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HANDSURGERY

Dorsal versus lateral plate fixation of finger proximal phalangeal fractures: a retrospective study

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Abstract

Introduction Unstable proximal phalanx fractures are relatively common injuries but consensus of standard treatment is lacking. Outcomes following plate fixation are highly variable, and it remains unclear which factors are predictive for poorer results. The purpose of this study was to compare dorsal and lateral plate fixation of finger proximal phalangeal fractures with regard to factors that influence the outcome.

Materials and methods A retrospective chart review of proximal phalanx fractures treated with dorsal and lateral plating over a 6-year study interval was performed. Demographic data and injury-specific factors were obtained from review of clinic and therapy notes of 42 patients. Fractures were classified based on the OTA classification using preoperative radiographs. Outcomes investigated included final range of motion (ROM) and total active motion (TAM) of all finger joints. Complications and revision surgeries were also analyzed.

Results Fracture comminution, dorsal and a lateral plate position, occupational therapy, and demographic factors did not significantly influence the outcome, complication, and revision rate after plate fixation of finger proximal phalangeal fractures.

Conclusions Based on the results of this study, no differences in the outcome of finger proximal phalangeal fractures treated by both dorsal and lateral plate fixation were observed.

Level of evidence Therapeutic, retrospective comparative, level III.

Keywords Proximal phalanx · Phalangeal fracture · Dorsal plate fixation · Lateral plating · Complications · Interphalangeal joint stiffness

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Introduction

Phalangeal fractures account for nearly a quarter of all fractures in the hand and wrist, with the proximal phalanx most likely to be involved [1–4]. Despite their commonality, the optimal treatment for proximal phalanx fractures remains to be debated. Closed reduction and immobilization or functional bracing is reported, but requires careful selection of patients with fracture patterns amenable to non-operative treatment [5, 6]. In those patients requiring surgical fixation, treatment options are vast and include: closed or open reduction and fixation with percutaneous pinning, extra- or intra-osseous wiring, lag screws, intramedullary devices, plates or external fixation [7–15].

Plate fixation of finger proximal phalangeal fractures has the advantage of initial stability for early postoperative motion [16]. However, plate fixation often leads to postoperative complications [13, 17–22]. Stiffness of the involved digit, fixed flexion contractures of the proximal interphalangeal joint (PIPJ), and extensor lag are commonly reported after plate fixation, and often necessitate secondary surgery to treat tendon adhesions or remove symptomatic hardware in order to maximize function [17, 18, 20]. Among surgical approaches for fixation of finger proximal phalangeal fractures, neither dorsal nor lateral plate fixation of finger proximal phalangeal fractures has been established as a standard treatment and both are routinely applied [13, 14, 17, 18, 20, 22–25]. Few previous studies have compared outcomes between both approaches and their analyses were limited by e.g. varying cohorts, inclusion of adjacent metacarpal bones, and/or middle phalanges, or small numbers of patients [20, 23, 26].

The primary purpose of this retrospective study was to compare the outcome of finger proximal phalangeal fractures treated by dorsal and lateral plate fixation. It was hypothesized that dorsal plating with an extensor split led to a higher complication rate including stiffness and revision surgery compared to lateral plate fixation. Second, demographic factors as age, gender, handedness, diabetes, smoking, and Workmans' compensation influenced the outcome of dorsal and lateral plate fixation respectively after a mean of 20 weeks follow-up.

Materials and methods

After obtaining approval from an Institutional Review Board/Ethics Committee, a retrospective chart review of patients with proximal phalanx fractures of the triphalangeal digits, which were treated with lateral or dorsal plate fixation from October 2010 to September 2015 was performed. Exclusion criteria were: younger than 18 years of age at the time of surgery, more than one fracture on the affected hand necessitating fixation, arterial and/or tendon injury requiring repair, incomplete follow-up visits, lack of pre- and postoperative radiographs, lack of range-of-motion (ROM) data at final visit. Open fractures were not specifically excluded unless they met one of the aforementioned exclusion criteria.

Demographic data including age, gender, handedness, diabetes, smoking Workmans'compensation, affected digit, open or closed injury were obtained from office visits by the treating surgeon and from sessions with the occupational therapist.

Clinic and therapy notes were also queried for the following quantitative outcomes: final ROM of the involved metacarpophalangeal (MPJ), PIPJ and distal interphalangeal joint (DIPJ). Total active motion (TAM) was calculated from the sum of motion at the MPJ, PIPJ and DIPJ for each of the digits studied. The occurrence of complications including extensor lag, infection, malunion, delayed union, nonunion, and tendon rupture were recorded and classified as major or minor using criteria adapted from Page and Stern [18] (Table 1). For those patients who required additional surgery following plate fixation, information regarding the reason, type and timing of secondary surgery were obtained.

Radiographic review was performed by a specialty-trained hand and upper extremity surgeon (L.P.R.) of Level II expertise according to the classification proposed

Table 1 Criteria for major and minor complications

Clinical finding	Major complication	Minor complication
Extensor lag	Lag ≥ 35°	35° > lag > 15°
Stiffness	TAM < 180°	MPJ < 75° or PIP < 80° or DIP < 40°
Contracture	Either of the following 2 flexion contractures: MPJ ≥ 35° or PIP ≥ 35° or extension contracture and TAM < 180°	Either of the following 2 flexion contractures: 35° > MPJ > 15° or 35° > PIP > 15°
Malunion	Symptomatic, requiring revision	No functional problems
Delayed union	Requiring revision	No specific criteria
Nonunion	Symptomatic, requiring revision	Asymptomatic or fibrous; no further intervention needed
Plate problem	Prominence requiring ROH	Asymptomatic loosening, breakage
Infection	Deep requiring surgical drainage	Superficial no further intervention needed
Tendon rupture	No specific criteria	Not defined for minor

TAM total active motion, *MPJ* metacarpophalangeal joint, *PIPJ* proximal interphalangeal joint, *DIPJ* distal interphalangeal joint, *ROH* removal of hardware by Tang [27]. Fractures were first classified based on the OTA classification [28] using preoperative radiographs, and divided into two main categories based on the analysis of interest (e.g., presence or absence of fracture comminution). Postoperative radiographs were used in conjunction with operative reports to determine fixation method and location of plate placement.

A priori power analysis was performed to detect significant differences ($P \leq 0.05$) between lateral and dorsal plating groups using Student's t test with an effect size of 1.0. Univariate analysis was performed to obtain descriptive data of the full patient cohort. Bivariate analysis was performed to compare numerical outcomes between groups using Student's t test, and categorical outcomes using Fisher's exact or Chi-square testing. Pearson's product moment correlation coefficient was utilized to determine the potential linear relationship between two numerical variables.

Results

Forty-two (23 male, 19 female) patients with proximal phalangeal fractures met the inclusion criteria. All fractures treated by fixed- or variable-angle locking plates. Mean age of the cohort was 39 years (range 19–81) and mean follow-up duration was 20 weeks (range 10–32). The ring finger was most commonly involved ($n=17$), followed by the small ($n=12$), index ($n=9$) and long finger ($n=4$). Twenty-five and 17 patients were treated with dorsal and lateral plating, respectively. There were no significant differences in demographic data between patients of both groups (Table 2). Final TAM was not statistically different between the dorsal (186°, range 80°–285°) and lateral plating (185°, range 132°–250°) cohorts.

Table 2 Demographic data

	Dorsal plating ($n=25$)	Lateral plating ($n=17$)	P value
Age (years)	38 ± 18	40 ± 20	0.84
Sex			1.0
Male	14	9	
Female	11	8	
Comminuted?			1.0
No	13	9	
Yes	12	8	
Fracture location			0.48
Diaphyseal	17	14	
Non-diaphyseal	8	3	
Open?			1.0
No	21	14	
Yes	4	3	
Dominant extremity?			0.53
Yes	15	8	
No	10	9	
Workmans' compensation?			0.41
No	22	13	
Yes	3	4	
Diabetic?			0.41
No	22	13	
Yes	3	4	
Smoker?[a]			1.0
No	17	8	
Yes	3	2	
Injury to surgery interval (days)	10 ± 7	14 ± 11	0.25
Surgery to motion interval (days)	8.6 ± 4.4	8.7 ± 3.9	0.91
Number of therapy sessions attended	8 ± 6	9 ± 7	0.79
Follow-up duration (weeks)	20 ± 16	21 ± 16	0.77

[a] Smoking history was not disclosed in 12 patients

Fracture characteristics

Using the AO/OTA classification system of phalangeal fractures (location = 78) on preoperative radiographs, [27] the cohort was comprised of the following groups: B2 = 12, A2 = 11, A1 = eight, C2 = five, and one patient each in groups A3, C1 and C3. Based on this distribution, there were 22 non-comminuted and 20 comminuted fractures. Thirty-three fractures were diaphyseal (AO types 78-A2, B2 and C2) and 11 were non-diaphyseal (all other groups).

Predictor variables and TAM

Age, gender, handedness, diabetes, smoking, and Workmans' compensation had no significant effect on TAM (Table 3). Finally, there was no significant difference in TAM based on plate position, fracture location (diaphyseal versus non-diaphyseal) or fracture comminution (Table 3). Motion at the MPJ was significantly better in diaphyseal than in non-diaphyseal fractures (87° ± 5° versus 75° ± 16°, $P=0.03$). No significant difference was evident when motion at all three joints were summed together in TAM.

Complications and revision surgery

None of the aforementioned variables had a significant effect on complication rate or the rate of revision surgery. Utilizing our adaptation of the criteria established by Page and Stern [18] complications occurred in 34 (81%) patients (Table 4). Twenty (48%) complications were classified as major, whereas the remaining 14 (33%) were minor. Nine (21%) of the 42 patients required secondary surgery. One patient experienced two complications; postoperative TAM

Table 3 Total active motion (TAM) of affected digit based on demographic data, plate position and fracture characteristics

Variable	Mean TAM, degrees	*P* value
Sex		0.84
Male	187 ± 43	
Female	184 ± 44	
Dominant extremity?		0.32
Yes	192 ± 41	
No	178 ± 46	
Diabetic?		0.61
No	185 ± 47	
Yes	190 ± 15	
Smoker?[a]		0.12
No	194 ± 37	
Yes	160 ± 38	
Workmans' compensation?		0.41
No	185 ± 45	
Yes	187 ± 33	
Plate position		0.90
Dorsal	186 ± 51	
Lateral	185 ± 30	
Comminuted?		0.44
No	181 ± 48	
Yes	191 ± 37	
Diaphyseal?		0.42
No	175 ± 54	
Yes	190 ± 40	

[a]Smoking history was not disclosed in 12 patients

of 165° and malunion, which required revision surgery. To avoid double-counting the complications of this patient were categorized together as major complication. All other complications were related to lack of motion due to extensor lag, stiffness, and/or joint contracture. There were no delayed- or nonunions, infections or tendon ruptures. Although no complications were attributed specifically to plate prominence, hardware removal was performed in conjunction with tenolysis in eight patients in effort to regain motion. For the nine patients who required an additional surgery, the second operation was performed at a mean interval of 145 ± 54 days.

Discussion

The optimal surgical treatment for unstable proximal phalanx fractures remains unclear. Proponents of plate and screw fixation cite the unmatched stability that affords early motion as its true benefit [13, 21, 25]. However, previous investigations of outcomes following plate fixation of the proximal phalanx have proved inconclusive, and at times, contradictory [13, 17–22]. Interestingly, in one of the earliest studies of examining a single approach, Dabezies and Schutte [13] reported largely successful outcomes in 22 proximal phalangeal fractures treated with lateral plating via midlateral approach with lateral band excision, with a mean postoperative TAM of 243°. For reasons that remain unclear, later studies have largely failed to reproduce these results. Page and Stern [18] reported rather poor results in 39 phalangeal fractures treated with dorsal plate fixation, as only four fractures resulted in TAM greater than 220° and more than half yielded final TAM of less than 180°. Most recently, Brei-Thoma et al. [22] described results in a series of 32 patients with extra-articular proximal phalanx fractures treated with dorsal plate fixation using low profile variable angle locking systems. Two patients required secondary surgery for rotational malunion, 67% of patients had PIPJ extensor lags, and 8 of 32 had final TAM less than 180° [22].

In light of these findings, it could be assumed that dorsal plating would be a risk factor for stiffness. Omokawa et al. [23] reported on 39 phalangeal fractures treated with a low profile locking titanium implant and found that those plated laterally (81% TAM of the contralateral healthy side) faired significantly better than those plated dorsally (72% TAM of the contralateral healthy side). It is important to note, that plates were routinely placed laterally unless dorsal comminution or intra-articular fragmentation required dorsal plate placement. Thus, superior results following lateral plating may be attributable to less-complex fracture patterns. Onishi et al. [26] found dorsal fixation, comminution, and plating (versus screw fixation alone) all to be significant predictors for stiffness, both lateral and volar approaches were categorized together, potentially confounding their results.

Trevisan et al. [21] the authors report "very favorable" outcomes, although only 11 of 56 fractures were of phalanges, with metacarpals comprising the remainder. While there was no significant difference in TAM between the two groups, the complication rate in the phalangeal group was significantly higher (82 versus 31%). Basar et al. [14] stated that evaluation of outcomes following plate fixation of phalangeal fractures should be distinguished from those of metacarpals. With regard to functional outcomes and TAM, plate and screw fixation versus screw fixation alone showed no difference in the metacarpal group, while phalangeal fractures faired much worse when plated [14].

In light of these limitations, a comparison of lateral versus dorsal plating in similar cohorts comprised only of proximal phalangeal fractures is warranted. Surprisingly, this study demonstrated nearly identical outcomes between the lateral and dorsal plated groups. In addition, other factors such as the degree of comminution or soft-tissue injury, which have been proposed to play a role in determining final outcomes follow plating of proximal phalanx

Table 4 Occurrence of complications based on demographic data, plate position, and fracture characteristics

Variable	Complication rate (%)	*P* value
Sex		1
Male	83	
Female	9	
Dominant extremity?		1
Yes	83	
No	79	
Diabetic?		0.60
No	83	
Yes	71	
Smoker?		0.56
No	80	
Yes	100	
Workmans' compensation?		0.31
No	77	
Yes	100	
Plate position		0.44
Dorsal	76	
Lateral	88	
Open?		1
No	80	
Yes	86	
Comminuted?		1
No	82	
Yes	80	
Diaphyseal?		0.41
No	73	
Yes	84	

fractures, did not affect them in this study, similar to the findings of Kurzen et al. [20]. The only exception was the effect of non-diaphyseal fractures on decreased MPJ motion, although this difference was no longer significant for TAM.

Finally, while this study's complication and revision surgery rates of 81 and 21%, respectively in this study seem unusually high. These should be considered in the framework of prior studies. The reason is that the criteria introduced by Page and Stern [18] were adapted in order to characterize the complications. Using this modification, issues related to bony union requiring additional surgery were considered as a major complication (Table 1). The resulting complication rate is comparable to that reported by Trevisan et al. [21] (82%), Ouellette and Freeland [19] (74%), and Kurzen et al. [20] (62%). However, there is a great variability of the definition of complications between these studies. Omakawa et al. [23] reported that only five (13%) of 39 phalangeal fractures resulted in complication, although symptomatic hardware was removed in 30 patients. It remains unclear how many of these hardware removals were performed in metacarpal fractures ($n = 12$). This shows first the necessity of standardized criteria to describe outcomes following plate fixation of proximal phalanx fractures, and second the necessity to distinguish between proximal phalanx and metacarpal fractures.

This study has a number of limitations including those inherent to any retrospective review. Although the lateral and dorsal plating cohorts were statistically similar at baseline, it is difficult to eliminate all confounding variables without a prospective matched-design. Additionally, some informations from chart review were incomplete, such as smoking history in 12 patients. As a result of these missing data, smoking may have had an effect on outcomes, although this study was unable to find any statistically significant effect.

In conclusion, based on the results of this study, no differences in the outcome of finger proximal phalangeal fractures treated by both dorsal and lateral plate fixation were observed. Fracture comminution, dorsal and a lateral plate position, occupational therapy, and demographic factors seem not to influence their outcomes, complications, and revision rates.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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Ethical approval This paper was approved by the Thomas Jefferson University Institutional Review Board.

Informed consent Informed consent was not required due to the retrospective nature of this study.

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