Finger Injuries in Ball Sports

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KEYWORDS

- Finger injuries • Ball sports • Athlete • Return to play • Orthoses

KEY POINTS

- Knowledge of bony and ligamentous anatomy of the digit is vital in treatment of finger injuries.
- Treatment of finger injuries in elite athletes remains a challenge for hand surgeons given the inherent demand for an expeditious return to play.
- Communication with the athlete and the coach is important to understand the particular sport and position of play, what orthosis may be allowable, and financial constraints.
- Occupational therapy and functional orthoses may greatly facilitate return to full activities.

INTRODUCTION

Ball sports are the leading cause of hand injuries in professional athletes.[1] The use of the hand for ball control and contact with the opponent leaves the fingers exposed to injury. Management of finger injuries in athletes often presents a challenge for hand surgeons. Multiple factors must be considered, such as appropriate timing of treatment, long-term functional outcome, and (often the most difficult issue) return to play. This article discusses the management of common finger injuries in ball sports and provides return-to-play recommendations for professional athletes.

MALLET FINGER

Mallet finger injuries are common in ball sports such as baseball, basketball, and football.[2] They are usually a result of forced hyperflexion of an extended finger on a ball or direct contact with another player (Fig. 1). The middle, ring, and small fingers are the most frequently involved digits.[3]

The athlete typically presents with a flexed posture at the distal interphalangeal (DIP) joint and impaired active extension (extension lag). Plain radiographs including posterior-anterior and lateral views of the affected finger are recommended to evaluate for fractures and joint subluxation. Mallet injuries can be categorized as soft tissue or bony mallet injuries.[2,3] Soft tissue mallet injuries are described as terminal extensor tendon avulsion from the insertion on the distal phalanx with no associated bone fragment. When there is a fragment of bone associated with the terminal extensor tendon avulsion from the distal phalanx, it is a bony mallet injury. A bone fragment involving greater than a third of the articular surface may result in loss of joint congruency and volar subluxation.

Closed mallet injuries that involve tendon only or that have a small avulsed bone fragment can be treated nonoperatively with DIP joint extension splinting. The splint should span the width of the finger and the length extend from fingertip to just distal to the proximal interphalangeal (PIP) joint
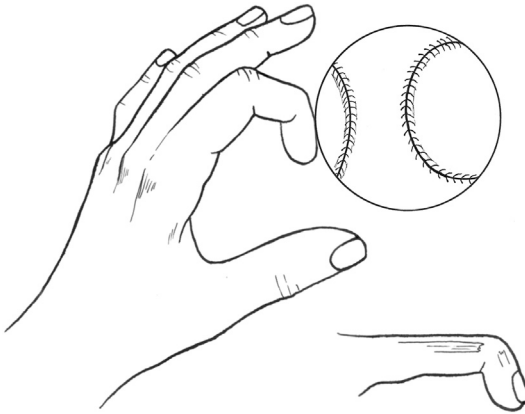
Fig. 1. Mechanism of injury of mallet finger. A flexion force on the tip of an extended finger by a ball can result in avulsion of the terminal extensor tendon on the dorsal lip of the distal phalanx base.

to allow for PIP joint motion.[2] Care should be taken to avoid skin ischemia, which can result from direct pressure on the skin by a tightly applied splint or by hyperextension of the DIP joint. With regard to splint type, a systematic review revealed that there are no substantial differences in treatment between prefabricated or custom-made orthoses (Fig. 2).[4] The key to treatment success is patient compliance with splinting. It is recommended to splint the DIP joint in full extension for 6 to 8 weeks followed by a similar period of nighttime splinting.[3] Patient compliance with wearing and properly positioning the splint is necessary for a good outcome.

Operative management is considered when there is volar subluxation of the distal phalanx with significant joint incongruity. Closed reduction and percutaneous internal fixation of the DIP joint using a Kirschner wire (K-wire) by extension block pinning is the preferred technique.[3] With the DIP joint maximally flexed, a K-wire is introduced at a 45° angle into the head of the middle phalanx to create an extension block for the fragment and allow reduction of the volar fracture piece to the dorsal fragment (Fig. 3). Another K-wire is introduced axially from the distal to the middle phalanx to maintain the reduction. An alternative is to perform an open repair with pull-out button suture (Fig. 4). It can be used with either soft tissue mallet or bony mallet. Open reduction has the advantage of direct access to the extensor tendon but has significant risk of complications, including skin necrosis, infection, nail dystrophy, osteoarthritis, and stiffness.[5]

Wehbe and Schneider[6] advocated nonsurgical management of closed mallet fractures with large fracture fragments, even with volar subluxation of the distal phalanx. They found that subluxated mallet fractures heal and remodel the DIP joint articular surface with preservation of the joint space. In a study with 22 closed mallet finger fractures, it was shown that even nonoperative treatment of mallet injuries involving greater than one-third of the articular surface with or without subluxation resulted in satisfactory outcomes.[7] Based on the current literature, there is no clear indication for surgical treatment and insufficient evidence to support operative rather than nonoperative treatment of mallet fractures. Most clinicians consider operative intervention when there is volar subluxation and loss of DIP joint congruency. Close follow-up with lateral radiographic views is needed to guide treatment and ensure maintenance of DIP joint congruency.

Return to Play

Immobilization of the DIP joint in full extension may prevent optimal play for athletes and some may opt to delay treatment or to have no treatment.[8] Effective treatment of stable, closed mallet finger
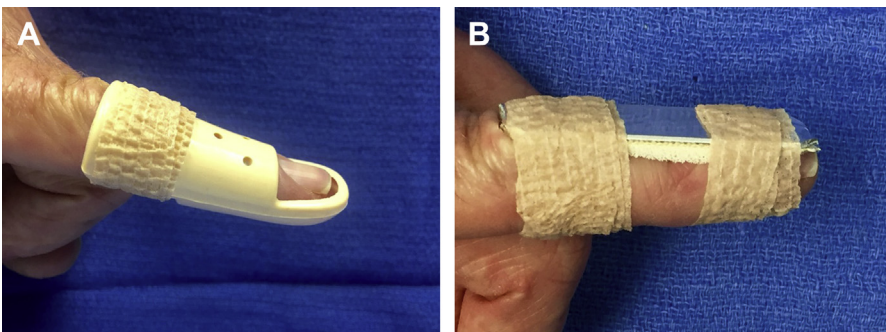

Fig. 2. (*A*) Stack splint. Prefabricated stack splint immobilizes the DIP joint in full extension. (*B*) Dorsal aluminum splint. Dorsal aluminum splint for mallet finger should be secured with 2 strips of tape to maintain the DIP joint in an extended position.

Fig. 3. Extension block pinning of mallet finger. A K-wire is inserted into the head of the middle phalanx at a 45° angle and proximal to the fractured fragment to create an extension block. The volar fracture is reduced and a second K-wire is passed retrograde across the DIP joint to maintain reduction.

injuries involves full-time splinting for at least 6 to 8 weeks followed by nighttime splinting of a similar duration. Athletes are expected to adhere strictly to the full treatment course and continue with immobilization during strenuous activity, including return to training.[9–11] Splinting during training and play runs the risk of maceration, loss of immobilization, and injury to other joints. During immobilization, consider including the adjacent joints in the splint, using a circumferential cast (QuickCast, Patterson Medical) and buddy taping to limit risk of injury to PIP and metacarpophalangeal (MCP) joints (**Fig. 5**). Also, the use of Dynamic Tape (Vanuatu) or Kinesio Tape (Kinesio Holding Corporation) in conjunction with the splint or cast can greatly decrease the risk of maceration.[12]

If players cannot tolerate the external splint because of the demands of their positions, some investigators have advocated internal splinting by percutaneous pins, also for at least 6 weeks.[8] However, there is a risk of another jamming injury breaking the pin in the joint of for pin migration.

As with all injuries, options need to be tailored to the urgency to return to play, the position and type of sport, and the specific injured finger.

Following discontinuation of immobilization, players are permitted to return to play and to resume ball handling as tolerated. Athletes must be aware that even with strict compliance with splinting, a residual 5° to 10° extensor lag and dorsal joint prominence may be present. Without treatment, permanent flexion deformity, swan neck deformity, and DIP joint osteoarthritis can develop.[5]

CHRONIC MALLET INJURIES AND SWAN NECK DEFORMITY

Chronic mallet deformities, categorized as more than 4 weeks from injury, may be successfully treated with extension splint even several weeks after the injury.[13] Swan neck deformity is characterized by hyperextension of the PIP joint and flexion of the DIP joint. It can result from failed treatment of mallet finger injuries and is most common in athletes with a hyperextensible PIP joint. A trial of splinting of the DIP in extension and the PIP in flexion for 4 to 6 weeks is initiated. Adjustments to the splint are made as the deformity begins to correct itself. The duration of splinting may be switched to part-time or nighttime splinting for maintenance. If there is a persistent deformity after nonoperative treatment of chronic mallet deformities, tendon rebalancing with a central slip tenotomy or spiral oblique retinacular ligament (SORL) reconstruction can be considered.[3,13] The athlete should be examined for the degree of
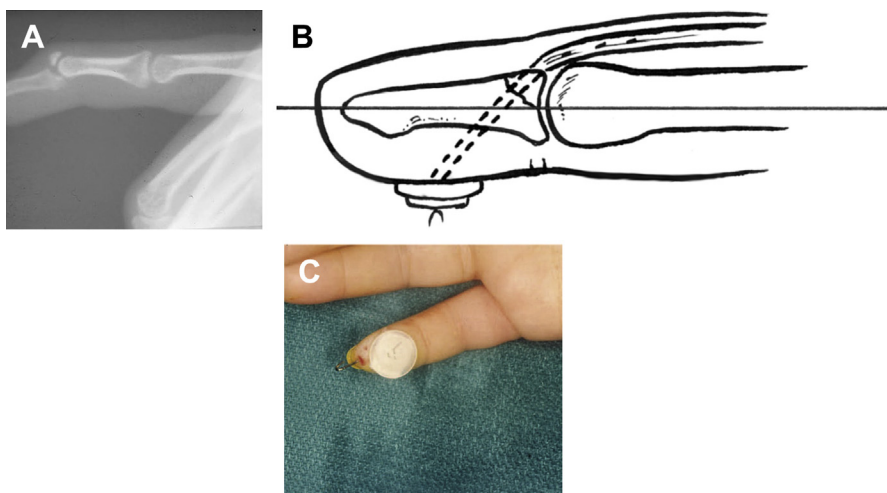

Fig. 4. Pullout button suture. (*A*) Mallet finger with avulsed bone fragment and volar subluxation of the distal phalanx. (*B*) A pullout button suture is used to secure the terminal tendon to bone. (*C*) An axial or oblique wire inserted through the DIP joint is necessary to maintain reduction.
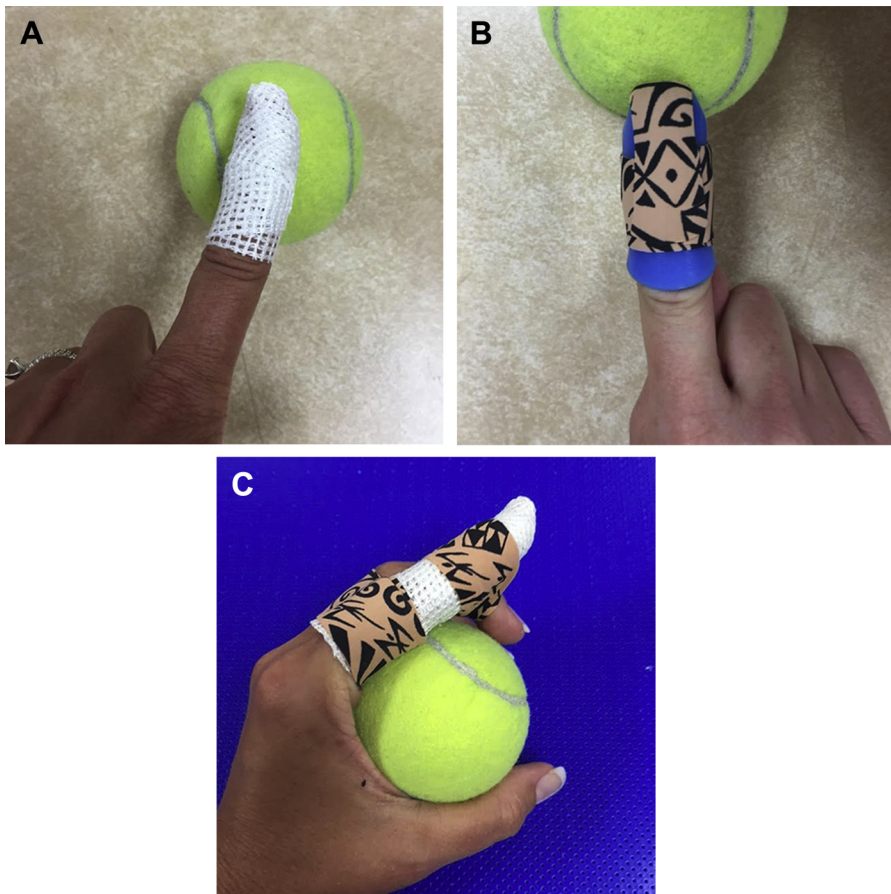
Fig. 5. Mallet finger orthosis. (*A*) QuickCast (Patterson Medical) digital cast can be rapidly applied and easily removed for the duration of the sporting activity. (*B*) Custom dorsal mallet orthosis can be sufficiently rigid to avoid repeated jamming injuries. (*C*) Full-finger digital cast with buddy taping provides even better support provided the positional play allows this. Full-finger immobilization, in contrast with only distal immobilization, avoids placing the PIP joint at risk for a new jamming injury. Splinting, where possible, should not only protect the injured joint but also avoid the risk of loading adjacent joints and sustaining a new injury.

extension lag at the DIP and PIP joint. An extension lag at the DIP joint less than 36° is best treated with Fowler central slip tenotomy.[14] SORL procedure is recommended when there is an extension lag at the DIP joint greater than 45°.[3]

The Fowler central slip tenotomy is designed to reduce the extensor tone at the PIP joint resulting from retraction of the extensor apparatus. It involves transecting the central slip proximal to its insertion into the middle phalanx base and allowing the extensor mechanism to slide proximally to correct the DIP extensor lag. Care is taken not to violate the triangular ligament so that development of extensor lag at the PIP joint and boutonnière deformity is avoided. The timing of the operation is delayed until at least 6 months after injury to allow for tendon maturation.[3] Fowler central slip tenotomy in several case series showed good results. In a series of 20 patients with chronic mallet finger treated with central slip tenotomy, an average extensor lag of 37° before the operation corrected to 9° after the operation.[15] Houpt and colleagues[16] found that, in 35 patients with mallet finger and an average extensor lag of 45°, 26 patients achieved full extension after treatment with Fowler central tendon tenotomy. The postoperative splinting protocol involves splinting the PIP joint at 25° of flexion and the DIP joint in full extension for 10 to 14 days, followed by a finger cast immobilizing the DIP joint only for 2 additional weeks. After the pin is removed at 4 weeks, full active range of motion of the DIP joint is begun. The PIP joint is started on full active and passive range of motion. By 6 months, maximal range of motion of both joints is obtained.

The SORL reconstruction is intended to restore the tenodesis of the oblique retinacular ligaments in promoting DIP joint extension with active PIP joint extension (Fig. 6).[3] A free tendon graft, typically the palmaris longus or toe extensor tendon, is harvested and secured distally to the dorsal base of the distal phalanx. The graft is then passed volar in a spiral fashion around the radial aspect of the middle phalanx and is secured proximally to the ulnar side of the flexor tendon sheath at the level of the proximal phalanx or directly to bone. Next, the DIP joint may be pinned in extension and the PIP joint in 10° to 15° of flexion with an oblique K-wire.[3] In a series of 12 patients who underwent the SORL reconstruction for chronic mallet finger caused by terminal tendon disruption, the mallet finger deformity was corrected in all cases.[17] One patient required flexor tenolysis for adhesions to obtain full range of motion and another patient required lengthening of the oblique retinacular ligament graft to obtain full PIP joint extension. An alternative to SORL reconstruction is flexor digitorum superficialis (FDS) tenodesis with combined flexor digitorum profundus joint fusion (Fig. 7).

Rehabilitation after SORL is challenging because the structures are so delicate. The goals of rehabilitation are to dynamically facilitate DIP extension with PIP flexion, allowing for functional grasp and prehension in a tenodesis manner.[18,19] Initial immobilization includes a dorsal gutter splint incorporating the PIP and DIP joints for 6 weeks followed by a figure-of-eight orthosis for an additional 4 weeks. Return to play should be discouraged for the initial 4 to 6 weeks for any team sports. Immobilization at the time of return to play should include the PIP in a flexed posture and DIP in an extended posture using a custom orthosis or digital cast. Again, maceration is a common complication, so consider using Dynamic Tape or Kinesio Tape under the cast or orthosis. Return to play with buddy taping can be entertained at 12 to 16 weeks as per tendon healing and strength assessment.

BOUTONNIÈRE DEFORMITY

A boutonnière deformity is characterized by flexion at the PIP joint and hyperextension at the DIP joint.[20] The precipitating injury leading to this chronic flexion deformity is disruption of the central slip, which causes continued flexion at the PIP joint and leads to attenuation of the triangular ligament followed by volar subluxation of the lateral bands (Fig. 8).[3] In athletes, disruption of the central slip can be caused by forced
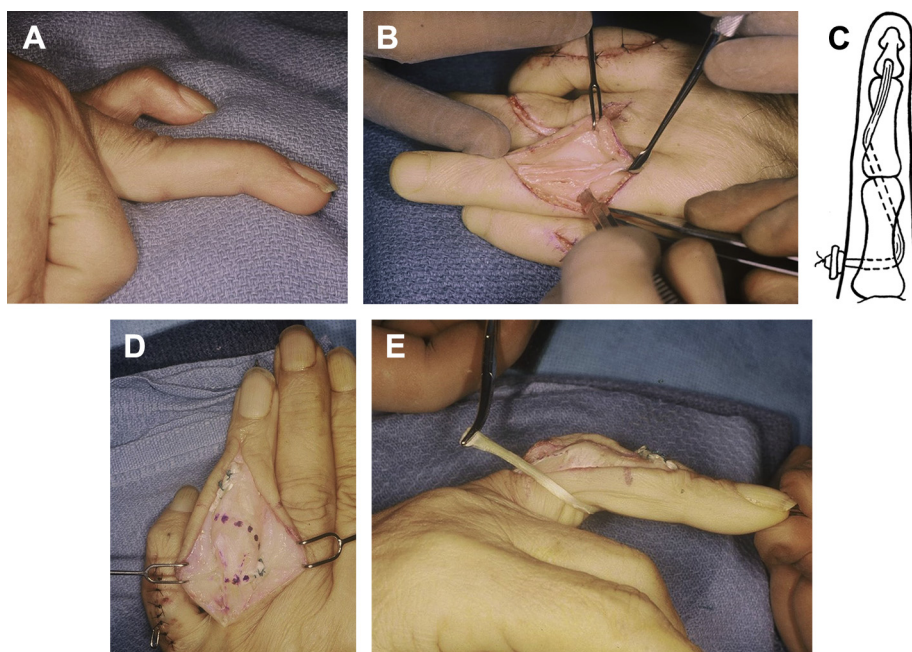

Fig. 6. Spiral oblique retinacular ligament reconstruction. (A) A 45-year-old woman with multiple swan neck deformities. (B) Dorsal capsulotomy of the PIP joint proximal to the central slip was performed. (C) The tendon graft is fixed to the distal phalanx, passed volar in a spiral fashion around the middle phalanx, tunneled through the shaft of the proximal phalanx, and secured with a bone anchor or suture button. The direction and course of the tendon graft is shown in the (D) dorsal and (E) lateral views.
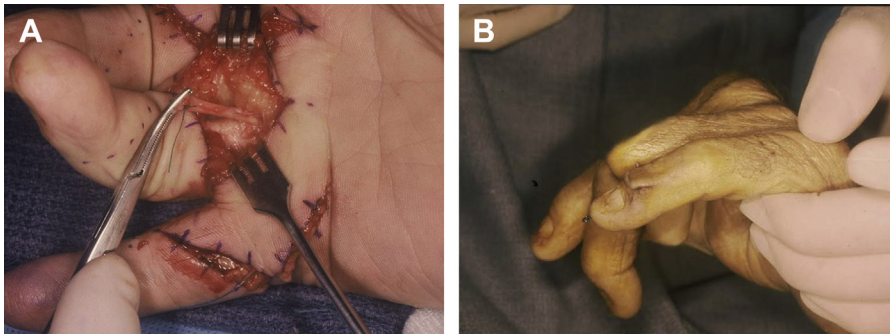
Fig. 7. FDS tenodesis and DIP joint fusion. (*A*) One slip of the FDS is transected proximal to the PIP joint, leaving the distal attachment intact. With the PIP joint flexed 20° to 30°, the detached FDS slip is passed under and wrapped around the A1 pulley. (*B*) FDS tenodesis can be combined with an arthrodesis of the DIP joint if the flexion lag of the DIP joint is severe.

hyperflexion at the PIP joint, such as when catching a ball with an outstretched hand. It can also result from an occasional open injury with laceration to the central slip or from crushing injury, or volar dislocation at the PIP joint.

Early recognition and intervention is key to preventing boutonnière deformity. If the athlete reports jamming the finger or having a finger put back into place after any injury, the clinician should be suspicious for central slip rupture.[20] Volar dislocation of the PIP joint reduced on the field can result in a boutonnière deformity if a central slip injury is unrecognized and left untreated.[21] The Elson test is a useful clinical assessment to determine whether the patient has a central slip tear before the deformity develops (Fig. 9).[22] It is performed by flexing the PIP joint to 90° and having the athlete extend the middle phalanx against
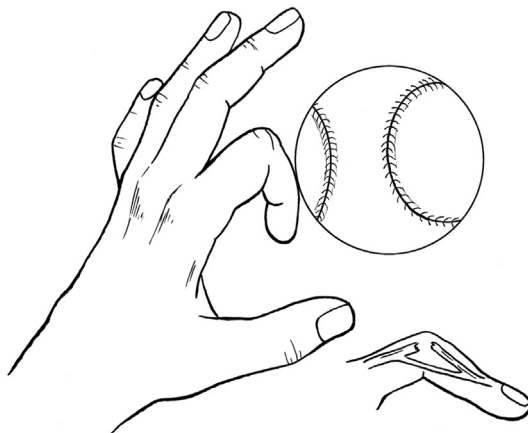

Fig. 8. Mechanism of injury of boutonnière deformity. A boutonnière deformity may develop in the acute setting from forced hyperflexion of the PIP joint, causing disruption of the central slip at the base of the middle phalanx.

resistance. The test is positive if the DIP joint is able to extend because of the recruitment of the lateral bands in the setting of a central slip deficient finger. A digital block may be necessary to accurately perform this test because pain may prevent performance of the test. Plain radiographs should be obtained to evaluate for dorsal fracture of the middle phalanx with or without volar subluxation or dislocation of the PIP joint.[20]

Early diagnosis of closed central slip injury can be treated nonoperatively with splinting of the PIP joint in extension for 6 weeks to promote healing of the central slip to the middle phalanx followed by 6 weeks of nighttime splinting. The DIP joint is left free to allow flexion, which promotes dorsal translation of the lateral bands. Athletes are encouraged to perform DIP joint active and passive flexion exercises hourly throughout the splinting course.[3]

Operative management is recommended for open injuries, large avulsion fractures, volar dislocation, or fracture-dislocation of the PIP joint.[20] Central slip injuries associated with small avulsion fractures that are nondisplaced can be managed nonoperatively. Larger, displaced fragments can be repaired with K-wire or screw fixation. Central slip laceration warrants open repair with reattachment of the tendon and placement of a transarticular K-wire to maintain the PIP joint in extension during healing.[3]

Return to Play

For closed central slip injury, athletes are generally allowed to return to play as long as it does not obviate use of the splint and buddy taping is recommended as an adjunct for game time protection.[23] Merritt[24] advocates relative motion splinting, which permits immediate full active motion of the injured extensor tendon if it is placed in
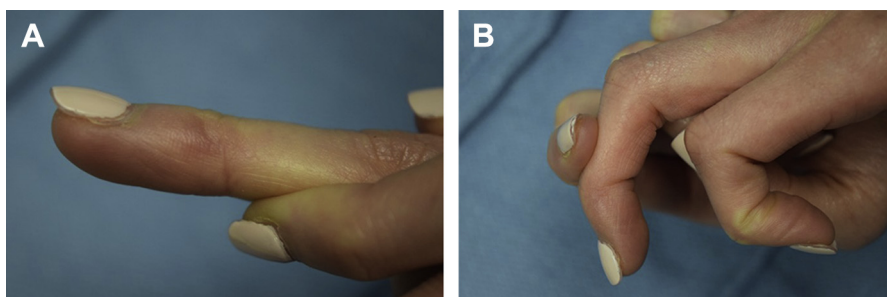
Fig. 9. Elson test. (*A*) With the PIP joint extended, the DIP joint can actively extend. (*B*) With the PIP joint flexed, the DIP joint cannot actively extend. In the presence of central slip injury, the DIP joint can be extended when the PIP joint is flexed because of the recruitment of the lateral bands.

15° to 20° less relative motion than adjacent tendons. The rationale for relative motion splinting is for the injured tendon to experience less force than adjacent tendons during motion. In boutonnière deformity, attenuation of the triangular ligament enables the lumbricals to act as flexors at the PIP joint and to extend the DIP joint without an opposing force. Placing the injured digit into 15° to 20° greater MCP flexion relative to adjacent digits allows the lumbricals to relax, which increases the tension on the extensor hood and promotes dorsal migration of the lateral bands.[24] Using the relative motion flexor splint when not playing enables extensor tendon rehabilitation but caution is needed when using this orthosis for return to play because of the high risk of injury to the adjacent fingers or unprotected hyperflexion injury of the affected finger (Fig. 10). Return-to-play protection should include Dynamic Tape

and/or circumferential digital casting with the PIP and DIP joints in full extension.

CHRONIC BOUTONNIÈRE DEFORMITY

Chronic boutonnière deformities can be categorized by the Burton classification. Stage I is a supple, passively correctable deformity; stage II consists of extensor mechanism contracture that is not passively correctable but does not involve the joint; stage III is a fixed contracture with involvement of the volar plate, collateral ligament, and intra-articular joint; and stage IV is stage III plus PIP joint arthritis.[3] Stages I and II can undergo a trial of dynamic splint or serial casting to regain passive extension of the PIP joint. If this is unsuccessful, an open joint contracture release can be performed. If an active extensor lag persists but full passive PIP joint was obtained, there are tendon rebalancing
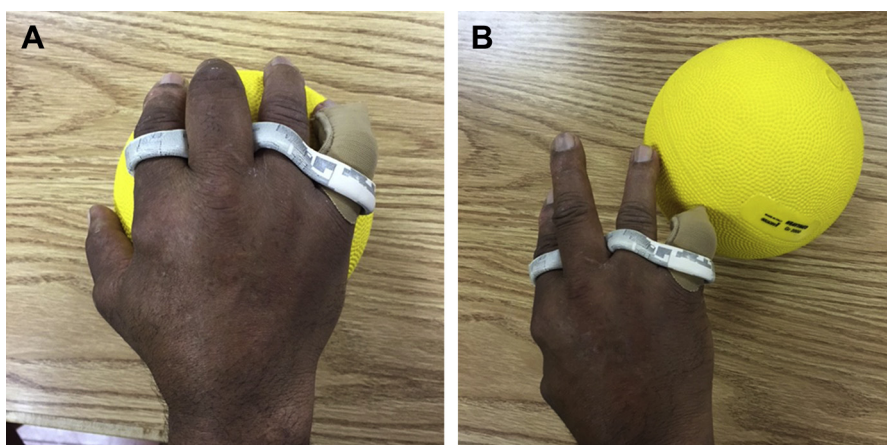

Fig. 10. Relative motion splint. (*A*) Relative motion splint allows for neuromuscular retraining of extension. (*B*) The PIP joint is left unprotected for repeated hyperflexion jamming injury. It also exposes the athlete to other injuries. For example, a forceful extension fall on an outstretched hand may lead to proximal phalangeal fracture. Rigid entrapment of adjacent fingers by the orthosis may lead to susceptibility to ligament injuries in these fingers.

procedures that can be considered. Before undergoing any surgical correction of a chronic boutonnière deformity, patients should be fully informed of the risks and expected outcomes of the procedure, particularly the possibility of jeopardizing flexor function in an attempt to gain extension.

Terminal tendon tenotomy (distal Fowler or Dolphin tenotomy) was designed to decrease the extensor tone at the DIP joint and to allow the extensor mechanism to retract and increase the extensor tension to the PIP joint.[25] It is most valuable in patients who report more difficulty with DIP joint hyperextension rather than the lack of PIP joint extension.[26]

Staged reconstruction of boutonnière deformity, described by Curtis and colleagues,[27] is performed with wide-awake anesthesia to allow assessment of active extension intraoperatively at each stage (Fig. 11). In stage I, an extensor tenolysis is performed. If active extension is not present, the surgeon proceeds to stage II, in which the transverse retinacular ligament is transected to allow dorsal translation of the lateral bands. In stage III, if full correction is not achieved and the PIP joint extensor lag is less than 20°, a Fowler tenotomy is performed. If PIP joint extensor lag is greater than 20°, the surgeon proceeds directly to stage IV, in which the central tendon is dissected free from its insertion and advanced to the middle phalanx base after 4 to 6 mm of scar tissue are removed from its terminal end.

A pseudoboutonnière deformity should be differentiated from a boutonnière deformity. Pseudoboutonnière deformities are usually caused by a hyperextension injury to the PIP joint resulting in volar plate and collateral ligament damage with no disruption of the central slip.[28] Scarring of the damaged structures leads to a PIP joint flexion contracture with a secondary mild DIP joint hyperextension deformity. Serial static or dynamic splinting and casting techniques are used to gradually restore extension of the PIP joint. For persistent PIP joint flexion contracture, surgical release may be necessary.[21]

Return-to-play guidelines are the same for conservative management of pseudoboutonnière and chronic boutonnière. Consider Dynamic Tape support to prevent further injury with or without orthosis. Most athletic trainers or athletes can be educated on independent application of this tape on the field of play for long-term management.[20]

PULLEY RUPTURE

Injuries to the finger flexor pulley system are common in rock climbers but have also been found in baseball pitchers.[29] The transfer of high forces to the A2, A3, and A4 pulleys during the crimp-grip position (MCP and DIP joints extended and resisted flexion at the PIP joint) is the likely injury mechanism for pulley rupture. Clinical findings include localized swelling at the level of the injured
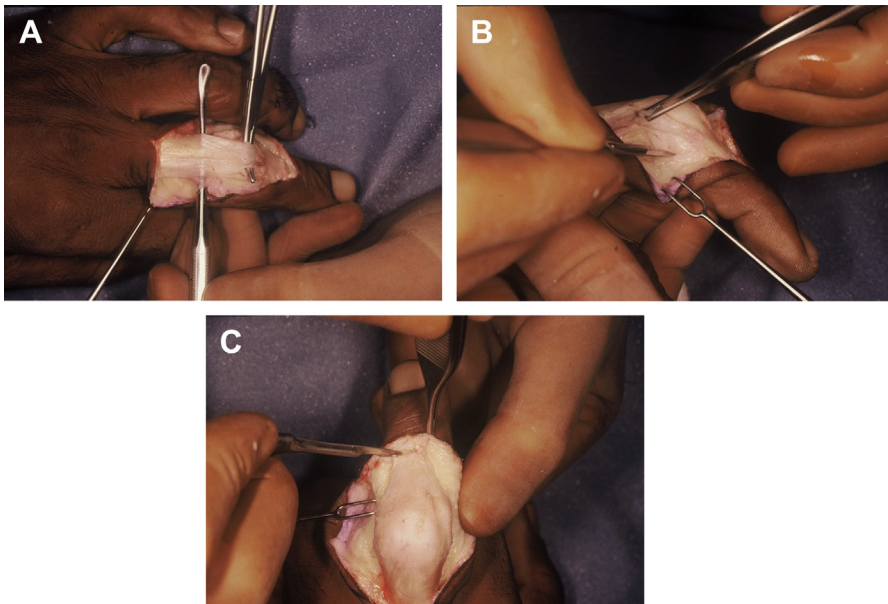

Fig. 11. Staged reconstruction for chronic boutonnière deformity. (*A*) Tenolysis of extensor tendon. (*B*) Release of the transverse retinacular ligament enables the lateral band to swing dorsally. (*C*) Fowler tenotomy can be performed if full extension is not obtained.

pulley and tendon bowstringing if the A2 and/or A4 pulleys are involved.[20] MRI can be useful in differentiating between a pulley strain and a partial or complete rupture (**Fig. 12**). The staging of pulley injuries and treatment protocol have been well described by Schoffl and colleagues[30] and this can be helpful in guiding treatment of professional athletes.

Return to Play

Grade I injuries are pulley strains that can be managed conservatively with nonsteroidal antiinflammatory medications. Easy sport activities can be started after 4 weeks and full sport activities after 6 weeks. Grade 2 injuries are complete A4 or partial A2/A3 ruptures that can be treated similarly to grade 1 injuries with the exception of a 10-day immobilization period. Complete A2/A3 ruptures are grade 3 injuries that can still be treated conservatively, but easy sport activities are restricted until 6 to 8 weeks and full sport activities until 3 months. Grade 4 injuries involve multiple pulley ruptures or single rupture combined with lumbrical muscle or ligament trauma. These injuries require pulley reconstruction, 14-day immobilization period after surgery, and 4 to 6 months of recovery before returning to sport activities. External pulley reinforcement can facilitate early return to play for athletes (**Fig. 13**).

PROXIMAL INTERPHALANGEAL JOINT DISLOCATION

Of the injuries in the hand, the PIP most commonly sustains ligamentous injuries.[31,32] The collateral ligaments and volar plate of the PIP joint create a three-dimensional ligament box that resists joint displacement until 2 sides of the box are disrupted (**Fig. 14**). These stabilizing structures of the PIP joint are vulnerable to the axial loading and extension force that is applied on an outstretched finger. Athletes who participate in ball sports are at risk for PIP joint injuries, either while catching a ball or falling. The spectrum of PIP joint injuries ranges from a minor volar plate strain to an irreducible dislocation of the joint. The joint should be inspected for an irreducible dislocation and any residual deformity or gross laxity.[33] Plain radiographs must be obtained to evaluate for avulsion fractures and the approximate percentage of the involved articular surface. The dorsal V sign may be a subtle indication of an incongruent or dorsally subluxated joint (**Fig. 15**).[31] PIP joint dislocations are classified by the direction of the middle phalanx in relation to the proximal phalanx, which can occur in one of 3 directions: dorsal, lateral, or volar.

Dorsal Dislocations

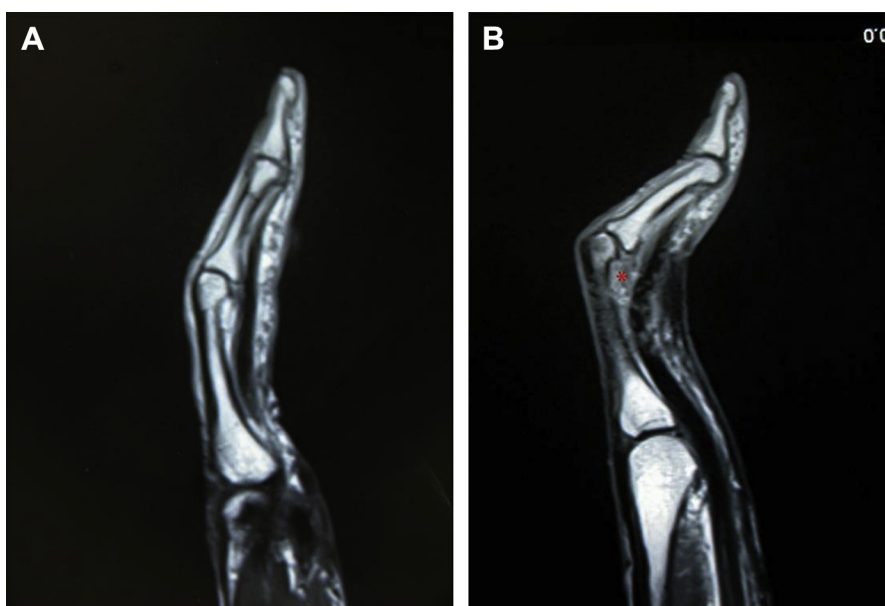Dorsal dislocations are the most common type of PIP joint dislocations and usually occur secondary

Fig. 12. Pulley rupture. (*A*) MRI of an uninjured finger. (*B*) MRI of a finger showing disruption of the A2 pulley with associated bowstringing deformity. The patient has also developed a fixed PIP joint flexion contracture with pseudoboutonnière hyperextension of the DIP joint. Asterisk shows scarring dorsal to the tendon and volar to the PIP joint.
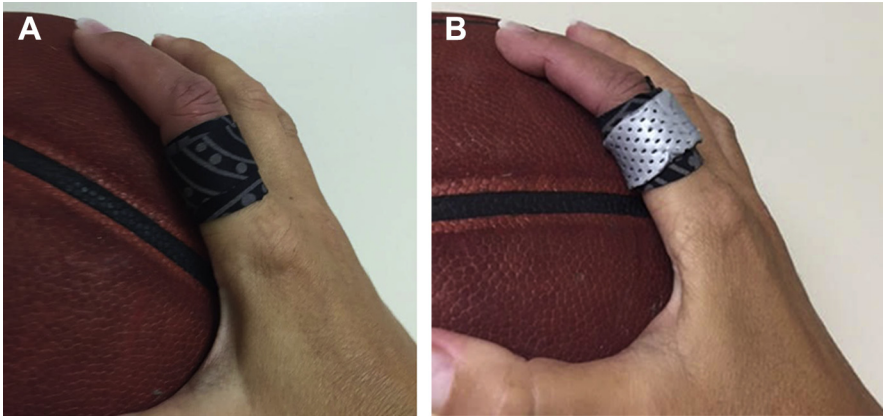
Fig. 13. Pulley ring. (*A*) Taped pulley reinforcement can allow early return to play in grade 1 and 2 pulley rupture injuries. (*B*) For grade 3 and 4 pulley ruptures, the use of a custom pulley ring with tape and padding is recommended during play for 4 to 6 months.

to hyperextension injury. Pure dorsal dislocations result in an avulsion of the volar plate at its distal attachment with the collateral ligaments remaining intact and joint congruity maintained.[31] With more longitudinal force, one of the collateral ligaments can be injured and result in a type I dorsal dislocation in which the joint surfaces are still touching or a type II dorsal dislocation in which there is a bayonet appearance (**Fig. 16**). Type I dorsal dislocation can be reduced with volar translation and flexion. Type II dorsal dislocation requires hyperextension of the middle phalanx followed by palmar force because the volar plate acts as a block to reduction with pure longitudinal traction.
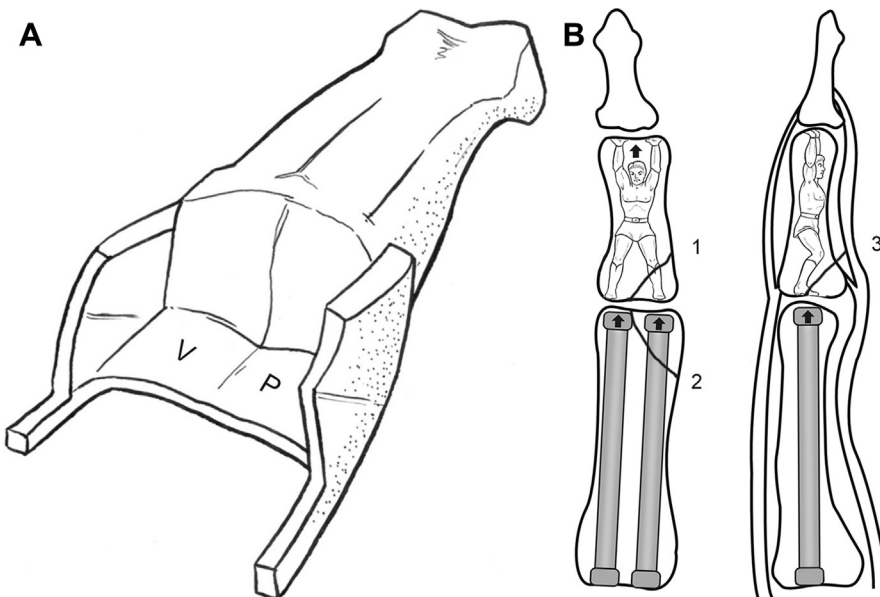

Fig. 14. (*A*) PIP joint three-dimensional ligament box. Collateral ligaments and volar plate of the PIP joint make up the ligament box. At least 2 sides of the box must be disrupted for joint displacement. (*B*) PIP joint bony stability. The 2 proximal phalangeal condyles provide 2 lateral columns for strength. The stability of the PIP joint is inherently provided by the congruency of the articular surface. Fracture lines 1, 2, and 3 result in lateral or volar to dorsal instability. (*Adapted from* [*A*] Merrell G, Slade JF. Dislocations and ligament injuries in the digits. In: Wolfe SW, Hotchkiss RN, Pederson WC, et al, editors. Green's operative hand surgery. 6th edition. Philadelphia: Elsevier Churchill-Livingstone; 2011. p. 292; with permission.)

Fig. 15. Dorsal V sign. On a lateral radiograph of a joint, dorsal joint widening can be a sign of joint incongruity and subluxation. (*Adapted from* Merrell G, Slade JF. Dislocations and ligament injuries in the digits. In: Wolfe SW, Hotchkiss RN, Pederson WC, et al, editors. Green's operative hand surgery. 6th edition. Philadelphia: Elsevier Churchill-Livingstone; 2011. p. 292; with permission.)
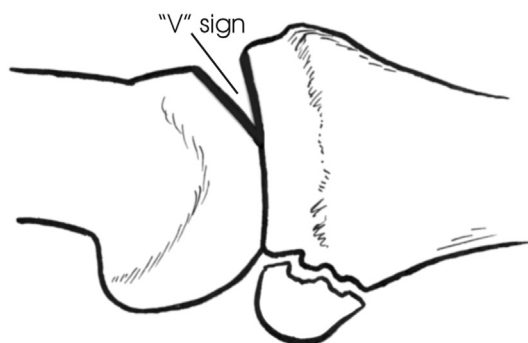
Return to play

If the joint is stable and has full range of motion after reduction, the athlete is allowed to return to play immediately with buddy taping for protection. If the joint is unstable, the player is placed in an extension block orthosis for at least 4 weeks with weekly reassessment and splint adjustments (**Fig. 17**). For irreducible dislocations, open reduction with extraction of the volar plate from the joint is the best option. Postoperative return to play requires 12 to 16 weeks with an extension block orthosis during play.

Lateral Dislocations

Lateral dislocations of the PIP joint result from rupture of the collateral ligament on one side and partial avulsion of the volar plate on the side of injury.[31] Assessment of lateral stability can trace which ligamentous structures are disrupted.

Greater than 20° of deformity in extension suggests complete collateral ligament disruption and at least 1 of the secondary stabilizers. Once lateral PIP joint dislocations are reduced, they are often stable by virtue of the double-column bony support.

Return to play

The athlete is allowed early movement with buddy taping for protection.[34] Open repair of the ruptured collateral ligaments has been performed in athletes to expedite return to play, although there is no significant evidence that it expedites healing or improves motion.[31] Occasionally, the collateral ligament becomes trapped in the joint and requires open reduction.[34] For unstable lateral dislocations and high-level sporting dislocations, return to play can include a ligament hinge brace with buddy taping (**Fig. 18**).

Volar Dislocations

Volar PIP joint dislocations are rare and usually occur from a sudden torque to the digit causing the base of the middle phalanx to dislocate volarly and rupture the central slip.[31] Even if the joint is reducible, clinicians should have a high index of suspicion for disruption of the extensor mechanism. Failure to immobilize the joint in extension to allow the central slip to heal can lead to a boutonnière deformity. Complex volar dislocations involve a rotatory component in which the condyle of the proximal phalanx buttonholes between the central slip and the lateral band (**Fig. 19**). Closed reduction can be attempted by relaxing the lateral bands through MCP joint and PIP joint flexion followed by gentle rotary manipulation. Most cases require open reduction because of failed reduction from the noose effect of the central slip and lateral band around the neck of the proximal phalanx. Less commonly, failed reduction can occur from
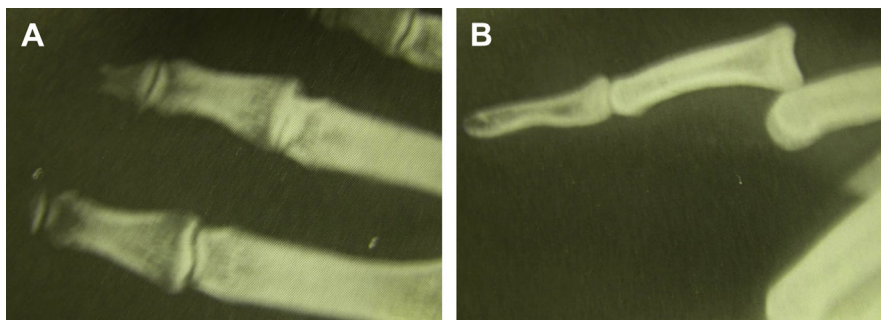

Fig. 16. Bayonet dislocation. (*A*) Anteroposterior and (*B*) lateral radiographs of a bayonet dislocation show the importance of obtaining a true lateral view for PIP joint fractures because the AP projection may look almost normal.

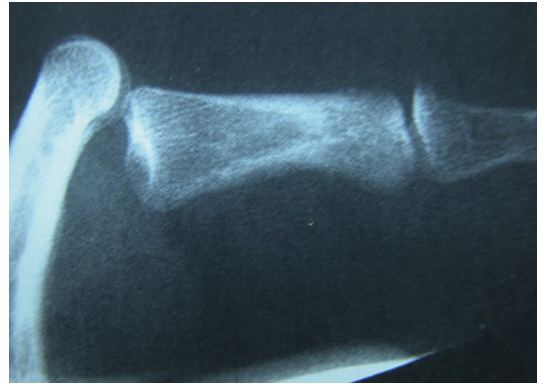**Fig. 17.** Figure-of-eight splint. Murphy ring brace.

Fig. 19. Volar PIP dislocation. Volar PIP dislocations that are irreducible have a high likelihood of an interposed structure such as the fracture fragment.

interposition of the central slip, lateral band, or torn collateral ligament within the joint.[35]

Return to play

PIP joint dislocation can be seen as a complication of other digital injuries that are returned to play with limited immobilization. For instance, an athlete with a metacarpal fracture who is immobilized in an ulnar gutter with the PIP joint excluded is at high risk of volar PIP joint dislocation when coming in contact with balls or players (**Fig. 20**). With conservative management of volar plate dislocation, the athlete can return to play in a digital cast and buddy taping after 2 weeks. At 6 weeks with joint stability, the athlete can transition to buddy taping for an additional 6 to 8 weeks.

Fig. 18. Hinged ligament splint. Consider using tape under and over the brace to limit skin maceration and brace translation during play.

PROXIMAL INTERPHALANGEAL JOINT FRACTURE DISLOCATIONS

PIP joint fracture dislocations are categorized into 3 fracture patterns based on the morphology of the middle phalanx base fractures: palmar lip fracture, dorsal lip fracture, or pilon fracture.[33] Further classification is determined by joint stability (**Fig. 21**). Both lateral and volar to dorsal stability of the PIP joint are imparted largely by the locking articular buttressing surfaces. Fractures that involve sufficient size of the articulating joint facets are inherently unstable.

Palmar Lip Fractures

Palmar lip fracture stability depends on the degree of articular surface involvement. Fracture fragment involving less than 30% of the articular surface is considered stable because sufficient collateral ligament attachments are retained.[36] Treatment is targeted at maintaining joint congruity and encouraging early mobilization. Protected motion treatments allow the joint to move in an arc through which it remains concentrically reduced, but is restricted from unstable positions. Buddy taping is an option in cases requiring only prevention from hyperextension.[36] When a slight degree of flexion is required to maintain reduction, a figure-of-eight splint is a better choice. A dorsal blocking splint is appropriate when full active flexion is permitted but the last 10° to 15° of extension are blocked to promote palmar plate healing.[37]

Tenuous palmar lip fractures are those involving 30% to 50% of the articular surface and are considered unstable if reduction is not maintained with 30° of flexion.[33,36] The preferred treatment of stable tenuous palmar lip fractures is extension block splinting (**Fig. 22**). Bent aluminum splints are secured to the proximal and middle phalanges
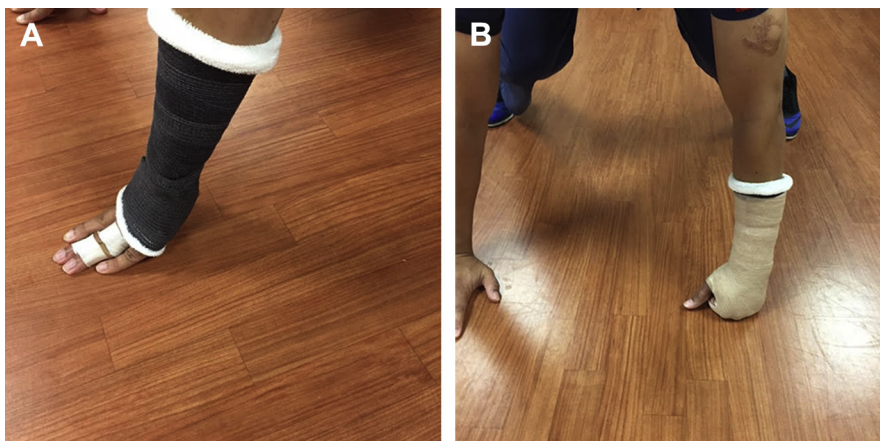
Fig. 20. Ulnar gutter splint. (*A*) Ulnar gutter splint or padded forearm-based orthosis with buddy taping of metacarpal fractures allows return to training. (*B*) Full-fist positioning should be considered for team practice and return to play because of risk of hyperextension injury to the digits.

in such a way that they allow PIP flexion but block extension beyond the point at which subluxation occurs.[36] Confirmation of proper splint placement with true lateral radiographs is recommended. Extension block pinning achieves a similar function to extension block splinting (**Fig. 23**). The K-wire is inserted retrograde into the proximal phalanx at a 30° angle to its long axis or at the angle that blocks unstable extension. Various methods of skeletal traction and dynamic external fixation have been used to treat unstable PIP

fracture dislocations (**Fig. 24**). The advantage to these methods is that they allow for early motion and prevent joint stiffness. Athletes are not permitted to return to play while they have these devices in place.

Unstable palmar lip fractures involve more than 50% of the joint surface or involve 30% to 50% of the articular surface and require more than 30° of flexion to maintain reduction of the PIP joint.[33,36] Treatment is focused on restoring the palmar buttress. Open reduction and internal fixation
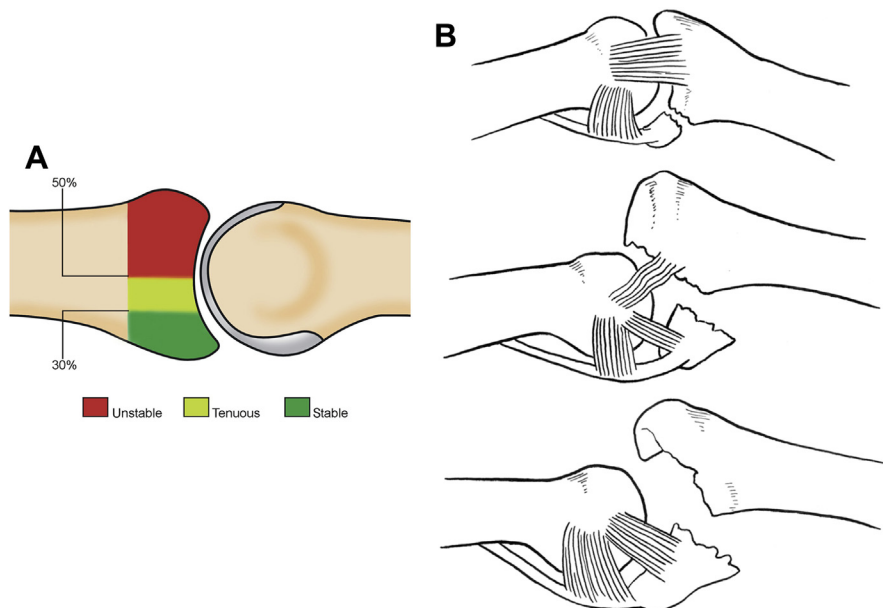

Fig. 21. PIP fracture dislocations. (*A*) PIP joint stability is classified based on the percentage of joint surface involvement. (*B*) The greater the percentage of articular surface involved, the more likely the ligamentous stabilizers are disrupted.
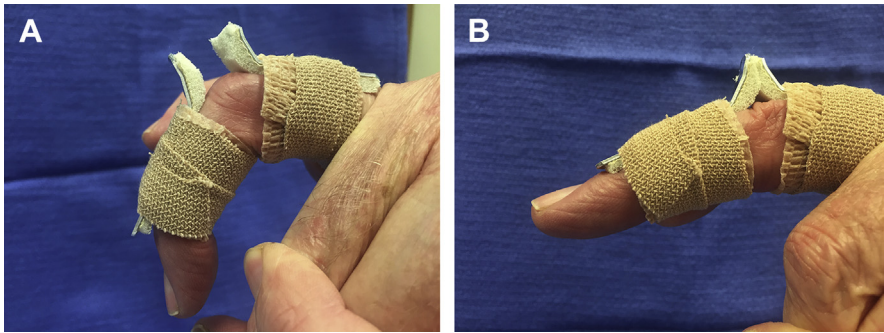
Fig. 22. Extension block splinting. (*A*) Full active flexion is permitted. (*B*) Extension is blocked beyond the point at which the joint becomes unstable.

with screws and K-wires is recommended for larger fracture fragments. For highly comminuted fractures of the base of the middle phalanx, cerclage wires can be used to stabilize the fragments by providing circumferential compression with wire tightening. When reconstructive procedures are required to restore or reconstruct the base of the middle phalanx, palmar plate arthroplasty or hamate osteochondral autograft arthroplasty are considered.

Dorsal Lip Fractures

Dorsal lip fractures commonly involve disruption of the central slip and are maximally stable in full extension.[36] Stable dorsal lip fractures are usually minimally displaced avulsion fractures involving less than 50% of the articular surface. Stable dorsal lip fractures with less than 2 mm of fragment displacement may initially be immobilized in extension by a splint or transarticular K-wire for 3 weeks. The PIP joint only should be immobilized and the DIP joint left free for active and passive range-of-motion exercises. The patient is then transitioned to a dynamic extension splint for 3 weeks to permit active flexion. At 6 weeks, passive flexion and strengthening exercises are started. Dorsal lip fractures with fragment displacement greater than 2 mm may have associated extensor lag and are best treated with open reduction and internal fixation with K-wires with or without a tension band wire, pullout suture, suture anchor, or lag screws.[36]

Dorsal lip fractures are categorized as unstable if there is any palmar subluxation or dislocation seen radiographically after closed reduction. Large fracture fragments are treated with open reduction and internal fixation. Highly comminuted fractures are better treated with closed reduction and percutaneous pinning of the PIP joint in full extension to allow the fragments to consolidate and the central slip to heal.

Pilon Fractures

Pilon fractures involve both palmar and dorsal lip fractures and are considered unstable. Traction is the treatment of choice because it provides alignment and permits early mobilization.[36] Open reduction and internal fixation is often not recommended because of an association with loss of reduction, stiffness, and infection.

Return to play

Professional athletes with stable PIP joint fracture dislocations who can function effectively with protected motion splints in place can return to play, although close observation and serial radiographic evaluation are needed to confirm maintenance of reduction.[33] Athletes with unstable PIP joint fracture dislocations are cautioned not to delay repair because it is associated with poorer outcomes and limited options. Return to play with functional protection is often permitted once stable fixation is obtained. Options for return-to-play immobilization include digital casting, taping, custom orthotics, or
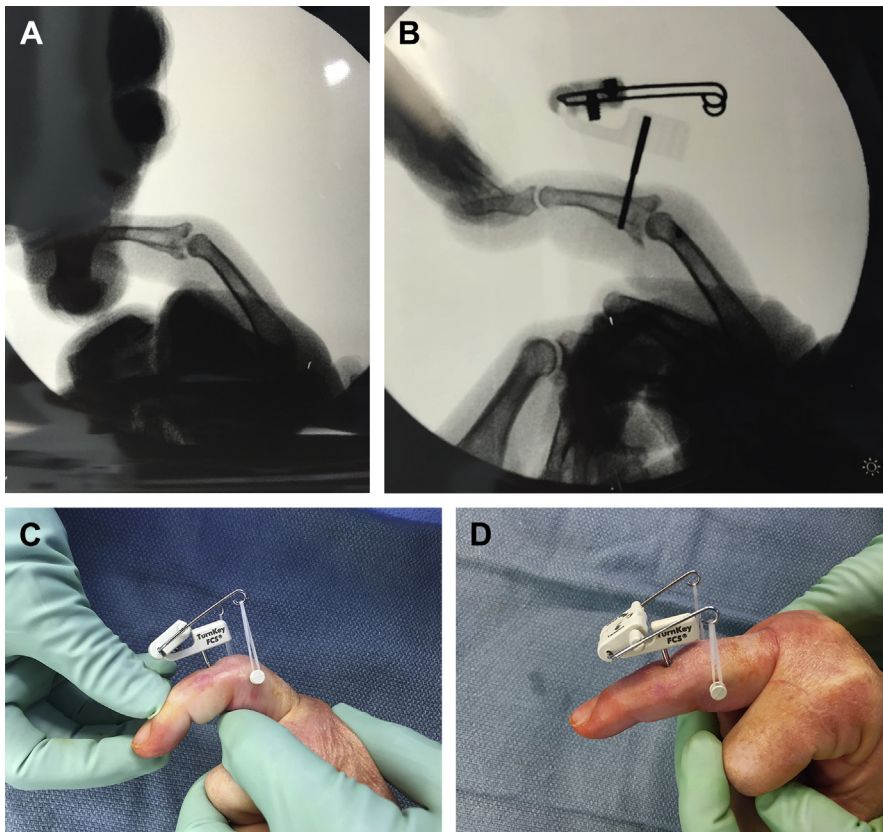

Fig. 23. Extension block pinning. Extension of the PIP joint is blocked with a K-wire advanced retrograde down the intramedullary canal of the middle phalanx.

Fig. 24. Dynamic traction with TurnKey FCS device (Biomechanics Lab, Inc. Sacramento, CA). (*A*) A 54-year-old man with an unstable PIP joint fracture-dislocation on lateral radiograph. (*B*) After the device is installed, lateral radiograph confirmed joint realignment. (*C*) Active flexion and (*D*) extension exercises are performed during fracture healing.

reinforced personal protective equipment. All decisions regarding immobilization should be researched for compliance with the sports regulatory agency.

PROXIMAL INTERPHALANGEAL JOINT CONDYLAR FRACTURES

Condylar fractures of the PIP joint can be classified into 3 categories: type I is a stable fracture without displacement; type II is an unstable, unicondylar fracture; and type III is a bicondylar or comminuted fracture.[38] All 3 radiographic views are necessary for appropriate evaluation of joint stability. An anteroposterior (AP) radiograph can assess proximal migration and articular step-off, a lateral view can evaluate for volar displacement, and an oblique view can provide fracture geometry. Although type I PIP joint condylar fractures are considered stable, they should be treated with caution and with close follow-up because they are inherently unstable. Type II and III condylar fractures are highly unstable and nearly all require

operative intervention. Fixation requires at least 2 points of fixation to control rotation. For severe comminution, consider dynamic traction.

Return to Play

Depending on the stability of fixation, an athlete may be able to return to sports only if there is stable external bracing to the finger. Otherwise, it may be best to await fracture union. However, early PIP joint range of motion is always encouraged if fixation is secure enough in order to avoid joint stiffness.

SAGITTAL BAND INJURY

Sagittal band injury in athletes is more commonly known as boxer's knuckle, although it can occur in any sports that involve a direct blow to the MCP joint, such as football and rugby.[13] The middle finger is most susceptible to injury because of its prominent metacarpal head when making a fist. Athletes usually present with MCP joint swelling,

tenderness, inability to initiate extension, and occasionally central tendon subluxation or dislocation. In addition to standard radiographic views, the Brewerton view may be helpful to identify collateral ligament avulsion injuries and occult fractures of the metacarpal head.[39] It is an AP view obtained with the MCP joint flexed 65° with the dorsal aspect of the fingers flat against the radiograph cassette and the beam angled 15° ulnar to radial. Rayan and Murray[40] classified closed sagittal band injuries into 3 types: type I, injury without extensor tendon instability; type II, injury with tendon subluxation; and type III, injury with tendon dislocation.[39]

Sagittal band injuries without extensor digitorum communis (EDC) subluxation can be managed with buddy taping to an adjacent digit for 4 weeks.[40] Acute injuries (<3 weeks) with EDC subluxation may be treated with an MCP joint flexion block splint, or sagittal band splint, for 8 weeks.[41] The splint is designed to hold the injured MCP joint in 25° to 35° of hyperextension relative to the adjacent digit, which allows for immediate active mobilization of the MCP joint with the splint in place. Catalano and colleagues[41] used the sagittal band splint to treat 10 patients with type III sagittal band injury. Eight patients had no pain, 3 patients had residual EDC subluxation, and 1 patient required sagittal band reconstruction.

For chronic sagittal band injuries (>3 weeks) or those who have failed nonsurgical treatment, there are several methods of sagittal band reconstruction that consist of sagittal band repair with realignment of the extensor tendon.[3] Carroll and colleagues[42] described a technique wherein a distally based radial slip of EDC is looped around the radial collateral ligament and sutured to itself for centralization. Postoperative rehabilitation may use a relative motion splint, as described by Merritt.[24] This method facilitates recovery and is less cumbersome than an outrigger orthosis with flexion block.

Return to Play

Athletes with acute sagittal band injury without subluxation can return to play with buddy taping within 10 days of injury. When EDC subluxation is present, the immobilization orthosis limits functional return to play and increases risk of injury to other joints in the hand. As such, return to play is discouraged for 8 to 12 weeks with chronic and postoperative sagittal band injuries. Once the athlete returns to play, buddy taping for 4 weeks is strongly encouraged. If the athlete returns to play before full tissue healing and return of

strength, there is a significant risk of recurrent rupture of the sagittal band.

RADIAL COLLATERAL LIGAMENT RUPTURE OF THE METACARPOPHALANGEAL JOINT

Athletes with isolated radial collateral ligament (RCL) rupture of the MCP joint often present with persistent swelling and pain along the radial aspect of a previously injured finger.[25] RCL rupture of the MCP joint is typically caused by forced ulnar deviation while the MCP joint is flexed. A Brewerton radiographic view should be obtained to evaluate for avulsed bone fragments.[37] MRI may be required and can help differentiate partial from complete tears. Grade I injury is described as pain without laxity, grade II is laxity with an end point in 60° of flexion, and grade III has no end point. Treatment of grade I and II generally involves splinting the joint in 30° of flexion and reassessment for stability of the RCL in 3 weeks.[31] However, athletes are very active and may benefit from early surgical repair because it has been shown that most patients improve and have satisfactory results with surgery. Grade III injuries, when acute, can be managed nonoperatively initially with immobilization in radial deviation for 6 weeks. Surgical repair may be reserved for those who fail nonoperative treatment or is sometimes the primary treatment in an effort to return the player back to sports sooner.

Return to Play

Early management includes casting in 30° of MCP flexion for 4 weeks. During this period, athletes are not encouraged to return to play. This period is followed by taping and custom orthosis wear for an additional 4 weeks, at which time range-of-motion exercises begin (Fig. 25). Return to play at this point depends on the athlete's level of play, sport, and the digit involved. At 8 weeks after injury, athletes are encouraged to wean from the orthosis by taping during practice and then taping during play (Fig. 26).

METACARPAL OSTEOCHONDRAL FRACTURES

Professional ball sport players are susceptible to intra-articular metacarpal head fractures involving the index metacarpal because of it being an unprotected, border digit.[38] The middle finger may also be affected, being the longest finger and more susceptible to axial impact than the adjacent fingers. Radiographic evaluation requires the standard 3 views along with the Brewerton view to accurately evaluate the articular contour.[43] Displaced ligament avulsion fractures and
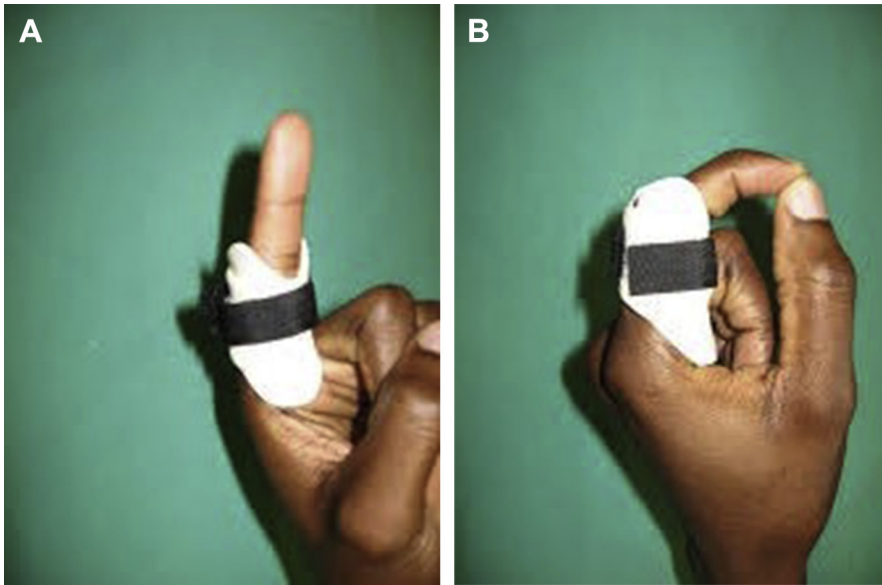
Fig. 25. Custom orthosis for MCP joint RCL rupture. (*A*) Lateral deviation and (*B*) MCP flexion can be restricted with a custom orthosis, which can be padded for return to play or taped for use in a glove.

osteochondral fracture should be managed with open reduction and internal fixation. Kumar and Satku[44] recommended that small osteochondral fragments should be reduced by approximating the capsule to trap and hold the fragments in place. Headless screws have facilitated intra-articular fracture fragment fixation.

Return to Play

Immobilization for metacarpal fracture healing includes ulnar gutter casting or custom orthosis for 10 to 21 days for callus formation. Although these types of immobilization are anatomically appropriate, care should be taken when immobilizing for return to practice or play in order to limit the risk of injury to other fingers.

THUMB ULNAR COLLATERAL LIGAMENT INJURY

Injury to the ulnar collateral ligament (UCL) of the thumb MCP joint was historically referred to as gamekeepers' thumb because of the chronic laxity
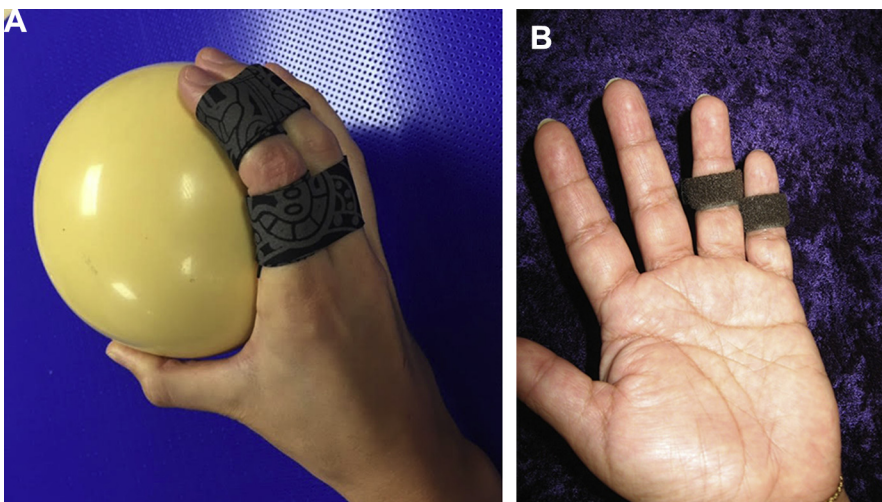

Fig. 26. Buddy taping for MCP joint RCL rupture. (*A*) Buddy taping permits early return to play and support. (*B*) For the small finger, a custom step-down strapping is required because of digital length discrepancy.
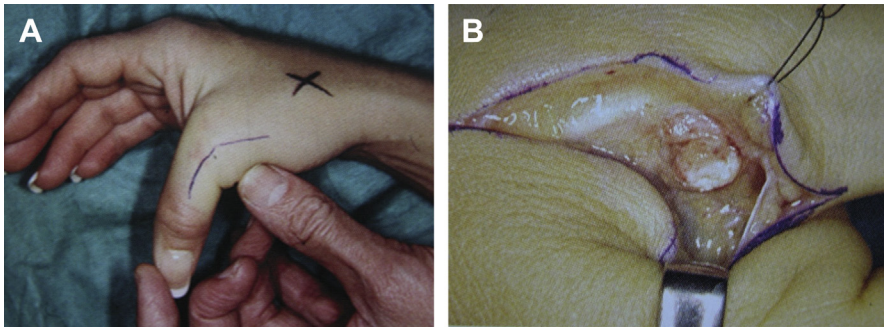
Fig. 27. Stener lesion. (*A*) A 35-year-old woman with unstable ulnar collateral ligament of the MCP joint of the thumb. (*B*) Distal insertion of the collateral ligament has avulsed and is blocked from reattachment to its insertion by the interposed adductor aponeurosis.

of UCL of the thumb observed in Scottish game-keepers.[45] It was later referred to as skier's thumb because this injury is frequently noted in skiers who fall on an outstretched hand strapped to the handle of a ski pole, causing forced abduction and extension of the thumb. Thumb MCP joint collateral ligament injuries are increasingly recognized in professional athletes who participate in ball-handling sports.[46]

Athletes typically describe a hyperabduction injury to the thumb and present with pain and swelling at the ulnar aspect of the thumb MCP joint. Radiographs may show an avulsion fracture at the attachment of the UCL to the base of the proximal phalanx or a widening of the ulnar aspect of the first MCP joint.[46] A local nerve block before valgus stress testing of the thumb MCP joint can be helpful to accurately assess stability. Tenderness without laxity indicates a partial tear. The criterion for joint instability is typically greater than 30° laxity with valgus stress or greater than 15° of increased radial deviation compared with the contralateral thumb.[47]

Acute partial ruptures of the thumb UCL can be treated with 4 weeks of continuous immobilization in a thumb spica cast or splint followed by protected range-of-motion exercises.[31] A complete tear generally warrants surgical repair with reattachment of the ligament to its bony insertion. However, large, avulsed, nondisplaced bone fragments may heal with immobilization alone. A Stener lesion is another indication for surgical repair. It occurs when the adductor aponeurosis is interposed between the distally avulsed UCL and its insertion at the base of the proximal phalanx.[48] Some clinicians are concerned that valgus stress testing of the thumb MCP joint can precipitate a Stener lesion that did not exist before (**Fig. 27**). Spontaneous ligament healing is inhibited because the ulnar ligament is not in contact with the bony insertion. Presence of a persistent firm mass on the ulnar aspect of the first metacarpal head is suspicious for a Stener lesion and should be confirmed with MRI or ultrasonography.

Return to Play

Return to play depends on the classification of the tear and the player's dominant hand. In baseball, early return to sport with a thumb spica splint is permitted for partial tears in the nonthrowing arm.[49] For partial tears in the throwing arm, 4 weeks of full-time immobilization followed by 2 to 4 weeks of protective splint during play is recommended. For complete tears that require operative repair, additional caution is taken to avoid reinjury with early return to play. It is advised to wait 6 to 8 weeks after surgery in the nonthrowing arm and 10 to 12 weeks in the throwing arm.

SUMMARY

Suggested orthoses, facilitations of return to play, and important considerations when returning an athlete to play are summarized in **Table 1**.[50] Although tissue healing is the primary consideration when treating finger injuries, in elite athletes there are several other factors to consider. The sport, position of play, level of play, hand dominance, age of athlete, financial considerations, and player compliance are all serious points to consider when determining the appropriate return-to-play style and timing. In addition, chronic use of performance-enhancing drugs, previous injury, and medical treatment to the area should be considered when determining healing time and prognosis for recovery. Communication between the athlete, surgeon, hand therapist, training staff, and coaches is often imperative for an informed decision-making process. These multifactorial considerations allow for great variance among injuries and athletes.

Table 1
Management of common finger injuries in ball sports

Injury	Orthosis	Return to Sport	Considerations
Mallet finger	• Full-finger cast or orthosis • Buddy tape to adjacent finger	• May return in orthosis based on edema and pain • Compliance with wearing and properly positioning the splint is necessary for a good outcome	• Hand dominance • Sport/equipment • Protect proximal and adjacent joints • Add tape under orthosis/cast to limit maceration and translation of orthosis
Swan neck deformity	• Full-finger cast/orthosis for 6 wk • Wean to figure-of-eight splint for 4 wk • Progress to PIP taping for 12 wk	• May return to training in figure-of-eight splint at 6 wk	• Consider full-finger cast with buddy tape for high-impact team sports • Add tape under orthosis/cast to limit maceration and translation of orthosis
Boutonnière deformity	• Closed injury: buddy tape • PIP extension orthosis for 6 wk at all times • Wean to nighttime splint for 6 additional weeks	• 0–10 d for closed injury based on comfort • May return with full-finger cast and buddy tape for nonoperative cases • For postoperative, 6–8 wk in cast	• Be sure to protect proximal and distal joints • Return to play in cast is based on sport and tissue integrity • Add tape/cohesive bandage under orthosis/cast to limit maceration and translation of orthosis
Pulley rupture	• Grade 1 and 2: tape support • Grade 3 and 4: pulley ring over tape	• Light sport activities such as training can be started after 4 wk • Full sport activities after 6 wk • At all times, use tape to support the pulley	• Confirm custom ring around sport equipment (bats, balls, rackets) and under protective devices (gloves). • Use tape under custom ring and over the fill finger to decrease ring translation during play
Dorsal PIP dislocations	• Buddy taping • Full-finger extension cast/orthosis • Figure-of-eight extension orthosis	• With stable joint and full range of motion, return to play immediately with buddy taping • If the joint is unstable, return to play at >4 wk with extension cast • Postoperative: return to play at 12–16 wk with buddy tape	• Joint stability and integrity • Position • Light vs heavy demands • Key player vs support player
Lateral PIP dislocations	• Buddy taping • Full-finger extension cast/orthosis • Hinged ligament splint	• Early movement with buddy taping for protection/deviation stability • 2–4 wk return to play with orthosis	• Joint stability and integrity • Position • Light vs heavy demands • Key player vs support player
Volar PIP dislocations	• Buddy taping • Full-finger flexion cast/orthosis • Figure-of-eight flexion orthosis	• In a digital cast and buddy taping after 2 wk • Continue buddy tape for 6–8 wk	• Joint stability and integrity • Position • Light vs heavy demands • Key player vs support player

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