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Management of Proximal Interphalangeal Joint Injuries

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Injuries about the proximal interphalangeal joint are common problems seen by emergency physicians and hand surgeons. Inappropriate management of these injuries may result in chronic pain, stiffness, deformity, or premature degenerative arthritis. The complex anatomy and biomechanics of this joint after make classification and management of proximal inter-phalangeal joint injuries difficult. The surgical literature has tensed to focus on specific types of proximal interphalageal joint injuries, most often in the form of case reports. It is the purpose of this paper to bring together the findings of these reports in association with the senior author's experience. Emphasis is placed on establishing both a precise anatomic diagnosis and a protocol for subsequent management so that appropriate treatment may be commenced to prevent chronic disability. Ideal treatment necessitates the restoration of a stable and congruent joint that will allow early mobilization.

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The proximal interphalangeal (PIP) joint of the finger is prone to injury and residual deformity. An extensive review of 96 injuries about the PIP joint by Benke and Stapleforth [1] found a 30% poor recovery rate, as characterized by joint instability, poor function, pain, or flexion deformities. An understanding of the anatomy and biomechanics of this joint forms the basis of analyzing patterns, mechanisms, and subsequent management of these injuries.

The surgical literature has tended to address these injuries in the form of case reports. This paper brings together the finding of these reports and adds the senior author's experience to present a comprehensive analysis of injuries about the PIP joint. A classification of injuries about the PIP joint is suggested to provide a practical guide to management (Table 1). The poor tolerance of the PIP joint to prolonged immobilization emphasizes the importance of accurate anatomic diagnosis, rational splinting, and early active protected motion.

Anatomy and biomechanics

The PIP joint is a hinged joint capable of flexion and extension, the simplicity of which belies the anatomic and functional complexity of this joint. The proximal surface of the PIP joint consists of a double condyle configuration, with the base of the middle phalanx providing the complementary negative image. The supporting ligaments and tendons provide the bulk of the static and dynamic stability of this joint as it travels through a normal range of

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Table 1
Management protocol for injuries about the PIP joint

Classification	Management
Subluxations and dislocations	
Reducible (commonly dorsal, lateral)	Reduce, postreduction radiograph, then buddy tape for 2 to 4 weeks
Irreducible (usually compound with volar/dorsal involvement, or complete ligamentous rupture)	Open reduction and repair, extension splint for 1 to 3 weeks (depending on the extent of ligamentous damage) then buddy tape for 2 weeks
Avulsions	
Dorsal (central slip insertion)	
Large fragment	Open reduction and fixation followed by early protected active motion
Insignificant fragments or none	Splint in extension for 3 weeks, then buddy tape for 2 weeks
Volar	
With fragment	Splint for 4 weeks in 30 to 40 degrees of flexion, then buddy tape for 2 weeks
Without fragment (rare; frequently seen with hypermobile joints)	Open repair with pullout wire, splint for 3 weeks in 30 to 40 degrees of flexion, then buddy tape for 2 weeks
Lateral (rare; one or both collateral ligaments)	Buddy tape for 3 to 4 weeks
Intra-articular fractures	
Simple (one or two large fragments)	Open reduction and fixation, early motion with extension block for 1 to 3 weeks
Comminuted (single joint surface)	Buddy tape for 3 weeks
Joint destruction	Buddy tape for 3 weeks or immediate/early replacement arthoplasty or primary or delayed arthrodesis

110 degrees [2–5]. The capsule surrounding the articular surface of the joint is composed of the volar plate, lateral and accessory collateral ligaments, and extensor expansion. These are arranged in a box-like configuration such that joint instability implies disruption of two or more structures (Fig. 1).

The volar plate forms a broad and sturdy attachment to the middle phalanx, where it is continuous with the articular cartilage, whereas proximally the volar plate becomes markedly attenuated to form a thin attachment continuous with the synovial reflection. The lateral margins remain thickened to form strong ligaments [2]. This configuration creates a cul-de-sac between the proximal half of the volar plate and the head of the proximal phalanx, which allows the base of the middle phalanx to sweep along the articular surface of the proximal phalanx as the joint flexes. As a result, the volar plate is not only a static restraint limiting hyperextension, but it also has a dynamic component that changes with the position of the flexor tendons and influences the mechanical advantage of these tendons at the initiation of PIP joint flexion.

The thick collateral ligament (true and accessory) of the PIP joint combines with the volar plate to provide lateral stability. The extrinsic extensor mechanism inserts at the dorsal aspect of the base of the middle phalanx and also produces slips that become confluent with the intrinsic mechanisms. This confluence constitutes the lateral bands, which are connected to the volar aspect of a capsule by the oblique and transverse retinacular ligaments. The flexor tendon system at the level of the PIP joint is less complex than the

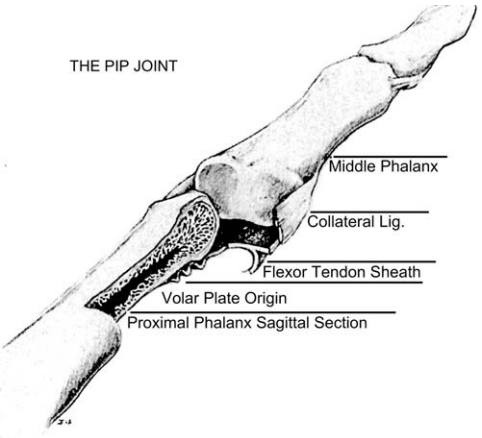

Fig. 1. Anatomy of the PIP joint.

extensor mechanism and contributes very little to injuries about the PIP joint.

Diagnosis

An accurate anatomic diagnosis and a rational treatment plan require a full history, careful physical examination, and appropriate radiographic assessment. The patient's age, occupation, handedness, type of finger (long and slender vs. short and stubby), hobbies, and history of previous hand deformity are all relevant. It is necessary to elicit a description of the actual mechanism of the presenting injury to ascertain the direction and magnitude of the causative forces involved.

Physical examination should start with an inspection of the type of hand, the attitude of the injured finger, and the localization of any swelling. The neurovascular status should be examined as in other hand injuries. Color, capillary refill, and digital temperature should also be assessed.

After this initial assessment, a thorough examination should include consideration of the bones, ligaments, volar plate, and tendons. Palpation of the PIP joint offers important information in an appropriate diagnosis and management of these injuries. Palpation of the joint over four planes (dorsal, volar, medial, lateral) allows assessment of point tenderness over ligamentous origins and insertions that is highly suggestive of underlying soft-tissue disruption. In cases in which the joint is grossly swollen and tender, this part of the examination may provide more accurate information several days after the injury.

Passive range of motion and joint stability must be established. In some cases, a digital nerve block may be required to permit complete assessment. Joint stability must be determined through dorsal, volar, and lateral stressing of the joint in a further attempt to isolate underlying soft-tissue disruption. It should never be assumed that lack of full active flexion or extension is merely secondary to joint pain or fusion, because closed rupture of the middle slip of the extensor hood is easily missed until the appearance of a boutonniere deformity.

Elson [6] describes a test in which, from 90 degrees of flexion, the patient tries to extend the PIP joint against resistance. The absence of extension force at the PIP joint, and fixed extension at the distal joint, indicate complete rupture of the central slip.

On occasion, when a digital block is necessary for accurate assessment, local anesthetic without adrenaline must be used. Finally, because simultaneous injury may be easily missed, any patient with a PIP joint injury must be examined carefully for injury of the adjacent joints.

A radiographic assessment requires anterior-posterior, lateral, and one or more oblique views that include the entire finger. With a true lateral view, there will be superimposition of the condyles of the head of the proximal phalanx that will allow detection of subtle joint abnormalities that may be otherwise overlooked. Comparative views of the corresponding joint in the opposite hand may be useful in ruling out congenital abnormalities and ongoing processes. It is important to note that in children with immature epiphyseal plates, nutrient arteries in the region of the distal condyles of the proximal phalanx may mimic an undisplaced fracture. After any attempts at closed reduction, a radiograph must always be repeated not only to assess the degree of reduction achieved but also to check for previously obscured fracture fragments.

General treatment principles

As with other hand injuries, management must include considerations of such general treatment principles as elevation of the injured part, appropriate range of motion, analgesia and tetanus and antibiotic prophylaxis (where appropriate).

An injury involving open communication between the joint and a superficial laceration is contaminated and at significant risk of developing serious sequelae [7]. In these cases, formal lavage with meticulous debridement of the soft tissues is mandatory [8], with additional consideration for antibiotic coverage where appropriate.

Most PIP joint injuries do not require open reduction. Open reduction and internal fixation are indicated for some intraarticular fractures, completely unstable fractures, and fractures that are stable only in flexion [9]. Early protected active motion of a stabilized injury must be provided to minimize stiffness arising from adhesions around tendons and joints while increasing the potential for biological modeling of the articular surface during bone and soft-tissue healing [10]. In the senior author's experience, in late follow-up, there are many more stiff than unstable joints. In general terms, most injuries about the PIP joint have been overtreated rather than under-treated.

Remember, the shorter the digit and the older the patient, the less immobilization is required.

Classification and management

Injuries about the PIP joint can be broadly classified into dislocations, avulsions, and intra-articular fractures (Table 1). After a careful clinical and radiographic assessment, a more detailed classification of the injuries forms the basis of the subsequent management.

Dislocations

Dislocations may be classified as reducible or irreducible and as dorsal, volar, or lateral: most are reducible. A dorsal dislocation, in which the middle phalanx is displaced dorsally to the proximal phalanx, is the most common type of dislocation (Fig. 2). In its simplest form, there is disruption of the volar plate as well as a portion of one or both collateral ligaments, usually at their insertion into the base of the middle phalanx, secondary to a hyperextension force. This type of injury is usually reducible and stable.

Occasionally, a more complex and irreducible dorsal dislocation may occur when there is a component of torque involved in the injury. With these forces, the head of the proximal phalanx may be displaced between the volar plate and the flexor tendon [11] and act as a buttonhole by tightly grasping the portion of the phalanx immediately behind the head, preventing closed reduction, Additionally, the distal attachment of the volar plate may rupture so that the volar plate becomes interposed between the joint surfaces [12,13]. These injuries are often compound (Fig. 3) and need immediate attention in the operating room. Other reported obstacles to closed reduction of this type of injury include interposition of the lateral band [14], the profundus tendon [15], the dorsal extensor aponeurosis [16], the articular cartilage of the base of the middle phalanx, and a markedly displaced epiphysis [14]. These dorsal dislocations require open reduction and repair, and subsequent active motion protected by "buddy taping" and an extension block (Fig. 4) commenced between 3 and 5 days postoperatively.

Fig. 3. Compound dislocation.

A volar dislocation, characterized by displacement of the middle phalanx anterolateral to the head of the proximal phalanx, is less common. These injuries tend to be irreducible because of interposed soft, or rarely, bony tissue [15] and are generally unstable after reduction [16].

These injuries are produced by a combination of varus or valgus forces and a severe anteriorly directed force on the base of the middle phalanx. Peimer et al [17] suggested that the combination of collateral ligament injury, volar plate damage, and extensor mechanism damage is pathognomonic of volar PIP joint dislocation. Management of a volar dislocation usually requires open reduction, after which the finger should generally be immobilized in extension for 7 days before active

Fig. 2. Dorsal dislocation.

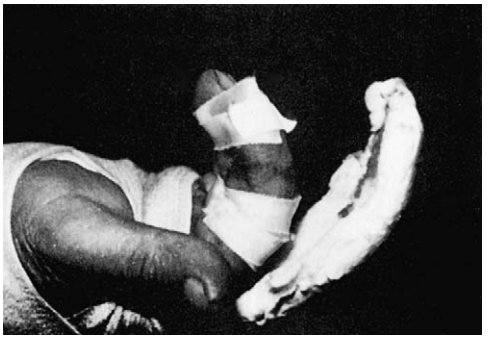

Fig. 4. Buddy taping with extension block.

protective motion is commenced. In cases involving complete central slip rupture, repair should be followed by 3 weeks of PIP joint immobilization in extension [17,18]. Unrecognized or inadequately repaired volar dislocation results in a chronic boutonniere deformity requiring later surgery [19], with generally poor late results.

Acute lateral dislocations at the PIP joint may involve a partial or complete tear of the collateral ligament complex. These usually reduce spontaneously or are easily reduced by closed methods and tend to be reasonably well stabilized after reduction [3]. Despite this, some authors believe that optimal treatment involves operative repair [11,20]. We and others believe that the joint is usually functionally stable after reduction, so the injury might be managed more conservatively [3]. We recommend minimization of valgus or varus strain on the injured joint for 3 weeks by simple "buddy taping" (Fig. 5) to a neighboring finger. The senior author has never seen a late collateral ligament injury requiring a ligamentous reconstruction.

Although absolute indications for operative management of a lateral dislocation of the PIP joint are few, a small number of these injuries cannot be managed by closed means. For example, cases that have required open reduction include entrapment of an extensor tendon [13] or a collateral ligament in a joint [20] and buttonholing of the head of the proximal phalanx through a tear in the dorsal apparatus.

Avulsions

Avulsions about the PIP joint may be dorsal, volar, or lateral and may be associated with small or large bony fragments. A dorsal avulsion occurs at the level of insertion of the central slip of the long extensor mechanism into the dorsal base of the middle phalanx (Fig. 6). If a large bony fragment is avulsed along with the central slip, the result is an unstable injury that should be referred for open reduction and fragment fixation. If there is no significant bony avulsion fragment, "fracture bleeding" does not occur and the site of injury appears to be compromised in its ability to scar and heal. This injury is best treated by splinting the PIP joint in extension for 3 weeks while allowing free movement of the distal and proximal joints. In a review of long-term results of 62 patients, Newport et al [21] found that 64% of the patients without associated injuries achieved good to excellent results with total active motion of 212 degrees using this type of conventional splinting. Another 2 weeks of buddy taping with the adjacent digit acting as a dynamic splint is then warranted to allow protected active motion. If the diagnosis of a dorsal avulsion injury is missed, there is progressive displacement of the lateral bands volar to the axis of rotation of the PIP joint, with subsequent shortening. The central tendon, therefore, heals in an attenuated position, and secondary hyperextension at the PIP joint follows to produce a boutonniere deformity.

A volar avulsion usually occurs at the insertion of the volar plate into the middle phalanx. Forced hyperextension or axial loading (as seen when the fingertip is hit with a baseball or volleyball) either ruptures the volar plate at the bone interface or avulses a fragment of the marginal metaphysis of the middle phalanx at the site of its attachment (Fig. 7). Because the check ligament attachment of the volar plate to the proximal phalanx is strong

Fig. 5. Buddy taping allows stable early motion

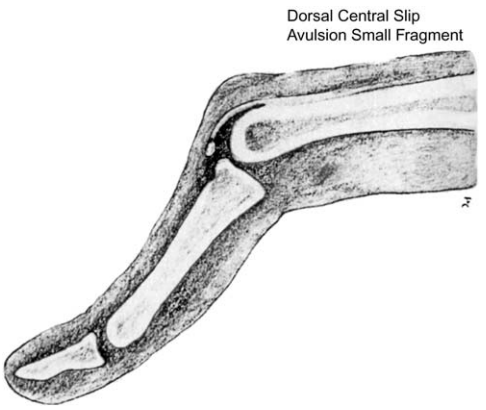

Fig. 6. Dorsal avulsion.

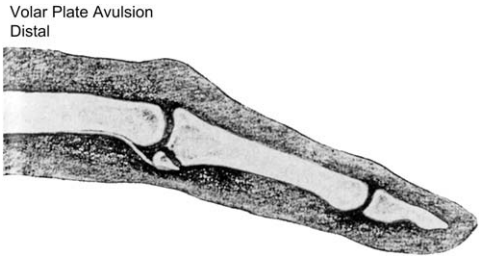

Fig. 7. Distal volar plate avulsion.

and pliable, rupture seldom occurs here (Fig. 8). This injury, although painful, is stable and often of minimal long-term consequence. The relatively sparse vascular network in the region of the distal insertion of the volar plate, however, may predispose this injury to ''non-union'' and subsequent hyperextension deformity [5], although this is rare. Poor healing may ultimately result in dislocation of the phalangeal condyles through the capsule to produce a volar boutonniere referred to as a ''recurvatum deformity,'' especially in the long slender fingers.

In the presence of any avulsed bony fragment, splinting is flexion for 3 to 4 weeks, followed by active protected motion using buddy taping for 2 weeks is advocated. The amount of flexion may vary from 10 to 40 degrees depending on the distance between the avulsed fragment and its origin. In the absence of a significant fracture and in the slender finger, the injury is best treated by open repair with a pullout wire or a Bunnell suture dorsally over a button [11]. These fingers should then be splinted in 30 to 40 degrees of flexion for 3 weeks followed by 2 weeks of active protected motion with buddy taping.

A lateral avulsion may involve one or both collateral ligaments (Fig. 9). A review of the literature reveals no clear guidelines for treatment. In

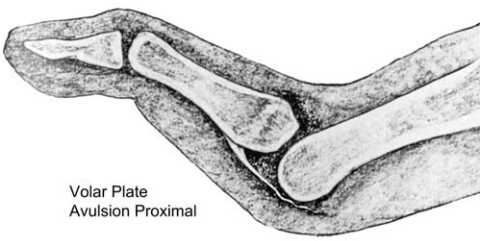

Fig. 8. Proximal volar plate avulsion.

Fig. 9. Lateral avulsion.

small series of patients with collateral mechanism disruption, the best results with respect to rapid pain relief and joint stability were obtained after surgical repair [22,23]. Other investigators have advocated splinting and immobilization, particularly with incomplete ligament tears [3].

We prefer a conservative approach with simple buddy taping to minimize valgus and varus strains for 3 to 4 weeks. The late results have been uniformly satisfying.

Intra-articular fractures

Intra-articular fractures (Fig. 10) may be classified along a continuum varying from simple, with only one or two large bony fragments, to comminuted, to complete joint destruction. The ideal treatment would include restoration of a stable and congruent joint surface that would allow early active range of motion.

Fractures that involve one or two large bony fragments tend to be unstable. Investigators have

Fig. 10. Unpolar intra-articular fracture.

used a number of different approaches to management. Internal fixation, however, is generally advocated, particularly in the presence of a large intra-articular fragment, marked obliquity, or a condylar fracture [24]. With transverse and short oblique fractures, excellent results have been reported using closed Kirschner wiring [25]. Alternatively, internal fixation using interfragmentary compression provides not only anatomic reduction but also increased stability, which allows for early postoperative mobilization [26]. We advocate open reduction and internal fixation or percutaneous pinning when possible to permit joint mobility for early active motion exercise with an extension block.

Treatment methods for unstable intra-articular comminuted fractures have included immobilization [27], open reduction [11], extension block splinting [25], silicone prostheses [28], and fusion. Each of these methods has potential for decreased range of motion at the PIP joint, and bearing in mind that the goal is to avoid joint stiffness and loss of function, buddy taping and early active motion in all cases is practiced by the senior author. A prospective, long-term, follow-up study is underway. The initial impression is that the results are satisfying.

Summary

Injuries about the PIP joint of the finger are commonly encountered by primary care physicians and are associated with significant morbidity, including pain, stiffness, instability, premature degenerative arthritis, and residual deformities. An accurate understanding of the regional anatomy and appreciation of the mechanism of injury allows for classification so that a treatment protocol can be formulated for each injury pattern. Emphasis on careful consideration of the implications of open reduction, rational splinting, and early, active, protected motion provides for the most favorable outcome.

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