Treatment for Acute Proximal Interphalangeal Joint Fractures and Fracture-Dislocations: A Systematic Review of the Literature

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Abstract

Keywords

- proximal interphalangeal joint
- fracture-dislocation
- finger
- hand
- fracture
- fixation
- treatment

Proximal interphalangeal joint (PIPJ) fractures and fracture-dislocations are common hand injuries and recognition of this injury pattern is essential in the management of these fractures. Although a variety of treatment options have been reported in the literature, the optimal treatment remains controversial. MEDLINE, EMBASE, and The Cochrane Library Database were screened for treatment strategies of PIPJ fracture and fracture-dislocation. Demographic data and outcome data were collected and recorded. A total of 37 studies including 471 patients and 480 fingers were reviewed. PIPJ range of motion (ROM) was greatest postoperatively in patients who underwent volar plate arthroplasty at 90.6 degrees. Dynamic external fixation resulted in the lowest PIP joint ROM with an average of 79.7 degrees. Recurrent pain and osteoarthritis were most often reported in extension block pinning at 38.5 and 46.2%, respectively. Open reduction and internal fixation had the highest rate of revision at 19.7%. Overall, the outcomes of PIP fractures and fracture-dislocations are based on the severity of injury, and the necessary treatment required. Closed reduction with percutaneous pinning and volar plate arthroplasty had good clinical and functional outcomes, with the lowest complication rates. Hemi-hamate arthroplasty and dynamic external fixation were utilized in more complex injuries and resulted in the lowest PIPJ ROM. This is a therapeutic, Level III study.

Introduction

The proximal interphalangeal joint (PIPJ) is a commonly injured joint in the hand. Fracture and fracture-dislocation of the PIPJ often occur from an axial load and result in a fracture of the middle phalangeal at the dorsal or volar lip or both (pilon) and resulting joint dislocation. The exact fracture pattern depends on the injury force vector and on the position of the finger.¹ The annual estimated incidence of all finger fractures and finger dislocations at any joint is 67.9 and 11.3 per 100,000 persons per year, respectively, in the

United States.² Early recognition of these injuries is critical, as untimely management can lead to recurrent subluxation and chronic stiffness, arthrosis, and pain. Unfortunately, initial presentation can be deceptively benign, and the severity of the injury is often underestimated.³

Wide ranges of injuries have been reported in the literature including joint sprain, dislocation, fracture, and fracture dislocation. Proper classification of the injury by fracture pattern and size, and thorough understanding of the resultant stability can help reduce lifelong morbidity.⁴ The goal of treatment is to create a stable and congruent

joint affording protected range of motion (ROM) to restore mobility and prevent both stiffness and disability.^{5,6} Many surgical approaches with a wide range of technical complexity have been described in the literature including extension block pinning,⁷ closed reduction and percutaneous pinning (CRPP),⁸ dynamic external fixation devices,⁹⁻¹¹ open reduction and internal fixation,¹²⁻¹⁴ volar plate arthroplasty,¹⁵ and hemi-hamate replacement arthroplasty.¹⁶⁻¹⁸ Although multiple studies have demonstrated improved outcomes when PIPJ injuries are treated early, there has been no consensus regarding the optimal surgical procedure for the varying degrees of PIPJ injuries.¹⁹⁻²²

This study attempts to review recent evidence of surgical outcomes in the treatment of acute PIPJ fractures and fracture dislocations. In addition, our review will provide the reader with a reference of the level and quality of evidence of the current available literature.

Materials and Methods

Search Strategy

This is a systematic review conducted by two independent reviewers according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, see ►Fig. 1 for flow diagram.²³ The following search terms were used in MEDLINE, EMBASE, and The Cochrane Library databases on November 14, 2019: PIPJ, fracture, dislocation, fracture-dislocation, and treatment.

Eligibility Criteria

The inclusion criteria were: (1) clinical study evaluating the treatment of fractures and fracture-dislocations of the PIPJ requiring procedural intervention, (2) published in a peer-reviewed journal, (3) written in English, and (4) full text of studies available. The exclusion criteria were: (1) review studies,

Fig. 1 Study selection flow chart. Selection criteria and literature search according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.

Table 1 Study demographics

	Overall	Hemi-hamate arthroplasty	Closed reduction and Kirschner wire pinning	Dynamic external fixation	Open reduction and internal fixation	Extension block pinning	Volar plate arthroplasty
<i>n</i> (studies)	37	5	4	16	6	3	3
<i>n</i> (patients)	471	42	40	224	59	74	32
<i>n</i> (fingers)	480	42	41	226	61	78	32
LOE	IV	IV	IV	IV	IV	IV	IV
Male/female	303/83	16/3	30/10	141/40	50/9	36/19	30/2
Age (y)	33.0	34.0	29	36.4	31.4	36.5	30.4
Injury to surgery (d)	8.9	9 (4–18)	7 (4–11)	9.7 (3–28)	13.9 (7–27)	6.7 (2–9)	7.0 (4–10)
Follow-up (mo)	43.7	29.8	74.7	18.0	32.6	50.3	56.7
% Articular	48.3%	61.4%	33.0%	46.5%	49.0%	51.5%	NR
Fracture patterns							
Volar fragment	77.1%	21.4%	100%	55.8%	85.2%	100%	100%
Dorsal fragment	1.1%	0%	0%	6.6%	0%	0%	0%
Pilon	5.4%	0%	0%	27.4%	4.9%	0%	0%
Comminuted	16.4%	78.6%	0%	10.2%	9.8%	0%	0%

Abbreviations: LOE, level of evidence; NR, not reported.

(2) case reports, (3) chronic fracture-dislocations (>6 weeks from injury to intervention), (4) animal studies, (5) cadaver studies, (6) biomechanical studies, (7) technical notes, (8) studies with mean follow-up less than 6 months, and (9) studies not separating outcomes by treatment type or chronicity.

Study Selection

The title and abstract were reviewed for all search results, and potentially eligible studies received a full text review. In addition, the reference lists of all included studies and all literature reviews found in the search results were manually screened for additional articles that met the inclusion criteria. If a consensus was unable to be made, a senior author was consulted who had the final decision.

Data Extraction/Analysis

The data of each clinical study were extracted using a standardized data sheet. The following information was recorded: patient demographics, treatment method, level of evidence (LOE), methodological quality of the evidence (MQOE), clinical outcomes, and radiographic outcomes. Clinical outcomes included PIPJ and distal interphalangeal joint (DIPJ) active arc of motion, PIPJ extension lag, grip strength (% of uninjured hand), VAS, the Disabilities of Arm, Shoulder, and Hand (DASH), QuickDASH, recurring pain (defined as any persistent discomfort), infection, secondary surgical procedures, and deformity on exam (rotation or clinodactyly). The primary radiographic outcomes of interest were recurrent subluxation and the presence of osteoarthritis (OA) at final follow-up.

Level and Quality of Evidence

The LOE was evaluated based on the Oxford Guidelines. The MQOE was assessed for randomized control trials using the MINORS score.

Results

Demographic Data and Study Characteristics

The mean demographics and fracture characteristics for each treatment group and overall are shown in ►Table 1. A total of 37 studies evaluating 471 patients (303 males and 83 females) and 480 fingers were included in this review. Mean age was 33.0 (12–87) years. The mean interval from injury to surgery was 8.9 (6.7–13.9) days. Mean follow-up across all studies was 43.7 (18–74) months. Overall mean articular involvement of the fracture was 48.3 (33–61)%.

The individual studies included in this review are shown in ►Supplementary Appendix A (available in the online version). Five studies evaluated hemi-hamate arthroplasty (HHA).^{22,24–27} A total of four studies evaluated CRPP: two trans-articular pinning^{28,29} and two fragment fixation with two to three Kirschner wires.^{30,31} Sixteen studies evaluated dynamic external fixation: eight with rubber bands,^{32–39} five without rubber bands,^{40–44} and three with Ligamentotaxor device (Arex, Palaiseau, France).^{45–47} Six studies evaluated open reduction and internal fixation (ORIF): four mini-screw fixation^{21,48–50} and two mini-plate.^{51,52} Three studies evaluated extension block pinning.^{53–55} Three studies evaluated volar plate arthroplasty: one suture-button,⁵⁶ one suture anchor,⁵⁷ and one suture repair directly to periosteum.⁵⁸

All 37 studies were LOE 4. The MINORS allow assessment of the quality of evidence in comparative and noncomparative nonrandomized trials with 0 being the lowest score and 16 being ideal for noncomparative and 24 for comparative studies. The average MINORS score was 11.7. The individual scores are listed in ►Supplementary Appendix A (available in the online version).

Clinical and Functional Outcomes

The specific outcomes reported in each study varied greatly. The overall frequency of outcome variables reported are shown

Table 2 Study outcomes

	Overall	Hemi-hamate arthroplasty	Closed reduction and Kirschner wire pinning	Dynamic external fixation	Open reduction and internal fixation	Extension block pinning	Volar plate arthroplasty
Device removal (d)	26.6	NA	26 (21–28)	33 (21–49)	NA	21 (20–22)	NA
PIPJ Arc	84.7	79.8 (69–95)	90.2 (85–102)	79.7 (64–90)	82.2 (66–100)	82.7 (80–85)	90.6 (85–94)
PIPJ extension lag	10.3	12.3	8	10.2	11.0	6.9	13.4
DIPJ Arc	61.8	56.9 (39–80)	66.2 (49–78)	59.5 (47–78)	58.6 (47–65)	72.5 (68–77)	58.0 (30–85)
DASH	5.4	3.4	8	9.2	2	4.5	NR
QuickDASH	11.4	7	NR	18.6	8.5	NR	NR
VAS	1.35	1.3	1.4	1.3	NR	1.4	NR
Grip strength (%)	90.1%	92%	NR	85.5%	91.7%	NR	91.3%
Complications							
Major							
Secondary procedure	6.8%	14.3%	0.0%	4.0%	19.7%	2.6%	0%
Subluxation	7.8%	0.0%	2.4%	1.8%	21.3%	15.4%	0%
Minor							
Recurring pain	15.9%	7.1%	7.3%	15.0%	21.3%	38.5%	6.3%
Infections	4.9%	0%	7.3%	16.4%	1.6%	3.8%	0%
OA	20.7%	26.2%	4.9%	18.1%	9.8%	46.2%	18.8%
Clinodactyly	6.5%	2.4%	0%	4.9%	9.8%	NR	15.6%
Rotation	1.1%	0.0%	0%	0.4%	NR	5.1%	0%

Abbreviations: DASH, Disabilities of Arm, Shoulder, and Hand; DIPJ, distal interphalangeal joint; LOE, level of evidence; NA, not applicable; NR, not reported; OA, osteoarthritis; PIPJ, proximal interphalangeal joint; VAS, Visual Analogue Scale.

in **►Supplementary Appendix B** (available in the online version). The most commonly reported outcomes were PIPJ ROM, infection status, secondary procedures, and recurring pain/discomfort. The DASH, QuickDASH, and VAS outcomes were reported the least, with less than 25% of studies reporting.

Clinical and functional mean outcomes are demonstrated in **►Table 2**. The PIPJ arc at follow-up was greatest in patients who underwent volar plate arthroplasty with a mean of 90.6 (85–94) degrees, followed by CRPP with a mean 90.2 (85–102) degrees. DIPJ arc was the greatest in patients receiving extension block pinning with a mean 72.5 (68–77) degrees. Dynamic external fixation exhibited the lowest PIPJ arc with a mean 79.7 (64–90) degrees. DIPJ arc was similar among HHA, mean 56.9 (39–80) degrees; volar plate arthroplasty, mean 58.0 (30–85) degrees; ORIF, mean 58.6 (47–65) degrees; and dynamic external fixation, mean 59.5 (47–78) degrees.

CRPP and dynamic external fixation had the highest mean DASH scores, 8.0 and 9.2, respectively; however, DASH was only reported in 22.2% of all studies and was not reported in the volar plate arthroplasty group. Grip strength was the lowest in dynamic external fixation with 85.5 (71–92)% and similar in HHA at 92.0 (76–104)%, ORIF with 91.7% (85–98)%, and volar plate arthroplasty at 91.3 (80–105)%. Grip strength was not reported in either CRPP or extension block pinning. VAS was low (1.3–1.4 out of 10) in HHA, CRPP, dynamic external fixation, and extension block pinning, indicating slight discomfort although was not recorded in the ORIF and volar plate arthroplasty groups.

Complication outcomes are also demonstrated in **►Table 2**. The most common complications overall included OA and recurring pain. The rate of OA was the highest in extension block pinning at 46.2% (36 of 78 fingers), followed by HHA with 26.2% (11 of 42) and lowest in CRPP at 4.9% (2 of 41). Recurrent pain was most frequent in extension block pinning in 38.5% of fingers (30 of 78) and ORIF in 21.3% (13 of 61). Minor superficial skin or pin tract infections occurred most frequently in dynamic external fixation, 16.4% (37 of 226), CRPP, 7.3% (3 of 41), and extension block pinning, 3.8% (3 of 78).

Major complications were considered to be recurrent subluxation and any secondary surgery or revision procedure. Hemi-hamate resection and ORIF experienced a higher rate of secondary surgical procedures at 14.3% (6 of 42) and 19.7% (12 of 61), respectively, while the CRPP and volar plate arthroplasty groups reported no additional procedures. Extension block pinning and ORIF had the highest rates of recurrent subluxation at 15.4% (12 of 78) and 21.3% (13 of 61), respectively. There were no cases of recurrent subluxation in either the hemi-hamate or volar plate arthroplasty groups.

Discussion

Although previous studies have demonstrated that early treatment of PIPJ injuries can improve clinical outcomes, the optimal surgical procedure for the varying severities of PIPJ

injuries remains controversial.¹⁹⁻²² Regardless of the treatment modality selected, three fundamental guidelines should be followed when attempting to surgically treat PIPJ fractures and fracture-dislocations. These include the following: (1) restore concentric gliding joint motion, (2) impart enough stability to the joint to allow early ROM, and (3) restore joint surface congruity.⁵⁹ The current classification divides these injuries into stable (<30% articular surface involvement), tenuous (30–50%), and unstable (>50%) fracture dislocations.⁶⁰ Comminution and extensive articular involvement increase the technical difficulty of both closed and open reduction fixation techniques.

The treatment of PIPJ fractures and fracture-dislocations may be best determined by the severity of injury. Good clinical and functional outcomes were found in tenuous fracture patterns when treated with either CRPP, extension block pinning, or volar plate arthroplasty. This review also demonstrates that HHA and dynamic external fixation were the treatment of choice for more complex and severe PIPJ injuries and resulted in modest outcomes postoperatively. Lastly, this review highlights that although the included studies received moderate MINORS quality scores, the majority of studies were noncomparative and of LOE 4.

Treatment with CRPP and volar plate arthroplasty resulted in the greatest PIPJ ROM postoperatively and the lowest rates of reoperation. However, these patients presented with the least amount of articular involvement and one could argue are minor injuries compared with the more extensive articular disruption. More severe injury patterns (greater articular involvement and pilon type) were more often treated with HHA, dynamic external fixation, and ORIF and subsequently reported lower PIPJ ROM. The greater operative soft tissue dissection and the need for retained hardware is required in ORIF and HHA, which may also contribute to lower PIPJ ROM and increased rates of secondary surgical procedures postoperatively. Inherently, the severity of the injury also has a large influence on the ultimate outcome.

Radiographically, all surgical treatments evaluated in this review reported varying degrees of postoperative OA; however, most were described as mild to moderate and there were very few cases of severe OA at 1.5% (7 of 480 fingers). The highest rate of postoperative osteoarthritis and recurring pain was reported with extension block pinning at 46.2 and 38.5%, respectively. And although the majority of studies reported a congruent and reduced PIPJ radiographically, two studies—one in extension block pinning and one in ORIF—reported high rates of recurrent subluxation. Grant et al reported “minor” dorsal subluxation in 84% of patients treated with open reduction and internal screw fixation; however, only 2 out of 11 patients were not satisfied with their outcome.²¹ In contrast, Waris et al reported on patients that received extension block pinning and found a 30% rate of recurrent subluxation and found significantly higher rates of pain in patients with recurrent subluxation compared with those without (67 vs. 22%, $p = 0.01$).⁵³

Extension block pinning can be an effective treatment option in less severe injuries while allowing for early mobilization and avoiding potential soft-tissue adhesions

associated with open dissection. Positioning of the Kirschner wires and the extension block pin allows for some limited active flexion and extension to the blocked position and thus preventing fracture displacement and joint subluxation.⁴ Although our review reports a high rate of recurring pain in extension block pinning, the mean articular involvement was greater than 50%. Ideally, this procedure would be reserved for fractures with less articular involvement. Maalla et al reported greater PIPJ ROM and less pain when utilizing extension block pinning in fractures with 10 to 20% articular involvement compared with those with >21%.⁵⁴

De Haseth et al reported that the threshold for stability is approximately 40% involvement of the articular surface of the base of the middle phalanx when treated with trans-articular CRPP.²⁸ In our review, the mean articular involvement was less than 40% in the studies utilizing CRPP and subsequently reported good outcomes and low complication rates. Volar plate arthroplasty has been used when fracture fragments are small or comminuted and thus fixation of the base is not attainable. This technique has had less reliable results in fractures with greater than 50% involvement of the articular surface as a volar buttress is crucial for stability.⁶¹ In fractures with large fragments and simple fracture patterns that cannot be reduced by closed methods, ORIF can be effective by restoring the essential volar buttress but also carries a higher rate of revision and recurring pain.

In more complex PIPJ fractures and fracture dislocations (extensive articular involvement, comminution), HHA and dynamic external fixation were the surgical treatments most often utilized. Dynamic external fixation is an effective procedure that can be implemented for difficult fractures while allowing for immediate mobilization; however, a higher rate of superficial skin or pin-tract infections can be expected. HHA had a higher rate of revision, but less pain and no recurrent subluxation. However, this technique requires extensive soft-tissue dissection and retained hardware, which may necessitate the need for tenolysis and/or hardware removal.

The success of the HHA procedure depends on both the immediate mechanical, as well as, the long-term biological fate of the graft.⁶² In the immediate postoperative period, the graft provides good PIP joint and donor CMC joint stability after the transfer, which has been demonstrated previously in a cadaveric study.⁶³ In addition, the osteochondral graft has shown to have high rates of long-term survival.²⁶ This review demonstrates that HHA and dynamic external fixation results in relatively less ROM at the PIP joint postoperatively. However, recent outcome studies have shown that joints with an average PIPJ arc of 70 degrees and an average flexion of 89 degrees have minimal functional limitations.²²

Limitations

This systematic review included 37 LOE 4 studies evaluating a total of 471 patients and 480 fingers. Although MINORS scoring indicated overall all good-to-excellent quality of the comparative and noncomparative studies included in this review, all were LOE 4 and therefore comparative conclusions within each study could not be made. In

addition, the clinical and radiographic outcomes assessed within each study were variable, thereby limiting cross-sectional comparison and statistical analysis. It is also important to note the various types of bias. Selection bias was present as the more extensive or complex injuries were more likely to be treated with HHA and dynamic external fixation, and inherently less satisfactory outcomes with more severe injuries. Additionally, detection bias was also present as not all studies reported on the same outcome measures, leading to large variation in the number of patients who were actually evaluated for any given outcome variable. The heterogeneity of the treatment groups, fracture patterns, postoperative rehabilitation protocols and length of follow-up also present limitations in this systematic review.

Conclusion

Overall, the outcomes of PIPJ fractures and fracture-dislocations are based on the severity of injury and severity typically dictates the type of treatment. When the amount of articular involvement is small, CRPP, extension block pinning, and volar plate arthroplasty demonstrated good clinical and functional outcomes with the lowest reoperation rates. HHA and dynamic external fixation were most often the treatment utilized in complex fractures with a relatively higher percentage of articular involvement and comminution. Although the overall outcomes and complications rates presented in this study would likely result in minimal functional limitation, patients undergoing treatment for fractures and fracture-dislocations of the PIPJ should be made aware that they are not likely to regain full ROM, may go on to develop posttraumatic arthritis, and require additional surgical procedures.

Conflict of Interest

J.T.C. reports personal fees from Axogen and Skeletal Dynamics outside the submitted work.

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