DISLOCATIONS OF THE PIP JOINT

The PIP joint may dislocate in one of three directions: dorsal, lateral, and volar. These refer to the position of the middle phalanx when joint deformation occurs.

Acute Dorsal PIP Dislocations

The mechanism of injury in dorsal dislocations is usually PIP joint hyperextension combined with some degree of longitudinal compression, which frequently occurs in ball-handling sports if the tip of the digit is hit with the ball. In the majority of cases, dorsal dislocation produces a soft tissue or bone injury to the distal insertions of the three-dimensional ligament-box complex. The greater the longitudinal force, the more likely the volar lip of the middle phalanx will be sheared off or impacted, producing a fracture-dislocation. On rare occasions, the volar plate ruptures proximally and can become interposed, perhaps with an osteochondral fragment, between the head of the proximal phalanx and the base of the middle phalanx. This results in an irreducible dislocation and necessitates an open reduction. The volar fracture fragment may even become trapped within the flexor sheath and inhibit motion. Dorsal displacement of the middle phalanx produces specific lesions of the ligament system that can be classified into three major types (Fig. 9-4). Each lesion represents a specific disruption of this ligament-box complex. Types I (hyperextension) and II (dorsal dislocation) rarely require surgical treatment, whereas type III (fracture-dislocation) injuries may require a more intensive, often surgical, treatment regimen.

Type I (Hyperextension)

Hyperextension injuries are characterized by partial or complete avulsion of the volar plate from the base of the middle phalanx, with or without a bone fragment, and minor longitudinal rents in the collateral ligaments. In cases where the initial deformity has been severe, the middle phalanx may actually become locked in 70 to 80 degrees of hyperextension. The articular surfaces remain congruent, but with the middle phalanx articulating with the dorsal third of the condyle of the proximal phalanx (Fig. 9-4A). True lateral radiographs will often reveal a small, minimally displaced avulsion fragment from the base of the middle phalanx that should have no impact on treatment.

Type II (Dorsal Dislocation)

With complete dorsal dislocation of the PIP joint, avulsion of the volar plate is accompanied by a major bilateral split in the collateral ligament system. The base of the middle phalanx rests dorsally on the condyles of the proximal phalanx, usually in bayonet apposition with the shafts of the phalanges essentially parallel. There is no contact between the articular surfaces (see Fig. 9-4B).

Type III (Fracture-Dislocation)

Occasionally, the compressive force is of sufficient magnitude to shear off or impact the volar
Fracture-dislocations can be subdivided into two types, stable and unstable, which have very specific implications for reduction and treatment (Fig. 9-5).

Stable Fracture-Dislocation.

Fracture-dislocation with a small triangular fragment representing less than 40% of the volar articular arc results in a dorsal displacement much like simple dorsal dislocations. The transverse disruption, however, occurs through the base of the phalanx rather than at the insertion of the volar plate. The dorsal portion of the collateral ligaments remains attached to the middle phalanx, which is what renders these injuries inherently stable on reduction (see Fig. 9-5A).

Unstable Fracture-Dislocation.

Fracture or impaction of a larger segment of the volar articular surface of the middle phalanx may also result in dorsal dislocation. However, this represents a major loss of articular and ligamentous support for the PIP joint. With disruption of greater than 40% of the volar articular segment, the majority of the collateral ligament-volar plate complex is attached to the fragment, not the remaining intact base of the middle phalanx. Accurate closed reduction is difficult to achieve and even more difficult to maintain. Adding to the instability is the loss of the buttressing effect of the volar margin of the middle phalanx that partially cups the proximal phalangeal condyles (see Fig. 9-5C). Treatment is described in the section on open reduction.
Figure 9-4 Pathology of dorsal dislocations of the PIP joint. A, Type I (hyperextension). The volar plate is avulsed and an incomplete longitudinal split occurs in the collateral ligaments. The articular surfaces maintain congruous contact. B, Type II (dorsal dislocation). There is complete rupture of the volar plate and a complete split in the collateral ligaments, with the middle phalanx resting on the dorsum of the proximal phalanx. The proximal and middle phalanges lie in almost parallel alignment. C, Type III (fracture-dislocation). The insertion of the volar plate, including a portion of the volar base of the middle phalanx, is disrupted. The major portion of the collateral ligaments remains with the volar plate and flexor sheath. A major articular defect may be present. (From Eaton RG, Littler JW: Joint injuries and their sequelae. Clin Plast Surg 3:85-98, 1976.)
alignment. C, Type III (fracture-dislocation). The insertion of the volar plate, including a portion of the volar base of the middle phalanx, is disrupted. The major portion of the collateral ligaments remains with the volar plate and flexor sheath. A major articular defect may be present. (From Eaton RG, Littler JW: Joint injuries and their sequelae. Clin Plast Surg 3:85-98, 1976.)

Schenck introduced a 16-component classification system in an effort to more specifically characterize the type III (fracture-dislocation) injuries just discussed. The PIP joint is examined on the lateral radiograph and assigned one of four fracture grades (I to IV) and one of four subluxation grades (A to D). The injury is thereby classified into one of the 16 possible permutations. This was devised as an attempt to standardize published reports and facilitate comparative analyses of different treatment methods for the specific PIP injury patterns.

Pilon Fracture.
Figure 9-5 Comparison of type III stable and unstable fracture-dislocations. **A,** Stable. Fracture of less than 40% of the volar base of the middle phalanx leaves a significant portion of the collateral ligaments still attached. This portion will guide the displaced middle phalanx to a congruous reduction. **B,** Normal. Collateral ligament insertion into the volar third of the middle phalanx and volar plate. **C,** Unstable. Fracture of greater than 40% of the volar base of the middle phalanx leaves little or no collateral ligament attached. Congruous reduction is unlikely without these ligaments. Frequently the articular surface is impacted into the subcondylar bone and produces an irregular, depressed volar articular defect.

Fracture-dislocations of the PIP joint usually occur when the vector force of compression is not directly axial and the PIP joint is flexed to some degree. When an axial compressive force occurs with the proximal and middle phalanges being collinear, a pilon fracture may occur. (See Chapter 8 on fractures of the metacarpals and phalanges.) This fracture is primarily intra-articular without dislocation or subluxation of the joint, but there is often widening of the base as dorsal and volar
fragments are driven apart and more central cartilage surfaces are impacted into the cancellous bone of the base. \textsuperscript{106a,123} Treatment modalities such as those used for fracture-dislocations may be necessary.

Depression of the concave articular surface of one or both condylar fossae of the middle phalangeal base mimics certain tibial plateau fractures. Angular deformities are common especially if only one condyle is involved. These fractures are subtle on plain radiographs of the involved digit, and the clinician should maintain a low threshold for obtaining a CT scan of the PIP joint to better visualize the articular depression. Aggressive treatment should lessen the risk of persistent or worsening angular deformity, stiffness, and arthritis. Nevertheless, excellent results are difficult to achieve, with residual stiffness likely. \textsuperscript{106a}

\textit{Treatment of Stable PIP Joint Injuries}

The PIP joint is contaminated in an open dorsal dislocation. Therefore, adequate débridement and irrigation should be performed under ideal conditions, usually in the operating room, and antibiotics given based on the condition of the wound and the nature and location of the injury. \textsuperscript{106}

Type I (hyperextension) injuries may be quite painful but are relatively benign injuries in the majority of cases. \textsuperscript{44} The two most important aspects of treatment are patient education and the avoidance of prolonged immobilization. Patients must be reassured that most of these injuries will return to normal function but that the swelling and stiffness may persist for several months, and occasionally for more than 6 months. These injuries are stable and should be immobilized for comfort and soft tissue recovery for no more than 1 week. It is rare to see problems arising from premature mobilization and common to see stiffness and contracture as a result of prolonged immobilization.

Few clinical studies have been performed on these ubiquitous injuries. Jesperson and associates prospectively evaluated 57 PIP joint hyperextension injuries, 57\% of which occurred during ball-handling sports. \textsuperscript{48} The ring finger PIP joint was most commonly affected, and 44\% had associated avulsion fractures. The four patients with persistent pain and instability all had hyperextension instability on the initial examination.

Type II (dorsal dislocation) injuries are usually stable to active and passive testing and require more protection than simple hyperextension injuries but still no more than 2 to 3 weeks of immobilization or controlled mobilization \textsuperscript{101} (see \textit{Authors' Preferred Methods of Treatment}).

Type III (fracture-dislocation) injuries must be carefully assessed to determine whether the dislocation is stable or unstable. Stable fracture-dislocations can generally be treated conservatively with 3 weeks of dorsal block splinting followed by range of motion exercises. Intermittent static or dynamic splinting may be necessary to overcome the natural tendency to develop stiffness and flexion contracture. \textsuperscript{49,122} Most patients will require formal hand therapy to regain full motion and function. In our experience, the patient's personality and initial response to the injury may play more of a role than the specific injury in determining the extent to which therapy is needed.

\textit{Treatment of Unstable PIP Joint Injuries}
Unstable type III PIP fracture-dislocations must be evaluated and treated with great attention to detail, because in the best of circumstances these injuries may still lead to complications, permanent dysfunction, and dissatisfaction. The continuing development of new treatment techniques for these injuries may imply that none of the current techniques produces consistently good to excellent results in a majority of patients for a majority of hand surgeons.

Specific Techniques

Dynamic Skeletal Traction.

Variations on this theme have been recommended for several decades.⁴,16,81,93 Both early and current devices are founded on the principle of ligamentotaxis through which the fracture fragments and the articular surface are reduced as longitudinal traction tightens the intact components of the attached soft tissue envelope. Early range of motion may be instituted with the traction maintained.⁴,43,79,97,107 However, care must be taken to ensure that joint subluxation does not occur during any part of the motion arc. A review of several recent reports showed an average range of motion of approximately 85 degrees at 1- to 2-year follow-up.⁴,43,79,107 Pin tract complications ranged from 0% to 74% but rarely affected final outcome. The best results were achieved in fractures with less articular involvement and those treated acutely. Although design specifics vary, the effective application of certain of these devices can be difficult even for experienced hand surgeons.⁴,43,79,97,107 Dynamic traction devices can be cumbersome to wear and do not necessarily ensure optimal restoration of the articular surface, particularly when impaction of articular fracture fragments is present. Nevertheless, in certain fracture-dislocations and articular impaction and pilon fractures a dynamic traction device may be the only option. For pilon fractures, the dynamic traction device can help to neutralize the joint reactive forces after open elevation of the depressed articular surface and bone grafting of the resultant defect. Dynamic traction devices vary in design, one type deriving the distraction force from rubber bands and the other from coiled Kirschner wires.⁴,43,79,100a,100b,107 Regardless of which particular device is used, care must be taken to prevent creating a moment arm about the middle phalanx leading to re-subluxation.

Krakauer and Stern used a hinged device to allow early active range of motion after surgical procedures on the PIP joint that combined distraction arthroplasty with other techniques, including closed reduction, open reduction and internal fixation (ORIF), and volar plate arthroplasty.⁵⁹ Satisfactory results in 20 patients led the authors to recommend the selective use of this device in the treatment of fractures about the PIP joint.

Extension Block Splinting.

McElfresh and colleagues reported good results with active flexion using a dorsal splint to block extension beyond the point of potential redisplacement.⁷⁵ The PIP joint is brought into extension incrementally by reducing flexion in the splint by 10 to 15 degrees per week. However, in their series of 17 fingers, only four patients had a fragment size greater than 30% of the articular surface. This suggests that the technique is most useful in fractures with small volar fragments in which the majority of the collateral ligament remains attached to the middle phalangeal base.⁷⁵,79 Hamer and Quinton prospectively followed 27 patients for less than 2 years, with fracture-dislocations involving an average of 50% of the articular surface treated by extension block.
They reported a mean of 87 degrees of active PIP motion and good results in 70% of patients. Green also advocated this technique. Unstable fracture-dislocations tend to become stable only in marked flexion, and several authors have recommended immobilization or fixation in up to 75 degrees of PIP flexion. This, however, dramatically increases the risk for late flexion contracture. Short, small, fingers make the fixation of the extension block splint more difficult, and thick swollen fingers decrease the efficacy of this technique, given that re-subluxation and even re-dislocation may occur. Serial radiographs must be obtained to document the ongoing effectiveness of this technique in maintaining joint congruity.

Extension Block Pinning.

With this technique, a Kirschner wire is placed into the head of the proximal phalanx at an angle to mechanically block extension of the PIP joint and prevent dorsal subluxation of the middle phalanx. However, reports of this technique include only a small number of cases, and its clinical efficacy must be substantiated through further study.

Trans-articular Pinning.

Simple reduction and pinning of the PIP joint with no attempt at articular reconstruction has been advocated in a retrospective report by Newington and associates. Although preoperative data were limited, the authors used this technique for articular involvement greater than 25% and less than 60%. In 11 fingers with long-term follow-up, all of the PIP joints were congruent, average PIP motion was 85 degrees, and 3 of 10 patients had some residual pain.

Open Reduction with Internal Fixation.

This method has many advocates and is most likely to be successful in acute cases with a single, large fragment. Anatomic restoration of the articular surface is technically difficult even with a large, single fragment, especially because the remaining articular contour may be disrupted secondary to impaction of subchondral cancellous bone. As with dynamic digital traction, the relatively small series and short follow-up leave unanswered the question of whether the articular reductions are adequate to prevent late post-traumatic arthrosis. If early active motion is not instituted, the risk for joint contracture is greatly increased after open treatment, especially if pins are placed in positions that impale or tether the extensor mechanism.

Using a novel technique introduced by Hasting in 1999 (Scientific presentation, American Society for Surgery of the Hand, Annual Meeting, 1999) William and associates reported on 13 consecutive patients treated with a hemihamate autograft. The autograft is harvested from the dorsal distal aspect of the hamate centered at the fourth and fifth carpometacarpal articulations, spanning approximately one-half of each in both the radioulnar and dorsovolar planes. The graft is then rotated 180 degrees in two planes, keyed into the prepared bed at the volar base of the middle phalanx, and stabilized with two or three mini-fragment lag screws.

All 13 patients in this study had unstable dorsal PIP fracture-dislocations with 40% to 80% loss of the middle phalangeal articular base. These retrospectively studied patients achieved a mean of 85 degrees (range, 65 to 100 degrees) of PIP motion at an average of 17 months. Eleven of 12 patients were “very satisfied,” with two of 12 cases complicated by re-subluxation and four of 12 patients noting some pain at the donor site. The authors expressed cautious optimism as to the
longevity of the procedure. The authors maintained that while indications for this procedure largely parallel those of volar plate arthroplasty, the increased risk of re-subluxation with volar plate arthroplasty in the face of more extensive articular comminution may make the hemihamate graft a better option.

Volar Plate Arthroplasty.

Multiple authors have reported on the technique and efficacy of using the distal aspect of the fibrocartilaginous volar plate to resurface the comminuted volar articular surface of the middle phalanx, especially when other techniques are not feasible. The technique is described in detail in Authors’ Preferred Methods of Treatment.

As a variation on the theme of volar plate arthroplasty, Wiley proposed débridement of the fragments and insertion of a slip of flexor superficialis tendon into the defect to reduce the displacement by active tendon tone. The irregularity of the articular surface was not specifically corrected in his series.

Authors’ Preferred Methods of Treatment

Stable Injuries.

Most dorsal dislocations and fracture-dislocations of the PIP joint are amenable to nonoperative treatment. PIP joint injuries that are stable with active motion can be treated by immobilization with a dorsal splint usually in 20 to 30 degrees of flexion for comfort and to rest the soft tissues. The period of immobilization ranges from as little as 3 to 5 days for mild to moderate type I hyperextension injuries to 7 to 14 days for dislocations and stable fracture-dislocations. Duration of immobilization is individualized depending on the extent of the injury and resultant amount of soft tissue swelling; higher energy injuries with more swelling are rested longer. The PIP joint should not be immobilized in more than 30 degrees of flexion or a flexion contracture is likely to develop. After full-time splinting, the finger can be buddy-taped to an adjacent digit for further protection while active use and range-of-motion exercises are begun. Stiffness and swelling may persist for many months, and if patients are advised of this at the outset, they will better accept this slow but normal improvement.

Unstable Injuries.

Several satisfactory and no perfect treatment options exist for the treatment of unstable PIP joint fracture-dislocations. We are not wedded to a particular modality of treatment and allow the injury characteristics to guide our approach. The rare unstable pure dislocation with-out fracture is usually treated with extension block splinting and only with extension block pinning if subluxation occurs in the splint. Timely follow-up care with radiographs to document reduction and pin position are necessary for good outcomes. On the rare occasions that we use an extension block pin, the digit is splinted to decrease the risk for pin migration or pin tract infection. Gentle active motion exercises are possible with an extension block pin in place, but the pin must be placed obliquely between the central tendon and lateral bands, and patient compliance must be
Operative treatment is indicated only for those unstable fracture-dislocations in which a congruous closed reduction is not possible. These are usually type III unstable fracture-dislocations that have more than 40% of the volar articular surface fractured, leaving little if any collateral ligament attached to the middle phalanx. The goals of treatment are congruous reduction of the PIP joint, restoration of the articular surface, and active motion as soon as possible.

For fracture-dislocations, the only treatment option we do not use is transarticular pinning without articular reduction. We have found extension block splinting to be quite effective for cases where subluxation is relatively mild and articular involvement is less than 40% (Fig. 9-6). There are two important caveats in using this technique: (1) the joint must be reduced before applying the splint, and (2) care must be taken to ensure that dorsal subluxation (loss of reduction) does not occur during the course of treatment with the splint in place. If the PIP joint injury is amenable to extension block splinting, but the digit is too short, stocky, or swollen for such treatment, then we will occasionally use an extension block pin.

We find dynamic skeletal traction methods useful in select cases, especially with increased comminution and nondisplaced fracture lines extending dorsally through the base of the middle phalanx. We have tried most of the methods noted earlier and have found the device reported by Suzuki and colleagues to be the most reproducible in our hands (Fig. 9-7).
Figure 9-6 A, Type III fracture-dislocation of the PIP joint in which approximately 40% of the volar articular surface is displaced with the fracture fragment. B, Fracture-dislocations with 40% or less of the articular surface involved may be successfully treated with dorsal extension block splinting. The patient is allowed to actively flex the PIP joint, which is progressively extended over the course of approximately 4 weeks. The key to this mode of treatment is concentric reduction of the PIP joint.
Figure 9-7 A, Lateral radiograph shows a pilon-type fracture of the middle phalangeal base. B, The wires of a dynamic traction device are placed in the proximal and middle phalanges in a manner similar to that described by Suzuki and associates. C, The two wires are connected by rubber bands. D, Lateral view of the traction device. E, Postreduction lateral radiograph shows significantly improved position of the articular fragments. (Courtesy of Benjamin Rosenstadt, MD, New York, NY.)

ORIF is an excellent form of treatment when there is a single large volar fragment. The procedure is performed through a volar zigzag incision, based radially in the index and long fingers and ulnarly in the ring and small fingers to reduce the potential for contact hypersensitivity. The PIP joint is entered in the interval between the flexor sheath and accessory collateral ligaments on one or both sides of the joint. Careful preoperative evaluation of the lateral radiograph will have revealed any impaction of the remaining dorsal articular surface. This is elevated with a dental pick or Freer elevator, and the remaining void is filled with a small autologous or allograft cancellous crouton.

A single, large fragment may then be reduced and held with one or two small Kirschner wires, the goal being an anatomic, stable reduction. Mini-fragment lag screw fixation may be performed, if preferred over Kirschner wire fixation. In hard bone, the small screw head(s) are counter-sunk to
decrease flexor sheath irritation and care is taken to avoid screw tips extending beyond the dorsal cortex and irritating the extensor mechanism. Excision of the collateral ligaments attached to the fragment greatly improves visualization and ease of manipulation, but preserving the volar plate insertion on the fragment seems to maintain sufficient blood supply for fracture healing to occur. Protected early motion is the goal. (See Chapter 8 for more detailed description of ORIF techniques.)

The majority of unstable PIP dorsal fracture-dislocations are not amenable to ORIF, and we prefer to treat these with volar plate arthroplasty. Although not necessarily apparent radiographically, the volar fragment is frequently comminuted, making ORIF difficult or impossible. Through the same exposure, the feasibility of ORIF is assessed. If ORIF is impossible, then resurfacing of this depressed, irregular area can be achieved by advancement of the fibrocartilaginous volar plate.

Technique of PIP Volar Plate Arthroplasty.

The PIP joint is exposed using a radially based flap through a chevron-shaped incision with its apex at the ulnar midaxial point. The flexor sheath is excised between the A2 and A4 pulleys, and the flexor tendons are atraumatically retracted with a Penrose drain. The articular surfaces are very difficult to assess with the joint reduced. Hyperextension of the joint will usually expose the distal edge of the fracture fragment, facilitating entrance into the joint. To gain optimal exposure, the collateral ligaments that remain attached to the middle phalanx are excised except for the most volar remnants. These are preserved for later use in the procedure to suture each corner of the volar plate margin after advancement. Excising the collateral ligaments allows the joint to be maximally hyper-extended, as one would open a shotgun. With both articular surfaces completely exposed, the feasibility of reduction and fixation of the fragments can be determined.
Congruous reduction may not be possible if the fracture fragments are markedly comminuted or impacted. Loose bone fragments and the segment attached to the volar plate are débrided. The defect in the volar rim of the middle phalanx is shaped into a transverse groove perpendicular to the long axis of the phalanx. Deeply impacted fragments may be left undisturbed to serve as a buttress for the volar plate. The interval between the volar plate and both collateral ligaments is incised, and the fibrocartilaginous plate is mobilized if necessary to allow its advancement 4 to 6 mm distally into the defect in the middle phalanx. The more recent the injury, the more easily the plate will advance. In late cases, it is usually necessary to partially release the proximal checkrein ligaments to gain sufficient length for advancement.

The volar plate is advanced into the middle phalangeal defect by means of a pull-out wire or suture, which spirals along the lateral margins of the volar plate and is then passed through drill holes made by drilling a Keith needle from volar to dorsal, and the needles are threaded with the suture and pulled out dorsally. These holes should be as proximal as possible to draw the plate against the edge of the remaining articular cartilage. They should exit the dorsum of the middle phalanx more centrally through the triangular ligament of the extensor mechanism to avoid binding down the lateral bands. The DIP joint should be flexed 30 degrees as the suture is passed through the extensor mechanism to avoid tethering the tendon. Traction on the sutures emerging from the dorsum of the middle phalanx facilitates reduction of the joint as the plate is advanced into the defect.
holes in the lateral margins of the middle phalangeal defect (Fig. 9-8A). The holes are made by drilling a Keith needle from volar to dorsal, and the needles are threaded with the suture and pulled out dorsally. These holes should be as proximal as possible to draw the plate against the edge of the remaining articular cartilage. They should exit the dorsum of the middle phalanx more centrally through the triangular ligament of the extensor mechanism to avoid binding down the lateral bands. The DIP joint should be flexed 30 degrees as the suture is passed through the extensor mechanism to avoid tethering the tendon. Traction on the sutures emerging from the dorsum of the middle phalanx facilitates reduction of the joint as the plate is advanced into the defect.

Lateral radiographs are obtained to confirm that a congruous reduction has been achieved (see Fig. 9-8B). Maintenance of the reduction with articular gliding through the flexion arc (as opposed to hinging on the dorsal articular surface) must be documented. This is particularly true in chronic fracture-dislocations with dorsal adhesions. If hinging is present, then additional release is necessary, usually of the dorsal capsule, which may have become scarred and inelastic over time. Once a congruous reduction and arc of motion is ensured, the pull-out sutures are tied over felt and a button. A secondary suture is placed between each lateral margin of the volar plate and its adjacent remaining collateral ligament remnant. This reestablishes three-dimensional stability and ensures broad coverage of the condyles and phalangeal base. If there is too much laxity in the volar plate with the joint reduced, additional tightening sutures may be placed to further tie the sides of the volar plate to the accessory collateral ligaments, although this is rarely necessary. An oblique Kirschner wire is used to maintain the reduced joint in 20 to 30 degrees of flexion. On rare occasions, a perceived lack of osseous support distal to the volar plate insertion may be corrected with cancellous bone graft or even the fracture fragments that are not otherwise reconstructable.

Postoperative Management

DIP joint motion is started immediately. Three weeks after surgery, the Kirschner wire is removed and active, unlimited flexion of the PIP joint is begun using a dorsal extension block splint. Unrestricted active extension is permitted at 4 weeks after surgery, and dynamic extension splinting is begun if full active extension is not regained by 5 weeks after surgery. Unlimited sports activities are allowed at 8 weeks with buddy taping, and buddy taping is continued for 4 to 6 months. Swelling may persist for several months, and it may take up to 6 to 8 months to achieve final range of motion.26,46,47

Expected Outcome

CRITICAL POINTS: Volar Plate Arthroplasty for Dorsal Fracture-Dislocations of the PIP Joint

INDICATION

- Unstable dorsal PIP fracture-dislocations with more than 40% articular surface involvement and not amenable to ORIF
PREOPERATIVE EVALUATION

- Standard radiographs (anteroposterior, lateral, oblique) of digit
- Determination if remaining dorsal articular surface is anatomic or impacted
- Age of the injury

PEARLS

- It may be used as a bailout through same approach if ORIF is not possible.

TECHNICAL POINTS

- Use volar approach with chevron incision.
- "Shotgun" joint after proper collateral ligament excision.
- Excise comminuted fragments and elevate dorsal, impacted articular surface.
- Place holes for pull-out sutures as proximal as possible and avoid lateral bands dorsally.
- Establish ideal length of volar plate with joint reduced.
- Reduce joint, tie sutures with DIP flexed, and document congruency radiographically in flexion and extension.
- Pin in 20 to 30 degrees of flexion for 3 weeks only.

PITFALLS

- Leaving stable but impacted dorsal articular surface unaddressed
- Impaling lateral bands with pull-out sutures
- Failing to spread volar plate broadly across condyles
- Failing to identify hinged versus gliding flexion via dorsal adhesions

POSTOPERATIVE CARE

- Immobilize joint with Kirschner wire and splint for 3 weeks.
- Remove pin at 3 weeks with radiographs after pin removal.
- Use extension block flexion for 1 to 3 weeks and then unlimited extension.
- Use a dynamic extension splint at 5 to 6 weeks as needed.

ATHLETIC PARTICIPATION

- Contact sports including basketball can be resumed at 8 weeks with buddy-taping.

The hand surgeon will often see PIP fracture-dislocations after patients have been initially treated elsewhere, and the true nature of this complicated injury may not have been appreciated or conveyed to the patient. The patient must understand from the outset that while normal PIP joint function (as compared with the contralateral or adjacent digits) is possible, it is highly unlikely. They can be reassured that carefully planned treatment and compliance with postoperative
regimens will likely lead to long-term satisfactory to good results. Of course, overall results diminish with increased time from injury to treatment, especially beyond 6 weeks. 17a,26

Eaton and Malerich reported on 24 patients who underwent volar plate arthroplasty for both acute and chronic PIP fracture-dislocations, with a 10-year average follow-up. 26 The seven cases performed within 6 weeks of injury attained an average of 95 degrees of motion and a 6-degree flexion contracture. In contrast, the 17 patients with chronic (>6 weeks after injury) disease achieved 78 degrees of motion and 12 degrees of contracture. Only 3 patients reported any pain, and only with strenuous use. More recent reports have confirmed the reliability of this procedure in producing good results in a majority of patients. 8,22

Dionysian and Eaton have reviewed the results of 17 volar plate arthroplasties at a mean follow-up of 11.5 years and found that the long-term benefit of the procedure endured with an average arc of PIP motion of 85 degrees and no residual pain. 19

Complications

Careful preoperative planning, intraoperative attention to detail with awareness of potential pitfalls, and good patient compliance will minimize the risk of complications associated with treatment of these injuries.

Redisplacement.

Failure to achieve a stable reduction, pull-out suture failure, or inadequate protection to prevent extension during mobilization may result in recurrent dorsal subluxation. One cause of pull-out suture failure is damage from the transarticular Kirschner wire fixation. This complication may be obviated by pre-positioning of the wire in the middle phalanx after Keith needle passage but before the sutures are pulled through. With close clinical and radiographic follow-up, such problems can be more expeditiously addressed and their effects minimized.

Angulation.

Asymmetrical impaction of the base of the middle phalanx or failure to create a trough for the volar plate that is perpendicular to the long axis of the middle phalanx will occasionally result in angulation of the middle phalanx. Although postoperative angular deformity is usually mild and not functionally significant, patient satisfaction may be compromised and secondary corrective osteotomy at the base of the middle phalanx may become necessary. 26

Flexion Contractures.

Immobilization of the PIP joint in more than 30 degrees of flexion and failure to begin dynamic extension splinting by 5 weeks may result in lack of full extension. Recognition of this potential and common problem should help minimize it. Even with early motion and formal hand therapy, a certain percentage of patients will develop a PIP flexion contracture.
DIP Stiffness.

Failure to flex the DIP joint approximately 30 degrees or impaling the lateral bands while passing the pull-out suture through the extensor mechanism on the dorsum of the middle phalanx may cause limitation of DIP flexion. Modifications in the technique help to decrease the risk of DIP stiffness. These include using two separate sutures for each side of the volar plate, tying the suture knots beneath the skin dorsally, or using small suture anchors in lieu of the pull-out suture. It is imperative to start DIP motion immediately postoperatively to regain the maximal motion possible.

LATERAL PIP DISLOCATIONS

The critical anatomic lesions in a lateral dislocation of the PIP joint are a rupture of one collateral ligament and at least partial avulsion of the volar plate from the middle phalanx. Failure probably begins with disruption of the origin of the collateral ligament from either the proximal phalangeal head or the middle phalangeal base, proceeds through the junction of the collateral and accessory collateral ligaments, and finally detaches the insertion of the volar plate on the middle phalanx. To assess PIP stability after spontaneous or manual reduction of the joint, the examiner must test the joint in extension to assess not only the collateral ligaments but also the secondary stabilizers (e.g., volar plate, articular contour). More than 20 degrees of deformity on gentle static lateral testing indicates complete collateral ligament disruption and injury to at least one other secondary stabilizer. This is a major disruption of the four-sided ligamentous box, but with few exceptions the ligaments heal when the joint is reduced and early controlled motion begun. The joint should be protected with buddy-tapes to an adjacent uninjured digit. On occasion, these injuries may benefit from a malleable splint placed along the same side as the ligament tear to prevent inadvertent lateral deviation.

Repair of the ruptured collateral ligaments has been frequently reported after PIP dislocations in general and lateral dislocations in particular. Most of these series involve athletes, and surgery can be performed in selected patients to provide more predictable stability with reduced length of disability. Kato and colleagues reported on 11 primary repairs of acute PIP joint collateral ligament tears in athletes and manual laborers. Suture anchors were utilized in the repair, active motion was initiated at 2 to 3 weeks, and unlimited activities were allowed at 6 weeks.

Nevertheless, because the usual sequela of ligament injury of the PIP joint is stiffness and not instability, the surgical trauma of ligament repair may have an adverse effect on the ultimate range of motion after lateral dislocations. A clearer indication for surgical repair or reconstruction is the sub-acute or chronic collateral ligament rupture with persistent PIP instability and dysfunction.
VOLAR PIP DISLOCATIONS

Volar dislocations of the PIP joint are rare injuries. The base of the middle phalanx may dislocate volarly without rotation (volar dislocation) or may rotate on one intact collateral ligament so that the opposite side subluxates in a volar direction (volar rotatory subluxation). Appreciating the difference between these two related injuries and identifying them clinically can help ensure appropriate management.

Volar rotatory subluxation of the PIP joint is a rare injury. The mechanism of injury is usually a rotatory longitudinal compression force on a semiflexed middle phalanx that results in unilateral disruption of a collateral ligament and partial avulsion of the volar plate. One of the most common causes is catching the involved digit in a spin dryer that has not stopped spinning. As the middle phalanx displaces volarly, the involved condyle ruptures through the extensor mechanism. Usually this rupture occurs between the central slip and the ipsilateral lateral band. The involved condyle may buttonhole between the central slip and the thickened volar fibers of the lateral band. These fibers are caught behind the volar flare of the condyle, routing the distal lateral band through the joint as it remains in continuity with the central tendon over the middle phalanx. Because of this interposition, the usual reduction maneuver of traction and middle phalanx extension tends to further tighten this encirclement of the condyle and block reduction.

Occasionally, when a volar dislocation occurs without a rotatory component, the central slip is ruptured. If the dislocation is irreducible, there is a high likelihood of an interposed structure such as the central slip, a collateral ligament, or a fracture fragment. If the joint reduces easily, one must still be wary of a more profound injury that may have occurred to the extensor mechanism. This must be taken into account when deciding on the position of immobilization for the PIP joint.

Volar fracture-dislocations are also rare. Rosenstadt and coworkers reported on 13 cases treated surgically, of which 9 involved acute injuries. Variations in the size of the dorsal fragment and age of the injury dictated specific treatment (closed pinning versus ORIF). At an average of 4 1/2 years of follow-up, the acute injuries fared better than those that presented at 4 or more weeks. Average arc of motion was 91 degrees for the acute injuries and 70 degrees for the chronic injuries. Five patients had an average 25-degree extensor lag at final follow-up.

Volar fracture-dislocations with a large dorsal fragment may be treated with ORIF via mini-fragment lag screw fixation. Tekkis and coworkers reported two such cases with excellent clinical outcomes and attributed their success to rigid screw fixation and immediate active motion. Care must be taken to avoid distal thread extension into the flexor sheath; similarly, dorsal screw head prominence may require later screw removal.

The management of chronic volar dislocations of the PIP joint is complex and requires the simultaneous surgical correction of an incongruous and contracted joint as well as an incompetent extensor mechanism. There may be degeneration of the articular cartilage; if so, the prospect of restoring normal joint function is greatly diminished. Therefore, it is important to
recognize a volar PIP joint dislocation at the time of injury and adequately treat the disrupted extensor mechanism. Peimer and colleagues also pointed out the necessity of repair of the ruptured collateral ligament.

In this relatively large series of 15 patients with volar PIP dislocations, inspection at the time of surgery revealed disruption of the extensor mechanism, the volar plate, and one collateral ligament in all patients. In each, the extensor mechanism and collateral ligament were repaired, and motion with therapy was started at 4 weeks after removal of the Kirschner wire that transfixed the joint. Although all patients had painless, stable PIP motion, no patient achieved preinjury PIP motion.

**Authors' Preferred Method of Treatment** The management of volar rotatory dislocations of the PIP joint is controversial. Volar rotatory dislocation has been described as irreducible or trapped by many authors and one that necessitates open reduction.* Open reduction is advocated not only to reduce the interposed extensor mechanism but also to repair the rent in this mechanism. Others feel compelled to repair the torn ligaments and volar plate as well. We believe that open reduction is necessary only if closed reduction fails and have a great deal of success using the specific reduction maneuver described next.

The majority of volar rotatory dislocations can be reduced without surgery by applying gentle traction while holding both the MP and PIP joints flexed. This maneuver relaxes the volar-displaced lateral band so that with a gentle rotatory motion the intra-articular portion can be disengaged from behind the condyle and reduction accomplished. If necessary, further relaxation of the extensor mechanism can be gained by moderate wrist extension. Once the joint is reduced, active motion is tested. Because the ligament lesion is a collateral ligament disruption, when the joint is reduced the ligaments are usually restored to their anatomic alignment. Postreduction radiographs should confirm congruous reduction. After reduction of a volar rotatory dislocation, full active extension is usually possible (under digital block) because the contralateral lateral band and at least a portion of the central slip usually remain intact. If the patient cannot actively extend to neutral, the PIP joint should be immobilized in full extension for 6 weeks, just as one would treat a closed boutonnière deformity. The only indication for open reduction, therefore, would be failure to obtain a completely congruous reduction, confirmed by radiographs, and presumably due to the presence of ligament, capsule, or extensor mechanism trapped within the joint.

In volar dislocations without a rotatory component, the reduction is easily accomplished. However, one must assume an injury to the central slip of the extensor mechanism has occurred and thus treat the finger in the postreduction period as one would treat an acute boutonnière deformity, in full extension for 4 to 6 weeks.

**Technique of Open Reduction of Volar Rotatory PIP Dislocation**

Open reduction is approached through a midaxial incision on the side of the major ligament disruption. The lateral band is atraumatically extricated from the joint and reduction is easily accomplished. With the patient under local or wrist block anesthesia it is then possible to test active extension. If the lateral band is not severely traumatized, it may be carefully repaired. Should the band be ragged, it is best to excise it because the normal contralateral lateral band is sufficient to provide intrinsic extensor power. If full extension is demonstrable on examination, the finger should be immobilized in extension for 5 to 7 days until the wound has stabilized and then active range of motion begun. Dynamic extension splinting is alternated with a resting extension splint to protect the extensor mechanism.

*See references 15, 17, 33, 46, 47, 50, 51, 56, 76, 80, 85, 90, 99, 102, 118, and 124.