Chapter 15

Fracture and Dislocation of Proximal Interphalangeal Joint

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ABSTRACT
Proximal interphalangeal joint (PIPJ) injuries, involving fractures and dislocations, present significant challenges due to their complex nature and potential for disability, especially in individuals requiring fine motor skills. These injuries, often overlooked initially due to swelling, range from purely ligamentous dislocations to those with accompanying fractures.

The extent of these injuries necessitates a broad spectrum of treatments, from conservative to surgical, aimed at restoring joint stability, congruity, and facilitating early motion. Extension block pinning, closed reduction-K wire, volar plate arthroplasty are typically employed for less severe cases, resulting in promising outcomes. Conversely, severe injuries require interventions like hemihamate arthroplasty, dynamic external fixation, and open reduction internal fixation, although these lead to lower postoperative PIPJ range of motion.

Osteoarthritis post-surgery remains a frequent complication, underscoring the need for continued research to refine treatment strategies and manage complications, enhancing patient outcomes.

Keywords: Proximal Interphalangeal Joint, Fractures, Dislocations, Treatment, Postoperative Complications.
INTRODUCTION

Proximal interphalangeal joint (PIPJ) fractures and dislocations are seen as challenging, unforgiving injuries. Purely ligamentous PIP joint dislocations can be observed, or those accompanied by fractures (Hammert et al., 2012a). The development of pain, post-traumatic arthritis, swelling, and stiffness may occur despite being treated carefully and appropriately. Disability in athletes, musicians, and those whose work necessitates fine motor activity can be caused by these conditions. PIP joint injuries are commonly encountered but due to swelling, the possibility of them being overlooked by the initial examiner exists (Bentley, 2014).

Epidemiology

There is limited demographic information on PIP joint fractures and dislocations. In the USA, finger fractures occur at a rate of 67.9 per 100,000 and finger dislocations at a rate of 11.3 per 100,000 (Ootes et al., 2012). Another study indicated that finger dislocations occur at a rate of 11.1 per 100,000. Most commonly, 38.6% of these injuries are seen in the 15-19 age range and 78.8% are male. The majority, 35.9%, occur during sporting or recreational activities (Golan et al., 2016). In another study conducted in Taiwan, the rate of finger dislocations was found to be 4.6 per 100,000 (Yang et al., 2011).

Anatomy

The PIPJ is a synovial joint, make flexion up to 110 degrees as a hinge type joint. The proximal part of the PIP joint is formed by two concentric symmetrical condyles and is divided into two by the intercondylar sulcus. The size of the radial condyle is longer in 2nd & 3rd fingers, equal to the ulnar condyle in the 4th finger, and shorter than the ulnar condyle in the 5th finger (Hammert et al., 2012b). This condition forms the rotational movement of the fingers, causing the fingertips to converge when the fingers are flexed.

The distal part of the PIP joint, which is biconcave in shape, is formed by the base of the middle phalanx. The volar surface is important for joint stability and consists of two thickened corners and lateral tubercles.

The volar surface of the PIP joint is formed by the volar plate (Kamnerdnakta et al., 2018). The volar plate originates from the P1 with the checkrein ligaments and also from C1 pulley & A2 pulley, attaching its thick lateral fibers to corners of P2. Its thin central fibers attach to volar part.

There are proper collateral and accessory collateral ligaments in the PIP joint (Pang & Yao, 2018). The these ligaments originate from the lateral part of P1 and attach to the volar and lateral part of the P2. The principle task of the proper
collateral ligament is to provide stability in lateral plane. The purpose of the accessory ligament is more limited and it ensures the fit between the volar plate and the surfaces.

The volar plate and collateral ligaments form a box, ensure stability to PIPJ (Figure 1). For a dislocation to occur, these structures need to be compromised in at least two planes.

**Figure 1.** PIP joint anatomy

**FRACTURE TYPE AND MECHANISM OF INJURY**

Dislocations of the PIP joint can occur either with or without a fracture, and can be dislocated dorsally, volarly, or laterally (Figure 2).

**Figure 2.** Dorsal fracture dislocation PIP joint
**Dorsal dislocations**

Dorsal dislocations occur due to hyperextension and axial loading. Dorsal dislocations are the most common type and there are several classification systems for them. However, the Eaton classification is the most frequently used. Injuries to the volar plate are based on the Eaton classification: Type I is a hyperextension injury, Type II is a dorsal dislocation, and Type III is a fracture dislocation.

Type I involves partial or complete detachment of the volar plate. In Type II, the joint surfaces do not make contact and there is detachment of the volar plate along with splitting of bilateral collateral ligaments. In Type III, there is an avulsed bone fragment in the middle phalanx.

Along with the Eaton classification, the Keifhaber-Stern classification is one of the most frequently used today. According to this classification, injuries from volar plate avulsions are divided into three: stable avulsion fractures, tenuous avulsion fractures, and unstable avulsion fractures. In stable avulsion fractures, there is a fracture on < 30% of the joint surface of the P2. In tenuous avulsion fractures, this rate is between 30-50%. In unstable fractures, this rate is over 50%.

**Volar dislocations**

Volar dislocations are rarely occurring injuries. These injuries can be overlooked, often resulting in late-stage deformities. These injuries usually involve a central slip lesion. It can easily be missed, leading to a boutonniere deformity in the late period. These injuries are divided into three: simple volar dislocation, volar fracture dislocation, and volar rotary dislocation.

In volar dislocation, there is damage to the bilateral collateral ligaments, volar plate, and usually a central slip injury. In volar fracture dislocation, there is a fracture fragment, and in volar rotary dislocation, the head of the P1 has entered among the central slip & the lateral band.

**Lateral dislocations**

Lateral dislocations are rare injuries involving damage to the collateral ligament and the volar plate.

**DIAGNOSIS**

The diagnosis is initiated with detailed history of the patient and an understanding of the trauma mechanism. Whether there was a subluxation or dislocation following the trauma, and whether a reduction was conducted post-injury, is investigated. The occurrence time of the event is ascertained. On examination, the presence of swelling, redness, lacerations, bruising, and open
wounds is looked for. By palpation, the exact location of the pain and the area of greatest sensitivity are identified. The neurovascular status is recorded.

Anteroposterior (AP) and true lateral radiographs of the fingers are obtained. On the lateral radiograph, the superimposition of the condyles is considered important. Oblique radiographs in partial pronation and supination may also be acquired. On the AP radiograph, the existence of an impaction fracture is checked. On the lateral radiograph, the colinearity of the proximal and middle phalanxes is expected. Malalignment is interpreted as a sign of subluxation. Additionally, the existence of a dorsal "V" sign on lateral radiograph is looked for (Figure 3).

![V sign](image)

**Figure 3.** “V” sign

Record the joint range of motion and laxity, and check for instability. If seen as necessary, the examination can be repeated under fluoroscopy.

**TREATMENT**

In PIP joint injuries, the initiation of early motion is deemed critical for functional outcomes. The treatment decision is mostly influenced by the extent of the trauma, the status of the bone and musculoskeletal tissues. Treatment aims to achieve joint surface congruity, facilitate concentric gliding joint motion, and render the joint stable enough to allow early joint motion. If these conditions aren't fulfilled, chronic pain, joint stiffness, and injury related arthritis can be results of prolonged joint immobilization.
Among treatment options are extension block splinting, closed reduction-K-wire, open reduction internal fixation, volar plate arthroplasty, hemi hamate resurfacing arthroplasty, and dynamic external fixation (Figure 4 & 5). Hemi hamate arthroplasty and dynamic external fixator are generally employed for severe injuries (Ellis et al., 2007; Ng & Oliver, 2009).

![Dynamic external fixator (Suziki frame)](image)

**Figure 4.** Dynamic external fixator (Suziki frame)

![Suziki frame](image)

**Figure 5.** Suziki frame

**Dorsal Dislocations**

In dorsal hyperextension injuries, an extension block splinting is followed in mild flexion (around 30 degrees) for 1-2 weeks. In dorsal dislocation cases, a
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Figure 4. Dynamic external fixator (Suzuki frame)

Figure 5. Suzuki frame

Dorsal Dislocations

In dorsal hyperextension injuries, an extension block splinting is followed in mild flexion (around 30 degrees) for 1-2 weeks. In dorsal dislocation cases, a closed reduction and immobilization in slight flexion are performed for 1-2 weeks.

With dorsal dislocations with fractures, the length of the volar fracture fragment, its fragmentation, and angle at which reduction is compromised, are considered important. Extension block splinting (around 20 degrees) is applied and movement is immediately initiated in cases of stable and tenuous dislocation fractures.

For dorsal unstable dislocation fractures, procedures such as extension block pinning, open reduction internal fixation, external fixation, volar plate arthroplasty, or hemi hamate arthroplasty can be performed.

In the presence of a simple and sufficiently sized fracture fragment, open reduction with mini screws, K wires, or tension band wiring can be undertaken (Azari, 2007; Lee & Teoh, 2006).

For external fixation, static or dynamic options can be chosen. It can be used as an addition to internal fixation, allowing immediate joint movement and facilitating fracture reduction via ligamentotaxis (Figure 6) (Damert et al., 2013; Keramidas et al., 2007; Körting et al., 2009). It is contraindicated in proximal phalanx head fractures.

Figure 6. Suzuki frame addition to internal fixation
In volar plate arthroplasty, the damaged joint surface is resurfaced with fibro-cartilaginous tissue, achieving joint stability. This is typically used in highly fragmented and impacted fractures, with varying clinical results (Dionysian & Eaton, 2000; Rettig et al., 2001).

Hemihamate arthroplasty is used in unstable fragmented or impacted dislocation fractures, fractures involving more than 50% of the joint surface, and as a salvage operation (Afendras et al., 2010; Capo et al., 2008). A part prepared from the ipsilateral dorsal hamate is implanted in the defect area of the middle phalanx.

**Volar Dislocations**

For simple dislocations, a short-term immobilization is undertaken post-reduction in patients without extension lag, while a central slip repair is performed in those with extension lag. If a closed reduction cannot be achieved, an open reduction can be carried out.

In volar dislocation fractures, If the fragment is smaller than 20% of the articulating surface and is displaced by less than 2 mm, it is managed with a splint similar to Boutonnière injuries. If the fragment displacement is more than 2 mm or more than 20%, an open reduction internal fixation is applied.

**Lateral Dislocations**

These dislocations often self-reduce and are managed with a buddy splint.

**PROGNOSIS AND COMPLICATION**

For tenuous fracture patterns, treatments such as extension block pinning, closed reduction-K wire, volar plate arthroplasty have been observed to provide effective clinical and functional outcomes (Kamnerdnakta et al., 2018) (Figure 7). On the contrary, for comminuted and serious PIP joint injuries, interventions like HHA or dynamic external fixation are often required, which typically yield modest postoperative results. Some literature indicates that closed reduction-K wire, volar plate arthroplasty lead to the good postoperative range of motion at the PIP joint and have the lowest reoperation rates (Gianakos et al., 2020).
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When addressing severe injuries, particularly those involving extensive articular damage or pilon types, HHA, dynamic external fixation, and open reduction internal fixation are commonly used. However, these methods are associated with a lower postoperative PIP joint ROM.

Postoperative osteoarthritis (OA) is a frequent outcome across all surgical treatments, although severe OA cases are relatively few. Notably, extension block pinning was linked with a high rate of postoperative OA and recurring pain, which raises concerns. In addition, significant rates of recurrent subluxation have been reported in studies that examined extension block pinning and ORIF.

CONCLUSION

Proximal interphalangeal joint (PIPJ) injuries are complex and challenging. Treatments range from conservative to surgical, aiming to restore joint stability, congruity, and enable early motion. For tenuous fracture patterns, closed reduction-K wire, extension block pinning, and volar plate arthroplasty yield positive outcomes. Severe injuries often require HHA, external fixation (Suziki frame) or open reduction internal fixation, albeit with reduced postoperative PIP joint ROM. Postoperative osteoarthritis is a common complication across all treatments, particularly notable with extension block pinning. Further research is needed to refine treatment algorithms and develop strategies to prevent and manage complications, ultimately improving patient outcomes.
REFERENCE


