant designs may conceivably allow for earlier rehabilitation and, in turn, a more expeditious return to sport. Management of phalangeal injuries in the elite athlete often necessitates special treatment considerations.

Summary The majority of phalangeal bone and joint injuries in the athlete can be treated in a comparable manner to the non-athlete. The goals of treatment are restoration of bone and joint alignment and stability in order to hasten a return to competition. Surgery as a means to expedite return to play in the high-level athlete should be determined on a case by case

basis. Technological improvements in surgical implants may enable accelerated postoperative recovery. However, to our knowledge, there are no published studies to definitively support this assumption.

Keywords Hand fractures · Phalangeal fractures · Finger dislocations · Finger fracture-dislocations · Sports injuries

Introduction

Metacarpal and phalangeal fractures account for nearly half of all hand injuries presenting to the emergency room [1]. Finger fractures occur most commonly in young men in the second to fourth decades of life and are often the result of athletic participation [2–4]. Aitken and Court-Brown [5] reviewed 320 sports-related hand fractures at one facility and found that 54% of these fractures involved the phalanges. Contact sports and ball handling accounted for the majority of fractures in their series.

Fractures of the distal phalanx tuft are common and can be treated non-operatively in most cases. In contrast, displaced and unstable fractures of the phalangeal shafts or condyles can be problematic and may necessitate surgery for optimum outcome. Management strategies for reducible and relatively stable fractures parallel those for the non-athlete; however, a prolonged time away from sports participation can have a negative impact on the elite athlete. Operative treatment for a more expedient return to play in the high-level athlete has been entertained in recent publications [6, 7].

Dislocations and fracture-dislocations of the proximal interphalangeal (PIP) joint are also common injuries among athletes. Mall and colleagues [8] reviewed upper extremity injuries in the National Football League and found that PIP dislocations represented 17% of all injuries. Management of

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PIP joint trauma requires a clear understanding of fracture and/or joint stability after reduction. Dislocations and fracture-dislocations of the distal interphalangeal (DIP) are much less common and, in the absence of tendon disruption, may require only temporary protection.

We review the current treatments for finger phalangeal fractures, dislocations, and fracture-dislocations in the athlete, including suggestions on returning to play. Improvements in implant designs and surgical techniques may influence the decision toward operative intervention as a means of achieving earlier return to sport and/or improved functional outcome in the elite athlete.

General principles

The treatment of phalangeal fractures, interphalangeal joint dislocations, and interphalangeal joint fracture-dislocations in both the athlete and non-athlete are dependent upon fracture location and the inherent stability of the fracture and/or joint. Non-displaced, extra-articular phalangeal fractures tend to be stable and can be treated non-operatively with finger splinting followed by early rehabilitation. Buddy taping, with or without the addition of a protective splint, may allow early return to sports. A protective splint or a play cast will ideally incorporate the joints proximal and distal to the fracture [6].

Concentrically reduced interphalangeal joints, in the absence of an unstable intra-articular fracture or tendon disruption, are typically amenable to temporary splinting and buddy taping. Small avulsion fractures involving the volar plate from the base of the middle or distal phalanx are similar to simple interphalangeal joint dislocations and may be effectively treated with temporary splinting. In contrast, a displaced or comminuted base, shaft, neck, or head fracture can be unstable and require operative repair to restore anatomic alignment and solidity.

Clinical examination and dedicated finger radiographs are necessary to accurately diagnose phalangeal fractures and interphalangeal joint malalignment. The integrity of the soft tissue envelope, the neurovascular status of the finger, and the function of the finger flexor and extensor tendons are integral parts of the examination. When possible, an athlete with an on-field finger injury should undergo X-ray evaluation prior to attempted fracture or joint reduction in order to prevent additional injury.

An astute awareness for subtle finger deformities is important. Finger rotational and/or angular deformities may be difficult to discern due to traumatic swelling and pain. The alignment of the finger nail plates should mimic the uninjured hand, and the tips of all fingers should point toward the scaphoid tubercle with finger flexion [9]. The diagnosis of a rotational deformity of the small finger must be made with assiduity as the small finger will normally scissor with the ring

finger in mid-flexion, re-aligning with the other digits when fully flexed [10•].

Mechanism of injury and displacement

Sports-related phalangeal fractures typically occur as a result of a fall, direct blow, twisting, or crushing injury. The movements of the hand and body in different sports have a direct impact on the type of finger injury sustained [3]. Player position and hand dominance are also factors that may influence the injury pattern [9].

The majority of finger injuries in sports are the result of low energy trauma [11•]. Consequently, marked soft tissue damage is uncommon. Inherent stability of phalangeal fractures is affected by the surrounding soft tissues. For example, comminuted fractures of the distal phalanx tuft are normally stabilized by fibrous septa in the finger pulp.

Displaced fractures of the proximal phalanges will often exhibit apex volar angulation due to the pull of the extrinsic and intrinsic muscles originating in the forearm and hand, respectively. The central slip of the extensor apparatus draws the distal fragment of the proximal phalanx into extension, whereas the proximal phalangeal base flexes due to the deforming forces of the intrinsic lumbrical and interosseous muscles.

Fractures of the middle phalanx may angulate in either apex dorsal or apex volar directions, depending upon the location of the fracture with respect to the flexor digitorum superficialis (FDS) tendon insertion [9, 12]. A transverse fracture occurring distal to the FDS tendon insertion will angulate apex volar; whereas, a transverse fracture occurring proximal to the FDS tendon insertion will angulate apex dorsal.

Treatment options

Tuft and shaft fractures of the distal phalanx

The distal phalanx is the most common site of injury in the athlete's hand [5]. As previously mentioned, comminuted tuft fractures are inherently stable due to dense fibrous septa in the pulp. These fractures are usually amenable to temporary protective splinting.

With diaphyseal fractures of the distal phalanx, the nail plate may serve as an external splint and provide a stabilizing effect on the fracture. In treating non or minimally displaced shaft fractures, immobilization usually involves an alumafoam or thermoplastic “tip protector” splint with the proximal interphalangeal joint left free for mobility [6, 12].

In the case of a displaced diaphyseal fracture of the distal phalanx, the nail bed is likely disrupted. Nail plate removal and nail bed repair, alone or in combination with K-wire

fixation of the distal phalanx fracture may be indicated. The K-wire is drilled longitudinally across the fracture and into the middle phalanx with the DIP joint extended. The distal end of the pin may be buried beneath the skin surface and the athlete allowed to resume play with a protective splint or cast. The pin is removed after fracture healing, taking into consideration the athlete's schedule.

In the setting of a non-displaced distal phalanx fracture, even with an associated extensive subungual hematoma, removal of the nail plate is often unnecessary [13]. Early trephination of the nail plate can provide pain relief; however, this procedure is not universally performed.

Shaft fractures of the proximal and middle phalanges

Stable, extra-articular fractures of the proximal and middle phalangeal shafts can be treated non-operatively with splinting and buddy taping. The decision to return to sports participation is best directed by the treating physician. A protective splint or play cast may be utilized for 4 to 6 weeks.

Surgical intervention is often warranted to reduce and secure an unstable phalangeal shaft fracture. K-wire fixation in the hand is relatively simple and is associated with few major complications [14]. Nevertheless, in the high-level athlete who is injured in-season, K-wire fixation may not be the ideal choice. Screws and plates may provide superior biomechanical strength, a potentially decreased risk for soft tissue irritation, and allow for earlier joint motion [9].

Improvements in implant materials and designs have enabled the treating physician to more effectively manage phalangeal shaft fractures, particularly highly comminuted bone injuries. Low-profile, double-row plates permit clustering of screws over a short plate length and may allow for limited surgical exposure (Fig. 1a, b). Other plate designs accommodate for lateral placement along the phalangeal shaft, potentially minimizing the risk for extensor tendon adhesion [15].

Many new plating systems also allow for use of locking screws. Locking plates, with and without the option of variable angled screw insertion, are particularly advantageous in the treatment of unstable, comminuted fractures, and fractures with bone loss. Double-row locking plates can be secured with unicortical screws, providing excellent stability while potentially reducing the risk of iatrogenic injury to flexor tendons [16]. To our knowledge, however, there are no published studies that definitively support the use of locking plate technology in the hand [17].

The decision to operate for the purpose of returning the patient-athlete to competition early is understandably controversial and should be made on a case by case basis. Singletary and colleagues [18] reported that athletes, coaches, and parents may pressure the treating physician to return an athlete to sports competition earlier than deemed safe. The potential complications of surgery and the inherent risks of early return

Fig. 1 **a** Intraoperative photograph of a double row non-locking plate used to stabilize a comminuted proximal phalanx fracture. **b** Intraoperative fluoroscopy image of the repaired fracture

to competition must be weighed against the desires of these individuals.

In 2014, Kodama and colleagues [7•] retrospectively reviewed a series of 20 athletes who underwent surgical treatment of metacarpal and phalangeal fractures in an attempt to achieve early return to sports competition. No bone complications (i.e., displacement, delayed union, or nonunion) occurred, and all athletes were able to return to sports participation within the time frame desired. These authors outlined a specific treatment algorithm and postoperative protocol.

Finger stiffness is of paramount concern following open and percutaneous repair of phalangeal fractures. The extensor tendon mechanism is juxtaposed to the phalangeal shaft, predisposing to posttraumatic and postoperative tendon adhesions. The risk of scarring is conceivably decreased in the high-level athlete due to self-motivation, close supervision, and intensive physiotherapy [15].

Condylar fractures of the proximal and middle phalanges

Condylar fractures can be misdiagnosed as a dislocation and incompletely reduced. Unless gross finger deformity is initially evident, an athlete with this injury may present to the orthopedist late [15]. Condylar fractures have been classified into three types: type I—non-displaced and stable; type II—unstable; and type III—comminuted or bicondylar [19].

Weiss and Hastings [20] recognized ball handling sports as a risk factor for unstable condylar injuries. Fracture reduction and screw or plate fixation is recommended to potentially mitigate symptomatic arthritis and allow for early rehabilitation (Fig. 2a, b). Percutaneous headless screw fixation has been advocated for management of unicondylar fractures with the possibility of returning a player to sport within 1 week [15].

Fig. 2 **a** Displaced, unicondylar fracture of the middle phalanx. **b** Intraoperative fluoroscopic image of the fracture reduced and stabilized with two cortical screws

Dorsal and coronal articular shear fractures are particularly difficult to treat given the small fragment size and the limited surface area of bone available for implant insertion. Buried, trans-articular screw fixation has been reported as a successful technique to treat these difficult cases [21].

Interphalangeal joint dislocations and fracture-dislocations

Proximal interphalangeal joint

Athletes who participate in ball handling sports are particularly susceptible to PIP joint injuries [22]. The finger may be “jammed” in the act of catching a ball or falling. Proximal interphalangeal joint injuries include a spectrum of pathology from PIP joint sprains to fracture-dislocations. With respect to the latter, PIP joint post-reduction stability can be problematic, depending upon the size of the middle phalanx osteochondral fracture fragment.

The PIP joint is a congruent hinge joint and is inherently stable by morphological design. In addition to the shape of the joint, the collateral ligaments, a thick volar plate, and surrounding flexor and extensor tendons contribute to stability [22]. Despite these structures, dorsal PIP dislocations remain one of the most common injuries in sports participation.

A hyperextension injury to the PIP joint is the usual cause of a dorsal dislocation. Non-operative management of most dorsal PIP dislocations involves closed reduction, with or without a brief period of immobilization, followed by buddy taping for 3 to 4 weeks. Athletic participation can begin

immediately, or as improvement in symptoms permit. Currently advertised PIP joint “power splints” purportedly provide protection while permitting finger motion for sports participation (PowerSplint.com). We have no experience with use of this device.

An articular fracture at the volar base of the middle phalanx in the setting of a PIP joint dorsal dislocation may require more involved care. A small middle phalanx base fracture (the so-called volar plate avulsion fracture) is usually stable once the PIP joint is reduced. This injury can be treated similar to a simple dislocation with early motion, temporary splinting, and buddy taping. Articular fractures involving approximately 40% or more of the joint surface may necessitate protective dorsal extension block splinting or surgery to maintain PIP joint stability. Surgical options include closed reduction with K-wire fixation, extension block pinning, open fracture repair, application of an external traction apparatus, volar plate arthroplasty, and hemi-hamate autografting (Fig. 3a–d).

Lateral PIP dislocations, once reduced, can be treated with buddy taping and early return to play. In baseball pitchers, surgical repair of the collateral ligament has been suggested if lateral joint laxity greater than 20° persists under stress testing [23]. Authors of other reports have also supported surgical repair of a torn collateral ligament in athletes who require strenuous use of their hands [24, 25].

Volar dislocations of the PIP joint are uncommon and represent disruption of the central slip of the extensor apparatus from the dorsal base of the middle phalanx, with or without a fragment of bone. These injuries necessitate a 4- to 6-week period of PIP joint extension splinting to allow the central slip to heal. The DIP joint is not immobilized in order to permit extensor tendon excursion distal to the zone of injury. In athletes with large fracture fragments, open fracture repair with screws and/or K-wires may be necessary for fracture reduction and PIP joint stability.

In the event of an irreparable and symptomatic PIP joint injury, arthrodesis as a salvage procedure may be indicated. The recommended fusion cascade of increasing PIP joint flexion from the index finger (approximately 40°) to the small finger (approximately 55°) may not always apply. For example, a gloved soccer goalie may experience better control of the ball with the injured finger PIP joint fused in only partial flexion (Fig. 4a, b).

Distal interphalangeal joint

Dorsal dislocations of the DIP joint without fracture are much less common than in the PIP joint. Ball handling sports have been specifically implicated as a risk factor for these injuries. The thin tissue envelope over the dorsum of the DIP joint predisposes the dislocation to an open wound [26, 27]. With a simple DIP joint dislocation detected shortly after injury, a closed reduction is usually successful. A 2- to 3-week period

Fig. 3 **a** Radiographic image of an irreparable dorsal fracture-dislocation of the proximal interphalangeal joint. **b** Hemi-hamate autograft harvest from the ipsilateral wrist. **c** Provisional K-wire stabilization of the osteochondral graft into volar base of middle phalanx. **d** Fluoroscopic image of definitive cortical screw fixation of the osteochondral graft

of DIP joint splinting in slight flexion is recommended to permit collateral ligament healing. A cast or splint may enable the athlete to return to competition early, depending upon the sport and player position.

On occasion, a fracture fragment may displace from the volar base of the distal phalanx with concurrent disruption of the flexor digitorum profundus (FDP) tendon. These injuries have been classified into four types: type 1—FDP tendon avulsion, with or without an attached tiny fragment of bone, and retraction of the tendon into the base of the finger; type 2—FDP tendon avulsion with a small fragment of attached bone and retraction of the tendon into the mid aspect of the finger; type 3—FDP tendon avulsion with an attached large, non to minimally displaced fracture fragment holding the tendon out to length; and type 4—large, non to minimally displaced fracture fragment and a detached FDP tendon retracted proximally [28].

Sutures through bone tunnels, suture anchors, mini-plates, and K-wires are recognized methods of repairing the gamut of FDP tendon avulsion injuries. Kang and colleagues [29] reported the use of a 1.3-mm hook plate to secure the volar osteochondral fragment and FDP tendon in 13 patients. All patients achieved union without complications. Conceivably, mini-plate fixation for this fracture type may allow for early motion of the terminal joint.

Fig. 4 **a** Late recognition of a now symptomatic proximal interphalangeal joint fracture in the small finger of a professional soccer goalie. **b** Fusion of the proximal interphalangeal joint in approximately 30° of flexion

With respect to articular fractures at the dorsal base of the distal phalanx (the so-called bony mallet injuries), a relative indication for surgical repair is volar subluxation of the distal phalanx. An osteochondral fracture involving more than 50% of the joint surface has been shown biomechanically to predispose the DIP joint to volar subluxation [30]. Surgical stabilization of these fractures includes a variety of K-wire fixation methods, in addition to small hook plates and screws. To date, there is no consensus as to the ideal surgical technique to treat these injuries, or absolute indications for surgery. A recent retrospective study showed good functional results with simple terminal joint extension splint treatment of large bony mallet fractures, including those with DIP joint subluxation [31].

In the event of a symptomatic and irreparable DIP joint injury, fusion of the DIP joint may be indicated. An intramedullary screw positioning the joint in full extension can provide immediate stability and allow for an early return to play. Finally, in the skeletally immature patient, a non-reducible, transphyseal distal phalanx fracture may represent incarceration of the germinal matrix between the bone fragments (i.e., Seymour fracture). An open fracture reduction with nail bed repair is the recommended method of treatment.

Conclusions

Phalangeal fractures, dislocations, and fracture-dislocations are common sports-related injuries. The demands of the athlete, especially in-season, make early restoration of function essential in order to allow the player to return to competition. The decision to treat non-operatively or operatively is based upon a constellation of factors, including the injury type, the athlete's choice of treatment, and the sport-specific requirements for use of the hands. Innovations in surgical implants have provided means of rigidly stabilizing phalangeal fractures through more limited exposures. Limited surgical dissection and early rehabilitation in a highly motivated athlete may permit earlier return to play. Further studies are needed to validate this presumption.

Compliance with ethical standards

Conflict of interest Franklin Chen reports royalties from Acumed, Inomed, and Biomet, outside of the submitted work.

David M. Kalainov reports product design consulting personal fees from Acumed and Skeletal Kinetics, as well as product design discussion with OsteoMed, outside of the submitted work.

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