

Fracture–Dislocation About the Finger Joints

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Fracture–dislocations in the small joints of the fingers are challenging injuries. The surgeon must choose an appropriate treatment based on fracture pattern, joint stability, and injury chronicity. Fracture–dislocations of the proximal interphalangeal joint are notoriously unforgiving, with potential long-term sequelae of residual pain and stiffness. Similar injuries in the distal interphalangeal joint are more tolerant of fracture displacement and even joint subluxation. Dorsal dislocations of the metacarpophalangeal joint may be associated with shearing fractures of the metacarpal head but are most notable for the volar plate interposition that may block closed reduction. (*J Hand Surg* 2009;34A:1140–1147. © 2009 Published by Elsevier Inc. on behalf of the American Society for Surgery of the Hand.)

Key words Dislocation, fracture, interphalangeal, metacarpophalangeal, phalanx.



HEREIN WE DESCRIBE fracture–dislocations of the proximal interphalangeal (PIP) joint, the distal interphalangeal (DIP) joint, and the metacarpophalangeal (MCP) joint focusing on treatment methods and outcomes.

PIP JOINT DORSAL FRACTURE–DISLOCATIONS

Introduction

The majority of PIP joint fracture–dislocations are dorsal dislocations with an associated fracture of the volar articular surface of the middle phalanx (Fig. 1). This injury pattern results from an axial load applied to an extended digit. The PIP joint is vulnerable to injury as a result of a long lever arm for forces applied to the fingertip and a highly congruent joint permitting only a single plane of motion. The PIP joint has minimal laxity to compensate for angular, axial, or rotational stresses. Even with adequate treatment, injury can result in chronic pain, stiffness, and swelling. The unforgiving

nature of PIP joint injuries is multifactorial and attributed to the bony injury, cartilage shearing, articular impaction, and soft tissue disruption.

Injury assessment

PIP joint fracture–dislocations are classified by their mechanical stability as well as the percentage of joint surface fractured.¹ Injuries are categorized as stable or unstable, which guides nonsurgical versus surgical treatment. The assessment of injury stability includes clinical examination coupled with radiographic/fluoroscopic evaluation. Dorsal fracture dislocations are most unstable in full extension. Joints that remain concentrically reduced with 30° or less of flexion and fractures involving 20% or less of the middle phalanx articular surface are generally stable. When increasing flexion is required to maintain reduction and when 30% or more of the articular surface is fractured (30% to 50% is tenuous), these injuries are less amenable to nonsurgical treatment (Fig. 2). On the lateral radiograph, dorsal subluxation of the joint results in separation of the dorsal proximal and middle phalanx articular surface, producing a radiolucent “V” indicative of subtle instability (Fig. 3).

Observing active flexion and extension of the affected joint offers invaluable information. A metacarpal block may be required, but many patients presenting for an initial office visit can comply without excessive pain. Under real-time fluoroscopic examination, the joint is

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examined both for the degree of flexion necessary to maintain concentric alignment and to determine if PIP joint flexion is the result of gliding versus hinging motion.¹ Even with volar impaction of the articular surface, if the joint glides normally (middle phalanx rotating concentrically around the proximal phalanx head) as opposed to hinging on the edge of the fracture (flexing the digit by allowing the proximal phalanx to “fall” into the depressed surface), then the injury may be appropriate for nonsurgical care. Hinging motion is expected to result in posttraumatic degeneration, stiffness, and pain if untreated.

Treatment and outcomes

Treatment options for PIP joint fracture–dislocations vary with the injury pattern and surgeon preference. The goals of treatment are to obtain a concentric PIP joint reduction, restore joint stability, re-establish gliding motion, and allow early motion. Edema control is an additional early component of the postinjury regimen. Dorsal fracture dislocations have been treated by extension block splinting,^{2,3} extension block pinning,⁴ K-wire joint transfixion,⁵ exter-

nal fixation,^{6–8} dynamic traction,^{9–13} open reduction and internal fixation,^{14–17} volar plate arthroplasty,^{15,18–22} and hemihamate arthroplasty.²³ Each of these surgical interventions has been reported to generally provide functional outcomes for the unstable injury. However, the majority of outcomes data is presented in small case series without controls (level IV evidence).

EDUCATIONAL OBJECTIVES

- State the prime factor that determines stability after a PIP joint fracture–dislocation
- List the various treatment options for PIP joint fracture–dislocations
- Discuss the indications for volar plate arthroplasty
- Recall the indications, technique, and contraindication for hemihamate arthroplasty
- Identify the blocking structures in complex dorsal MCP joint dislocations
- Compare and contrast the volar versus dorsal surgical technique for irreducible dorsal MCP joint dislocations

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Extension blocking: Cooperative patients with stable dorsal fracture–dislocations are managed with extension block splints. Splints are fabricated to maintain the necessary degree of flexion for a concentric reduction. The splints are simple to apply but require patient compliance. Blocking extension can maintain joint congruity but does not anatomically reduce fractures. Small bony avulsions may appear rotated and

displaced just volar to the PIP joint space but rarely block flexion. Either dorsally applied static splints or figure-of-eight splints work well. In all cases, the DIP joint is left free. Splints are progressively extended weekly to allow full extension by 3 weeks, with the exact duration depending on the injured joint’s degree of hyperextensibility.¹ Patients are instructed on Coban wraps (3M, St. Paul, MN) or digital sleeve application for edema control and allowed to actively flex and extend the digit within the limits of the splint. As patients complete their splinting, they return to activity with buddy straps to protect the injured digit. Hamer and Quinton in 1992 reported 70% good results in 27

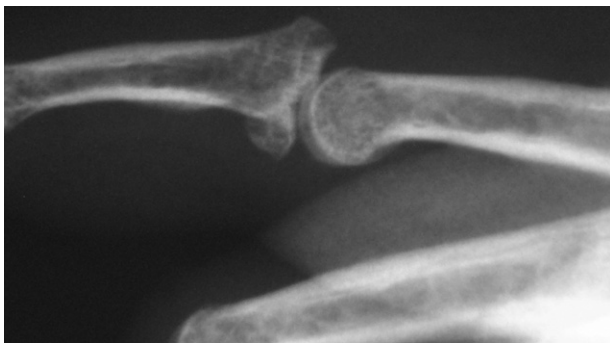


FIGURE 1: Lateral radiograph after attempted reduction of an unstable dorsal fracture dislocation of the PIP joint.

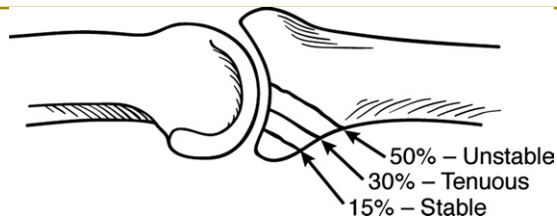


FIGURE 2: Diagram of anticipated fracture stability according to joint surface involvement as seen on lateral view of the PIP joint.

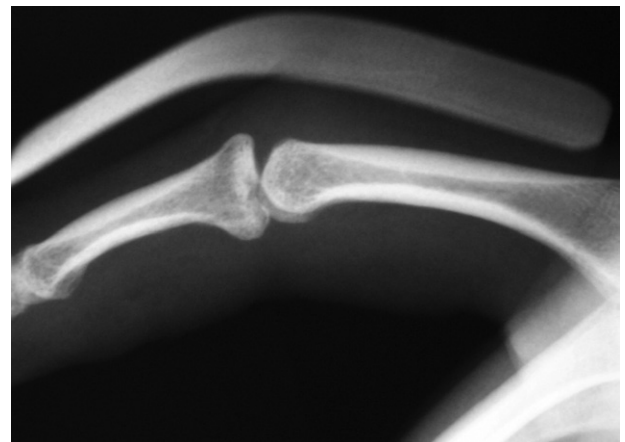


FIGURE 3: Dorsal “V” sign on a lateral radiograph of a PIP joint.

patients treated in this manner.² They noted poor results in those digits that lost reduction in splints and recommended serial radiographs after initial reduction. Alternatively, an extension block K-wire may be placed in the dorsal articular margin of the proximal phalanx.⁴

External fixation: External fixation and dynamic traction offer two minimally invasive surgical treatment options for the unstable injury. External fixation is indicated for highly comminuted fractures or as an adjunct to internal fixation. Several digital external fixators are commercially available, offering static and dynamic settings.^{6,7} Although potentially used as isolated treatment, outcomes of the Compass Hinge (Smith & Nephew Inc., Memphis, TN) have been reported as an adjunct to other procedures, such as open reduction and internal fixation or volar plate arthroplasty.^{7,8} Khan and Fahmy have used the S-Quattro external fixator (Surgicraft Ltd, Redditch, UK) in 100 intra-articular phalangeal fractures and reported 92° of motion across injured PIP joints.⁷ Disadvantages of commercial fixators include increased cost relative to K-wire dynamic traction with similar risks of pin-track infection and pin loosening.

Dynamic traction: Dynamic traction systems composed of K-wires and rubber bands have been well described in a variety of configurations.^{9–13} Most systems are constructed similarly such that the pins counteract the tendency of the middle phalanx to subluxate, and the rubber bands apply constant longitudinal traction preventing further impaction/displacement of fracture fragments. The PIP joint is not transfixed, so active motion is possible (Fig. 4). Traction systems, like external fixation devices, are effective for dorsal and volar fracture–dislocations as well as pilon-type injuries. Ruland et al. treated 34 patients (26 dorsal fracture dislocations, 8 pilon injuries) and regained 88° arc of PIP joint motion and 60° arc of DIP joint motion.⁹ Twenty-five percent of their patients developed pin-track infections but there were no major complications. Concentric reduction has been noted to be critical to outcomes while small articular step-offs are of little impact.¹⁰ Dynamic traction consisting of K-wires alone or K-wires with spring-loaded fixators have been reported with similar results.^{11,12} Dynamic traction treatment requires diligent regular follow-up to ensure that adequate joint reduction is maintained.

Open reduction and internal fixation: Open reduction and internal fixation for articular middle phalanx frac-

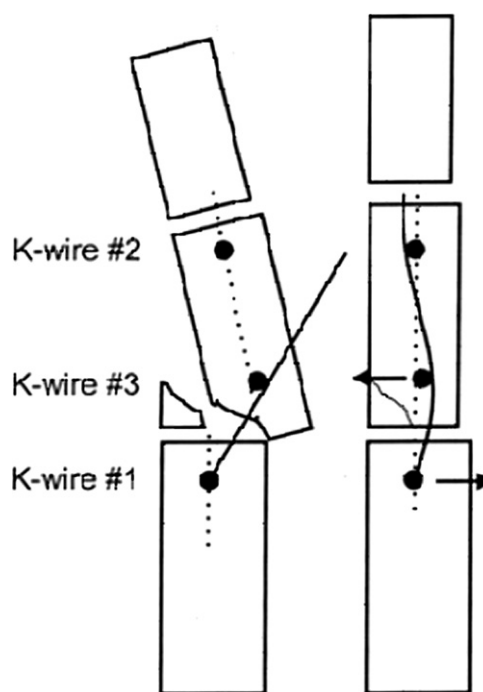


FIGURE 4: Diagram of pin placement for dynamic external fixation. (From Ruland RT, Hogan CJ, Cannon DL, Slade JF. Use of dynamic distraction external fixation for unstable fracture-dislocations of the proximal interphalangeal joint. *J Hand Surg* 2008;33A:19–25. Reprinted with permission.)

tures that compromise joint stability has been performed from volar and dorsal approaches. Open reduction and internal fixation is technically demanding even with the current minifragment screws available. Anatomic fixation sufficient for early range of motion protocols generally requires a partial articular fracture (volar or dorsal) with minimal comminution. Hamilton et al. repaired volar fracture fragments in 9 patients and reported nearly universal residual flexion contractures and better results with fewer fracture fragments (mean PIP joint arc 85° with 1 fragment, 65° with multiple fragments).¹⁴ Similar fractures have also been approached from the dorsal side. Lee and Teoh reported their results in 12 digits, regaining a mean total interphalangeal motion of 132° with 85° at the PIP joint.¹⁶ Seven of the 12 digits had flexion contractures at final examination. Re-dislocations have been associated with failure of fixation and the treatment of chronic injuries, which highlights the importance of obtaining firm fixation.^{15,17} In simple, noncomminuted fracture patterns amenable to screw fixation and early motion, open reduction and internal fixation is generally favored over volar plate arthroplasty or hemiamate arthroplasty.

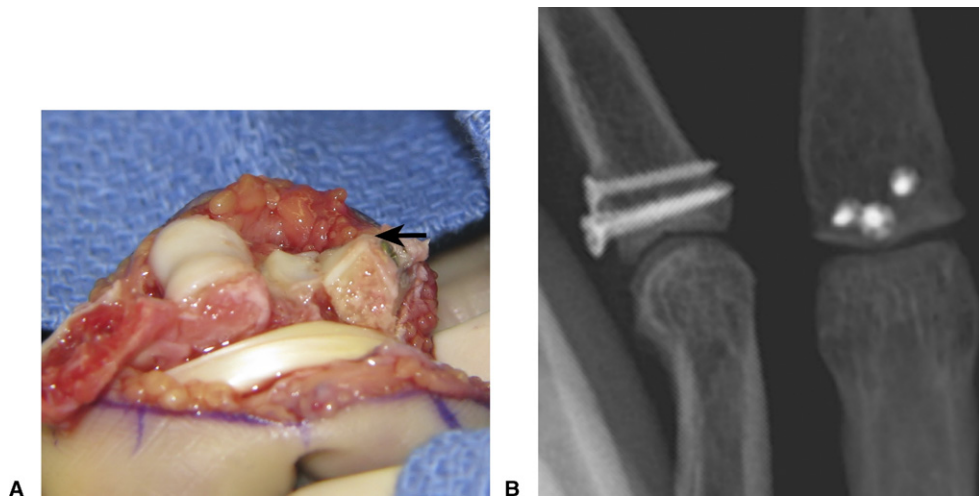


FIGURE 5: **A** Lateral view of hyperextended PIP joint with hemihamate recreating volar buttress (marked with arrow). **B** Lateral and posteroanterior radiographs of healed hemihamate autograft.

Volar plate arthroplasty: Volar plate arthroplasty as described by Malerich and Eaton restores a volar soft tissue buttress or tether to the dorsally unstable PIP joint.¹⁹ This time-tested procedure has reliably restored function when dorsal fracture–dislocations involve less than 50% to 60% of the articular surface. In 1980, Eaton published his 10-year experience in 24 patients.²² Greater PIP joint flexion was achieved when surgery was performed within 6 weeks of injury (95° vs 78°). Coronal plane deformity was noted in 3 patients (range, 15° to 30°). Subsequent investigators have demonstrated similar results with volar plate arthroplasty.^{15,20,21} As fracture severity increases and compromises more than 50% of the articular surface, re-dislocation becomes a concern as the proximal phalanx may settle into the pliable volar support.^{15,24} Volar plate arthroplasty has been augmented with bone graft placed within the bony void to provide additional support or using a slip of the flexor digitorum superficialis in a tenodesis fashion.¹⁵ Recently, volar plate arthroplasty has been reported using a bone anchor for fixation with digits beginning mobilization 2 weeks after surgery.²⁰ Similar results were obtained with PIP joint motion of 94° after acute injuries and 71° after chronic injury. Mild coronal deformity was noted. Proposed advantages included less soft tissue dissection and the elimination of external buttons/suture. Although the volar plate can be successfully advanced to fill bony defects involving greater than 40% to 50% of the joint surface, considerable flexion on the PIP joint is necessary to accomplish a task. A persistent PIP joint flexion contracture is inevitable.

Hemihamate arthroplasty: The hemihamate arthroplasty is an additional reconstructive option for dorsal

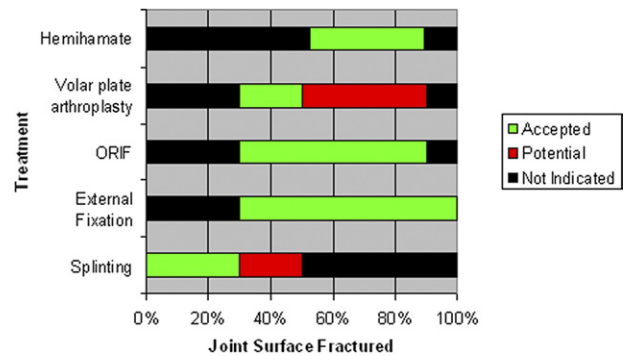


FIGURE 6: Applicability of treatment options for dorsal PIP joint fracture dislocations as a function of joint surface involvement. ORIF, open reduction and internal fixation.

fracture–dislocations involving more than 50% of the articular surface.²³ This procedure provides an autograft volar buttress to the PIP joint and is best suited for comminuted fractures not amenable to primary internal fixation and for chronic irreducible injuries (Fig. 5). The most recent results of this procedure were compiled from 22 patients at a mean of 5 years (Calfee et al., presented at the Annual Meeting of the American Society for Surgery of the Hand, 2008). The average PIP joint range of motion was from 19° to 89° , and the average DIP joint arc of motion was 54° . Residual pain was minimal, and there was no clinical evidence of carpometacarpal joint instability at the donor site. Chronic reconstructions performed at a minimum of 9 weeks after injury restored similar motion, but patients tended to experience more residual pain and reported less optimal patient-



FIGURE 7: **A** Lateral radiograph of palmar PIP joint fracture–dislocation. **B** Lateral radiograph demonstrating fracture reduction after relocation of the PIP joint.

rated function. One patient pursued a salvage surgery for a 10° coronal plane deviation postoperatively despite a pain-free 90° arc of PIP joint motion, and 1 patient, though satisfied, had an ankylosed small-finger PIP joint.

Figure 6 illustrates the authors' view of treatment options for dorsal PIP joint fracture–dislocations as a function of joint surface involvement. In the diagram, fractures involving less than 30% of the joint surface are presumed to be stable and surgical intervention unnecessary. Hemihamate arthroplasty, volar plate arthroplasty, and open reduction and internal fixation all require an intact dorsal cortex and at least 20% to 30% of intact dorsal articular cartilage and therefore cannot be applied to pilon-type fracture dislocations involving 100% of the articular surface. Often, an injury may be treated appropriately by one of several options, necessitating a choice based on surgeon preference.

PIP JOINT PALMAR FRACTURE–DISLOCATIONS

Palmar fracture–dislocations of the PIP joint are rarely reported. Thought to occur as a result of axial load combined with a palmar-directed force over the middle phalangeal base, these injuries produce variable-sized fractures of the dorsal middle phalangeal articular surface. Rosenstadt et al.²⁵ reported on a series of 13 palmar fracture–dislocations treated with closed reduction and percutaneous K-wire fixation (PIP joint transfixion and possible fixation across the fracture). They reported that correcting the joint subluxation was often sufficient to reduce the associated fracture (Fig. 7). In 9

patients treated acutely, PIP joint arc of motion averaged 91°, and DIP joint arc of motion averaged 60° at 55 months of follow-up. A mild flexion contracture of the PIP joint and an extensor lag at the DIP joint were common. Radiographs confirmed reduction of all joints (one with 13% subluxation) but commonly demonstrated an increased posteroanterior height of the base of the middle phalanx. In the patients with chronic injuries, the results were less satisfactory, with poorer motion.

DIP JOINT

Introduction

The majority of fracture–dislocations of the DIP joint are palmar dislocations with fractures of the dorsal articular surface. These injuries generally represent severe bony mallet injuries. Clinical and laboratory examinations have confirmed that the DIP joint will remain concentric when less than 43% of the joint surface is fractured.^{26,27} Subluxation is consistently observed when more than 52% of the articular surface is compromised.^{26,27}

Treatment and outcomes

At this time, there is no consensus indication for surgical management of palmar DIP joint fracture–dislocations. Surgery has been recommended when more than 30% of the joint surface is fractured and when the DIP joint is subluxated. Surgery offers the possibility of restoring bony anatomy but is not without complications. Stern and Kastrup identified complications in 53% of 45 surgically treated digits. Major complications included deep infection (4%), joint incongruity

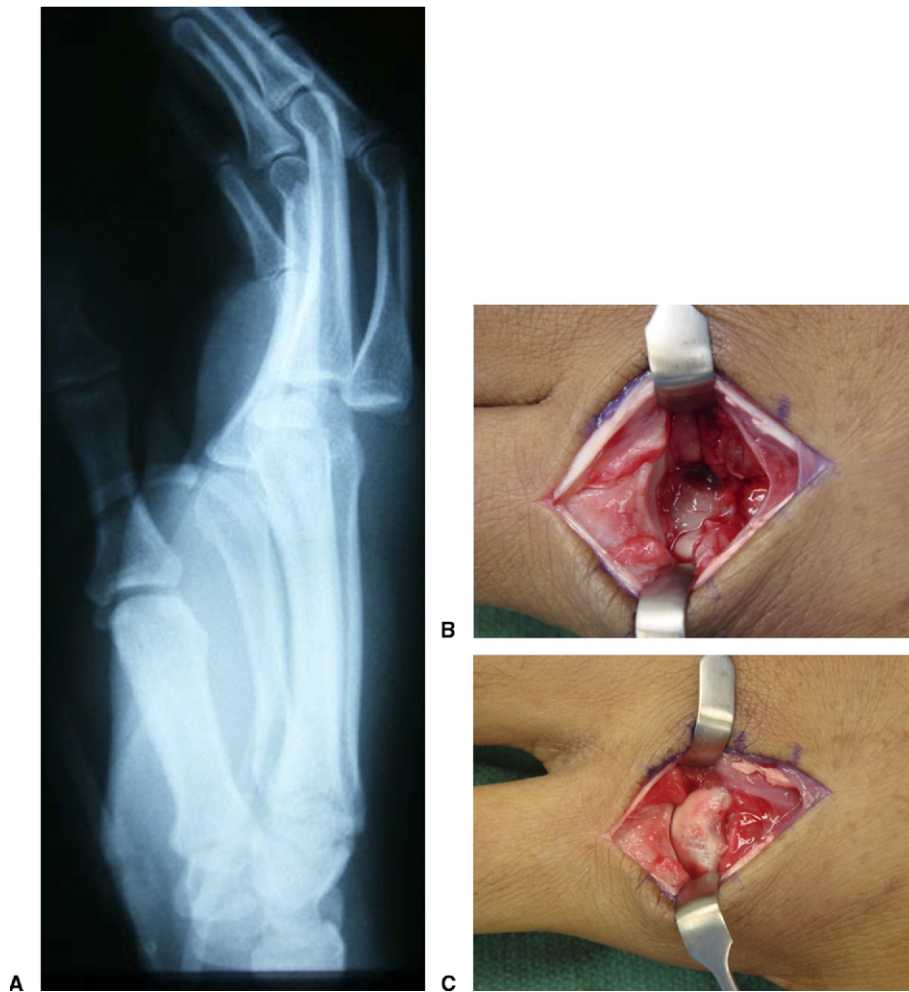


FIGURE 8: **A** Lateral radiograph of dorsal MCP joint dislocation. **B** View from dorsum of hand after incision for open reduction of MCP joint visualizing volar plate that can be mistaken for metacarpal head. **C** Dorsal view of now-reduced MCP joint. (Photographs courtesy of Joshua P. Moss, MD.)

(18%), and nail deformity (18%). No patient requiring reoperation achieved a satisfactory result.²⁸ In 2005, Kalainov et al. reported the outcomes of 22 patients with closed mallet fractures involving greater than 33% of the articular surface.²⁹ Thirteen of these patients had DIP joint subluxation. All patients were treated with extension splinting for approximately 6 weeks. Pain in all patients resolved with return of function. Across outcome measures, patients were least satisfied with the appearance of the finger. Extensor lag was greater in joints with residual subluxation. Although failing to reach STATistical significance, those digits with persistent subluxation joints more commonly had dorsal joint prominences, swan-neck deformity, and degenerative arthritis. These data suggest that the bony mallet with joint subluxation can be managed surgically or nonsurgically, based on patient preferences once he or she is informed of the risks associated with each treat-

ment. However, joint subluxation may negatively affect appearance and outcome.

Dorsal fracture–dislocations of the DIP joint occur infrequently. Although most fractures of the volar articular base of the distal phalanx result from avulsion of the flexor digitorum profundus, a small number of cases involve volar articular impaction with intact flexor tendons. Rettig and colleagues reported on 10 patients treated with volar plate arthroplasty at the DIP joint for chronic injuries; the average DIP joint arc of motion was 42°, with a mean flexion contracture of 12°. ³⁰ Similar restoration of motion has been reported with other surgical interventions and just over 70° of motion realized in a small number of patients treated acutely with either extension block splinting or pinning. ^{31,32} Given the limited number of patients with this injury, we cannot endorse a particular treatment for dorsal DIP fracture–dislocations.

MCP JOINT

Introduction

The MCP joints generally dislocate in a dorsal direction, with the index finger most commonly affected.^{33,34} Patients present with the injured MCP joint held in extension with mild reciprocal flexion at the interphalangeal joints. Complex MCP joint dislocations are not reducible by closed means. Puckering of the palmar skin overlying the metacarpal head is pathognomonic.^{35,36} Although several structures contribute to the complex dislocation, interposition of the volar plate between the proximal phalanx and the metacarpal is most often responsible.

Treatment and outcomes

Closed reduction of the dorsally dislocated MCP joint involves gentle re-creation of deformity (hyperextension) and then sliding the proximal phalanx back around the metacarpal head. Longitudinal traction is avoided because of a possibility of creating a complex dislocation by allowing the volar plate, which ruptures proximally, to interpose between the articular surfaces. Furthermore, the metacarpal head becomes “button-holed” between the lumbrical radially and the flexor tendons ulnarly, such that any attempt at traction only further serves to incarcerate the metacarpal head between these structures.

The optimal surgical approach to the complex MCP joint dislocation is debated. Dorsally, the joint can be easily accessed with minimal risk to the neurovascular structures. A dorsal incision is made directly over the joint, and the extensor hood can be split or sagittal bands divided. The volar plate is found dorsal to the metacarpal head, although it can be mistaken for articular surface given its smooth white appearance (Fig. 8). The volar plate is divided longitudinally to allow for reduction.

Through a volar approach, the joint can be accessed through a zigzag incision carried sharply through the skin only. The radial digital neurovascular bundle is often tented superficially over the metacarpal head and must be identified and protected.^{37,38} The flexor tendons generally are found ulnar to the metacarpal head, and releasing the A1 pulley relaxes the tension on the tendons. An elevator is used to free the volar plate from within the joint, which allows prompt reduction.

Either approach can be used based on surgeon preference. Postoperatively, patients are splinted with the MCP joints in slight flexion, and terminal extension is prevented for up to 2 weeks depending on joint stability. Advocates of the dorsal approach cite the ease of

the exposure with no risk to the digital neurovascular bundles. The dorsal approach is also useful if a shearing fracture on the dorsal metacarpal head requires treatment. Those surgeons who prefer the volar approach note the advantage of not having to longitudinally divide the volar plate. Whereas dividing the volar plate has been theorized to contribute to late MCP joint instability, this has not been substantiated.

There have not been any recent series documenting outcomes from this injury. Previous reports are limited to small case series focusing on surgical approaches. Barry et al. presented 4 patients who regained nearly full function after open reduction.³⁸ With a concentric reduction, it seems likely that patients will regain the majority of their preinjury motion within 4 to 6 weeks.³⁸

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