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REVIEW ARTICLE

The management of acute fracture dislocations of proximal interphalangeal joints: a systematic review

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ABSTRACT

A systematic review was conducted to identify the best management for acute proximal interphalangeal joint fracture-dislocations. A study protocol was designed in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement. Due to limited data in the primary assessment, the hypothesis was tested in a secondary analysis of articles that marginally met the inclusion criteria (i.e. studies that included patients under 18 years of age). A further tertiary analysis was conducted by dividing the studies into closed reduction techniques, open reduction internal fixation and 'other studies' and a narrative synthesis was performed. The study found a higher rate of complications and arthritis in the closed reduction group compared to open reduction internal fixation, suggesting that operative management should be considered for acute PIP joint fracture-dislocations.

Level of evidence: III.

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Introduction

The unprotected position and long moment arm of the proximal interphalangeal (PIP) joint make it vulnerable to injury [1,2]. Although there is a lack of demographic studies, it has been estimated that dorsal fracture-dislocations of PIP joint have an incidence of 9 per 100,000 people per year [3] whilst volar fracture-dislocations are uncommon [4].

Accurate diagnosis is essential for a favorable long-term prognosis [5–7]. The goal of the treatment is to alleviate pain by restoring stability, optimise function by maintaining maximal range of motion and prevent arthritis by restoring a congruent joint surface [7,8]. The reported outcomes vary widely in particular because the joint biomechanics are altered [9,10].

The aim of this study was to perform a systematic review of the outcomes of the surgical and non-surgical interventions for PIP joint fracture-dislocations.

Methods

Study protocol

A study protocol was designed in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [11] and registered with the International Prospective Register of Systematic Reviews (PROSPERO).

Literature search

A systematic search of Medline, Embase, Cinahl and Pubmed and the Cochrane Library for studies reporting the treatment of PIP joint fracture dislocations was performed. The bibliographies of all retrieved articles were hand-searched. Additional searches of the grey literature, such as abstracts from various hand surgery conferences, were not pursued. All articles were screened by title and abstract against the predetermined list of criteria by two independent reviewers. Full text articles were obtained and independently reviewed.

The following inclusion criteria were applied to the identified studies:

- Reports published worldwide between 1966 and 2017
- English language
- Surgical and non-surgical treatment of adults (age 18 and over) with isolated acute PIP joint fracture-dislocations (time to intervention 6 weeks or less)
- Outcome of intervention are reported using physical measures, clinical assessment and/or patient reported outcome measures
- Adverse events are included in the study

The following exclusion criteria were applied:

- Studies which report on less than ten patients/digits
- Open injuries
- Pilon fractures of the middle phalanx
- Cadaveric studies
- Systematic reviews, reviews, editorials, letters

Outcome measures

The active range of motion (ROM) was chosen as the primary outcome. It was postulated that success of a certain technique was directly related to restoration of active ROM.

The secondary outcomes were pain, grip strength expressed as percentage of the contralateral side [12], patient reported

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outcome scores, return to work/pre-injury activity, complications, secondary procedures and radiographic evidence of joint narrowing or osteoarthritis.

Data extraction

A data collection form was created using the Excel software. Data extraction was carried out independently by two investigators.

Data analysis

Due to heterogeneity in study design, treatments compared and outcomes reported, meta-analysis was not possible and instead a narrative synthesis was provided.

Because of the limited data available in the primary assessment of the four studies included in the systematic review, it was decided to further test the hypothesis by creating a second group of articles that marginally met the strict inclusion criteria (i.e. studies that included in their cohort patients aged between 15 and 18 years old or treatment just after 6 weeks). A separate narrative analysis ('secondary analysis') was conducted to investigate whether more evidence could be found.

To allow identification of possible trends, the studies included in the primary and secondary analysis were further grouped into three broad categories and a further analysis was carried out ('Tertiary analysis'):

1. Studies that evaluated techniques which were non-operative (extension blocking splints) or mini-invasive (closed reduction and K-wire fixation) aiming only to correct the subluxation of the PIP joint
2. Studies which addressed both the volar lip fracture and the subluxation of the PIP joint by means of open reduction internal fixation (ORIF)
3. Other studies (volar plate arthroplasty, hemi-hamate arthroplasty)

Results

A total of 502 references were identified in the literature search. Following electronic removal of duplicates and the title and abstract review, the full text of 66 articles were obtained. Sixty-two studies that underwent full text review were excluded from primary analysis (Figure 1). The search identified 14 articles that reported on volar fracture-dislocations, however none met the inclusion criteria of the systematic review.

Primary analysis

Four studies reporting on dorsal fracture dislocations fulfilled the strict inclusion criteria and were included in the primary analysis of the systematic review. The active range of motion (ROM) at PIP joint was consistently reported by all authors and varied widely between 20° and 110° (Table 1), whilst the secondary outcomes were reported in a heterogeneous manner and did not allow comparison (Supplemental Table S1).

Secondary analysis

Seven studies reported on patients aged 15 years and over with dorsal fracture-dislocations: four used closed reduction and extension block pinning and three ORIF. As in the primary analysis, only ROM at PIP joint was consistently reported across all seven studies (Table 2). The best results were recorded after ORIF using

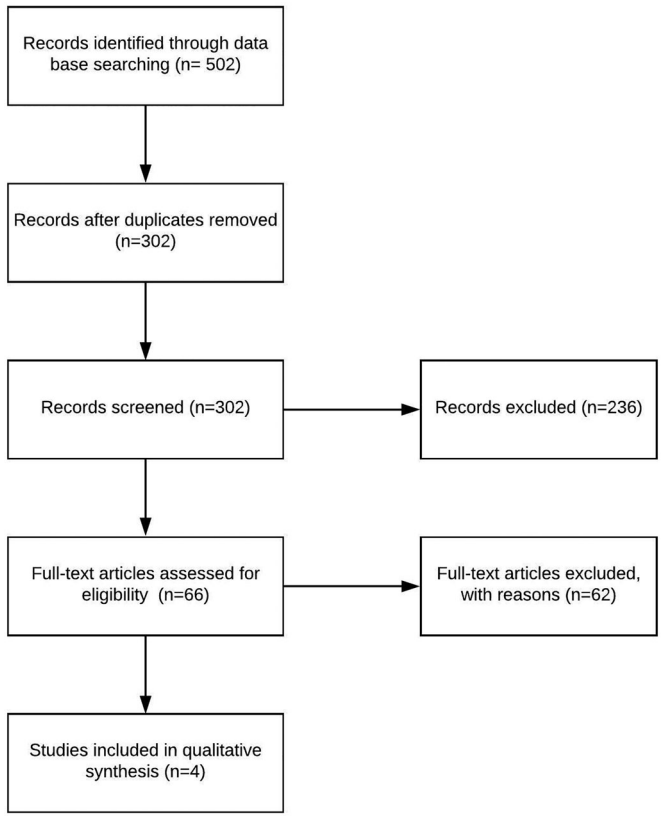

Figure 1. PRISMA flow chart depicting the selection process [13].

lag screws and a temporary K-wire stabilization of PIP joint, whilst the poorest ROM was noted after ORIF with mini-hook plates (Table 2). The mean ROM after extension block pinning was 81°, compared to 87° after ORIF. Due to differences in reporting the secondary outcomes, no further comparison was possible (Supplemental Table S2).

Tertiary analysis

Sixty-two digits underwent open reduction and various types of internal fixation, while 103 digits were treated with closed reduction and either K-wire fixation or extension block splinting (Table 3). The mean ROM at the PIP joint was similar in both groups (82° vs 83°). The difference in DASH scores between the two groups was small. Although not all studies reported pain as visual analogue score (VAS), there was a trend towards better pain outcomes after closed reduction than after ORIF.

At final review, radiographic osteoarthritis was 40% in the closed reduction group compared to 7% in the ORIF group ($p < 0.001$) (Table 3). There was an overall increased risk of complications in the closed reduction group (35% vs 18%, $p = 0.02$) (Table 3). The most frequent complication in both groups was recurrent subluxation (9% for ORIF and 17% for closed reduction).

Additional procedures were required in 11 out of 103 digits (11%) in the closed reduction group and 12 out of 62 digits (18%) in the ORIF group. The majority of secondary procedures in the ORIF group were tenolysis to improve active range of motion (Supplemental Table S3).

The third group of the tertiary analysis was represented by two studies [15,16] where the technique involved a different principle, usually deployed in devastating PIP joint injuries. Hence the comparison was made between the first two groups (closed versus open reduction).

Table 1. Primary outcomes in the primary analysis group.

Study	Technique	Number of patients	ROM at PIP joint	Extension deficit at PIP joint	ROM at DIP joint
Aladin and Davis, 2005 [14]	TKW	8	75° (60°–108°)	0°(0°–25°)	73° (50°–90°)
	ORIF (screw)	6	73° (24°–90°)	4°(0°–22°)	57° (52°–68°)
	ORIF (Cerclage)	5	48° (45°–60°)	30°(18°–38°)	48° (40°–66)
Hamer and Quinton, 1992 [3]	EBS	27	87° (20°–110°)	NR	NR
Lee et al., 2008 [15]	VPA	14	93° (80°–100°)	12°(5°–25°)	NR
Yang et al., 2014 [16]	HHA	11	85° (60°–100°)	NR	80° (60°–90°)

TKA: trans-articular K-wire.
ORIF: open reduction internal fixation.
EBS: extension block splinting.
VPA: volar plate arthroplasty.
HHA: hemi-hamate arthroplasty.
NR: not reported.
PIP: proximal interphalangeal.
DIP: distal interphalangeal.

Table 2. Primary outcomes of studies included in the secondary analysis.

Study	Technique	Number of patients/digits	ROM at PIP joint	Extension deficit PIP joint	ROM at DIP joint
Bear et al., 2015 [13]	EBP	12/12	84° (50°–110°)	NR	NR
Waris et al., 2016 [17]	EBP	39/41	80° (8°–86°)	6° (0°–30°)	68° (5°–90°)
Waris and Alanen, 2010 [18]	EBP	13/15	83° (65°–97°)	3° (0°–15°)	77° (45°–90°)
Cheah et al., 2012 [19]	ORIF (hook plate)	13/13	75° (10°–100°)	NR	65° (40°–90°)
Grant et al., 2005 [20]	ORIF (screw)	14/14	100° (65°–115°)	NR	NR
Lee and Teoh, 2006 [21]	ORIF (screw)	10/12	85° (65°–100°)	11° (0°–30°)	46° (20°–60°)
Weiss, 1996 [22]	ORIF (cerclage)	12/12	89° (72°–109°)	8° (0°–16°)	NR

TKA: trans-articular K-wire.
ORIF: open reduction internal fixation.
EBS: extension block splinting.
VPA: volar plate arthroplasty.
HHA: hemi-hamate arthroplasty.
NR: not reported.
PIP: proximal interphalangeal.
DIP: distal interphalangeal.
EBP: Extension block pinning.
NR: not reported.

Discussion

A variety of treatment options are available for the management of PIP joint fracture-dislocations [2]. Injury and patient characteristics as well as surgeon's experience often dictate the treatment chosen [23,24]. The difficulty reviewing the literature is also due to the presumed assumption that a fracture with only 30% joint involvement can be managed more conservatively than one with 50% involvement. Furthermore, in these more severe fractures with substantial joint involvement a delay in presentation would direct the surgeon into more of a salvage approach considering a hemi-hamate procedure as the primary management. Notwithstanding these difficult considerations in real life, we have analysed the included papers in relation to the set up for our Systematic Review (SR).

Hence, we feel that the strength of this review is that we have been able to identify and access all relevant studies in the literature. Four studies, reporting on six different methods of treatment, were included in the primary analysis. Only one study provided level two evidence [14] but was closed prior to inclusion of all planned patients due to a high incidence of complications within ORIF group.

For this reason, the systematic review was extended with a secondary and later a tertiary analysis. The secondary analysis included studies that were marginally excluded in the primary analysis (i.e. some patients being under 18 years of age included in the cohort), however once again without any clear conclusions.

Consequently, all studies in the primary and secondary analyses were further analysed (tertiary analysis) by being grouped into three categories: those which addressed only the PIP joint dislocation by conservative means of closed reduction and either dorsal block splinting or pinning (Group 1), studies that treated both the dislocation and the volar lip fracture by ORIF (Group 2) and 'other studies' (volar plate and hemi-hamate arthroplasty, Group 3). In this way we were able to find results to base our suggestions upon, i.e. that incidence of secondary arthritic changes was higher in the closed treatment group ($p < 0.001$) and that complications such as recurrent subluxations were more frequent in the closed group ($p = 0.02$) altogether suggesting that an operative approach in most situations should be considered. Persisting subluxation and incongruency of the PIP joint leads to a hinge type of movement instead of gliding, which results in limited range of motion, point loading and increased risk of post-traumatic osteoarthritis [20]. Whilst no single treatment method is suitable for all PIP joint fracture-dislocations, reconstitution of joint congruency (normal joint space with no marked increase in the antero-posterior height of the base of the middle phalanx and no resorption of comminuted central articular fragments [14]) and absence of

Table 3. Summary of the outcomes of the closed reduction and ORIF techniques.

Outcome (number of digits on which data is available)	Closed reduction (number of digits on which data is available)	ORIF (number of digits on which data is available)	*p* Value[c]
ROM at PIP joint[a]	83° (8°–110°)	82° (10°–115°)	N/A
(*n* = 165)	(*n* = 103)	(*n* = 62)	
Pain score (VAS)	1.5 (0–8)	9 (0–75)	N/A
(*n* = 99)	(*n* = 76)	(*n* = 23)	
Grip strength (% of contralateral hand)	95%	85%	N/A
(*n* = 66)	(*n* = 53)	(*n* = 13)	
DASH	6 (0–29)	4 (0–30)	N/A
(*n* = 81)	(*n* = 57)	(*n* = 13)	
Radiographic OA at final review	40%	7%	$p < 0.001$
(*n* = 165)	95% CI (31%–50%)[b]	95% CI (2%, 16%)	
	(*n* = 103)	(*n* = 62)	
PIP joint incongruency	11%	31%	$p = 0.002$
(*n* = 165)	95% CI (6%, 18%)	95% CI (20%, 43%)	
	(*n* = 103)	(*n* = 62)	
Complications	35%	18%	$p = 0.02$
(*n* = 165)	95% CI (26%, 45%)	95% CI (10%, 29%)	
	(*n* = 103)	(*n* = 62)	
Additional procedures	11%	18%	$p = 0.20$
(*n* = 165)	95% CI (6%, 18%)	95% CI (10%, 29%)	
	(*n* = 103)	(*n* = 62)	

[a]Results presented as weighted arithmetic means and averages; for studies which reported the median, a derivation of the mean was calculated.
[b]95% confidence interval.
[c]*p* Value calculated from a generalised linear regression model with a binary logistic dependant variable. A *p*-value less than 0.05 is evidence that there is a statistically significant difference between the two groups.
VAS: Visual Analogue Scale (VAS).
DASH: Disability of the Arm, Shoulder and Hand score.
OA: osteoarthritis.
N/A: not applicable.
ROM: range of motion.
PIP: proximal interphalangeal.
DIP: distal interphalangeal.

dorsal subluxation appear to be the most important element of a successful outcome [6,8,14,21].

Excellent ROM achieved after volar plate and hemi-hamate arthroplasty in acute PIP joint fracture dislocation was possible due to early active rehabilitation allowed by strong and stable bone fixation [15,16].

This systematic review is limited by the low evidence that has been included. Most studies were retrospective case series, with limited number of patients and medium-term follow-up. Many had mixed cohorts with both acute and chronic, open and closed injuries as well as pilon type fractures of the base of the middle phalanx and did not meet the strict inclusion criteria of our SR. Hence all studies reporting on dynamic external fixation, which are mainly used for these comminuted fractures, but without dislocation, were excluded from analysis even though external fixation is a reliable treatment for PIP joint fracture dislocations as such [25,26].

Important outcome measures such as pain, grip strength and patient satisfaction or return to work were often not reported or documented in a heterogeneous manner, preventing any further correlations.

The systematic review identified that there is a need for improved research with well-powered, multi-centre randomised controlled trials, but they are expensive, time consuming and not always feasible. A more attainable solution to the current lack of evidence would be to have more prospective cohort studies with a sound methodology and a standardised way of reporting the outcomes, so that comparisons can be made more easily in the future. A prospectively agreed data set, including PROMs that are specific and sensitive to hand injuries, with a minimum one-year follow-up should be used in the studies of the treatment of PIP joint fracture-dislocations.

We found insufficient evidence to make an evidence-based recommendation for the management of acute PIP joint fracture-dislocations based upon our strict SR criteria. However, through a tiered primary, secondary and tertiary analysis we could identify similar ROM at the final assessment independent of technique used, but it appears that closed reduction techniques have more complications and a higher incidence of radiographic arthritis when compared to ORIF, suggesting that operative management should be considered.

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Disclosure statement

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