

Postoperative Dorsal Proximal Interphalangeal Joint Subluxation in Volar Base Middle Phalanx Fractures

Kamilcan Oflazoglu¹ Suzanne C. Wilkens² Hinne Rakhorst¹ Kyle R. Eberlin² David Ring³
Neal C. Chen²

¹Department of Plastic, Reconstructive, and Hand Surgery, Amsterdam University Medical Center, location VUmc, Amsterdam, The Netherlands

²Department of Orthopedic Surgery, Hand and Upper Extremity Service, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts, United States

³Department of Surgery and Perioperative Care, Dell Medical School, University of Texas at Austin, Austin, Texas, United States

Address for correspondence Kamilcan Oflazoglu, MD, Department of Plastic, Reconstructive, and Hand Surgery, Amsterdam University Medical Center, location VUmc, De Boelelaan 1117, 1081 HV Amsterdam, The Netherlands (e-mail: k.oflazoglu@gmail.com).

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Abstract

Introduction This study was designed to assess factors associated with postoperative dorsal proximal interphalangeal (PIP) joint subluxation after operative treatment of volar base middle phalanx fractures. Our second purpose was to study the association between postoperative dorsal subluxation with postoperative arthritis.

Materials and Methods We identified 44 surgically treated volar base PIP joint fractures with available pre- and postoperative radiographs between 2002 and 2015 at two academic medical systems with a median follow-up of 3.5 months. Demographic, injury, radiographic, and treatment data that might be associated with postoperative dorsal subluxation were collected. Three hand surgeons independently assessed subluxation and arthritis on radiographs. Bivariate analysis was performed to analyze our two study purposes.

Results Six of 44 (14%) had postoperative dorsal subluxation after initial surgery. Bivariate analysis showed no factors with statistically significant association with postoperative subluxation, assessed independently by three hand surgeons on radiographs. Fifty per cent of the joints with postoperative arthritis had postoperative subluxation compared with 21% of joints without postoperative subluxation. No significant association was found between postoperative dorsal subluxation with postoperative arthritis.

Conclusion The association of persistent subluxation and early arthrosis in dorsal PIP joint fracture dislocations needs further study. At this time, it is unclear in what ways persistent subluxation or arthrosis affects the rate of reoperation.

Level of Evidence This is a therapeutic level IV study.

Keywords

- ▶ PIP joint
- ▶ fracture
- ▶ postoperative subluxation

Introduction

The most common fracture pattern of the proximal interphalangeal (PIP) joint is a volar base fracture of the middle phalanx, often with subluxation or dislocation of the joint.¹ Surgery should be considered for unstable fracture—subluxations or dislocations. The goals of treatment of these fractures are to establish a congruent joint and restore gliding

joint motion.² Reported rates of postoperative dorsal subluxation vary substantially for different treatment types.^{3–5} However, little is reported about the factors associated with postoperative dorsal subluxation.

Our purpose was to study the factors associated with postoperative dorsal PIP joint subluxation after operative treatment of volar base middle phalanx fractures. Our second purpose was to study the association between

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postoperative dorsal subluxation with postoperative arthritis.

Materials and Methods

A waiver of informed consent was granted by our Institutional Review Board for this retrospective study.

Subjects

We used Current Procedural Terminology codes (20900, 26740, 26742, 26756, 26776, 26785, 26535, 26536, 26860, 26861, 26862, and 26863) to identify all patients with potential operative treatment of a PIP joint fracture ($n = 1,778$), followed by selecting the cases with an open or closed middle or proximal phalangeal fracture using International Classification of Diseases, Ninth Revision codes (816.01, 816.03, 816.11, and 816.13; $n = 826$). The diagnosis was confirmed through manual review of the electronic records and all available radiographs. We identified 154 patients with operative treatment of fractures surface involving 161 PIP joints, of which 62 were volar base fractures. We excluded 15 patients without available pre- and postoperative radiographs. Additionally, two fractures treated with arthrodesis and implant prosthesis, and one pathologic fracture were excluded, which resulted in a cohort of 44 volar base middle phalangeal fractures, treated by 13 different surgeons between 2004 and 2015.

Demographic and clinical data were gathered from the medical records including sex, age at the time of surgery, race, comorbidities (diabetes, smoking, and body mass index), cause of injury (specifically describes as impact, sharp, or crush), affected side, injury severity (associated tendon, nerve, and/or vascular injury), type of surgery (open reduction and internal fixation [ORIF], percutaneous pinning, hemihamate graft, static external fixation, volar plate arthroplasty, or extension block pinning), immobilization duration in days, follow-up duration in months, hospital, surgeon, reoperation, and both days between injury and visit to a hand surgeon, injury and initial treatment, and reoperation. For a few variables, such as comorbidities, dominant hand, and cause of injury, we did not have complete data, due to consistent recording in the record. In these situations, we recorded and analyzed the available data.

Radiographs

All electronic measurements were performed on a computer independently by two physician researchers, and the senior author resolved any conflicts of measurements. To calculate the articular surface involvement, fragment size and the size of the intact surface were measured on a lateral view. Fragment displacement was measured by calculating the amount of fragment displacement described as a percentage of the total articular surface (→ Fig. 1).⁶ Since the calculations are relative measures, this eliminated the need for calibrating measurements or scale radiographs.

Congruency of the joint was evaluated by three independent reviewers who assessed anonymous radiographs and assessed the joint for subluxation and arthritis in 44 patients.

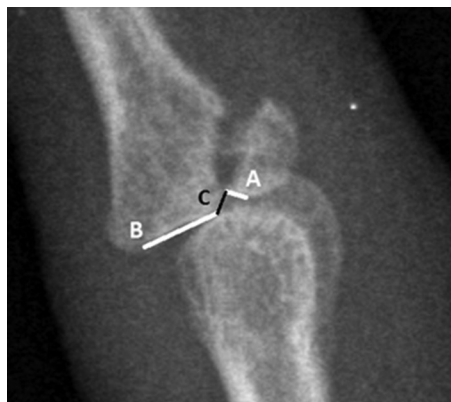


Fig. 1 Articular surface involvement (%) is calculated by dividing the fragment size (A) by the total articular surface (A + B). Fragment displacement (%) is calculated by dividing the fragment displacement (C) by the total articular surface (A + B).

Statistical Analyses

The number and percentages of categorical variables and mean and standard deviation or median and interquartile range (IQR) for continuous variables were calculated, depending on normality. In bivariate analysis, Fisher's exact test was used for categorical variables and Student's *t*-test or Wilcoxon's rank-sum test was used for continuous variables depending on normality. A *p*-value of less than 0.05 was considered statistically significant. The McNemar's chi-squared test (for paired dichotomous variables) was used to assess whether there was a significant difference in preoperative and postoperative subluxations. No multivariable analysis was done due to a small sample size.

Demographic Data

Of 44 patients who underwent operative treatment of a PIP joint fracture, 30 were men (68%). The median age was 39 years (IQR = 26–46). The ring finger was most frequently affected ($n = 16$; 36%), while the index finger was least frequently affected ($n = 4$; 9.1%). The majority of the PIP joint fractures (84%) were caused by impaction, of these 43% were sports related. ORIF was the most performed surgery (64%), followed by percutaneous pinning (20%), hemihamate arthroplasty (9.1%), static external fixation (2.3%), extension block pinning (2.3%), and volar plate arthroplasty (2.3%). Forty joints (91%) were subluxated prior to treatment (→ Table 1). Four patients received operative treatment without having a subluxated joint because of (1) an open fracture with extensor tendon injury, (2) additional distal interphalangeal joint and metacarpal neck fractures, and (3) large displacement of the fracture fragment in two patients. Three other PIP joint fractures had an associated tendon injury and one joint had an associated nerve injury that needed repair.

Results

Fourteen per cent volar base middle phalanx fractures had postoperative dorsal PIP joint subluxation (6 of 44; → Supplementary Appendix A, available in the online version). Bivariate analysis showed no factors with statistically

Table 1 Factors associated with dorsal subluxation in volar base middle phalanx fracture

Characteristics	All volar base fractures (n = 44)	Postoperative subluxation		p-Value
		No (n = 38)	Yes (n = 6)	
		Age, median (IQR)	39 (26–46)	
Sex, n (%)				
Men	30 (68)	26 (68)	2 (33)	>0.99
Women	14 (32)	12 (32)	4 (67)	
Race, n (%)				
White	34 (77)	29 (76)	5 (83)	>0.99
Other	10 (23)	9 (24)	1 (17)	
Smoking, n (%) ^a				
Yes	5 (13)	5 (15)	0	>0.99
No	33 (87)	28 (85)	5 (100)	
Diabetes, n (%) ^a				
Yes	1 (5.0)	1 (5.9)	0	>0.99
No	19 (95)	16 (94)	3 (100)	
BMI, median (IQR) ^a	25 (22–27)	25 (22–27)	31 (24–38)	0.38
Dominant side affected, n (%) ^a				
Yes	23 (58)	21 (58)	2 (50)	>0.99
No	17 (43)	15 (42)	2 (50)	
Affected finger, n (%)				
Index	4 (9.1)	3 (7.9)	1 (17)	0.60
Middle	11 (25)	9 (24)	2 (33)	
Ring	16 (36)	15 (39)	1 (17)	
Little	13 (30)	11 (29)	2 (33)	
Cause of injury, n (%) ^a				
Impact	32 (84)	29 (85)	3 (75)	0.51
Crush	4 (11)	3 (8.8)	1 (25)	
Sharp	2 (5.3)	2 (5.9)	0	
Open fracture, n (%)				
Yes	6 (14)	6 (16)	6 (100)	0.57
No	38 (86)	32 (84)	0	
Days between injury and first visit, median (IQR)	6 (2.0–12)	6 (2.0–11)	5.5 (4.0–18)	0.81
Days between injury and treatment, median (IQR)	11 (5.0–20)	9.0 (5.0–19)	17 (7.0–26)	0.28
Follow-up, mo, median (IQR)	3.5 (2.1–9.7)	3.5 (1.8–8.2)	3.6 (2.4–11)	0.77
Articular involvement, mean (SD), %	42 (19)	41 (20)	53 (13)	0.16
Fragment displacement, median (IQR), %	57 (35–79)	58 (35–79)	52 (44–79)	0.95
Comminution, n (%)				
Yes	20 (45)	15 (39)	5 (83)	0.077
No	24 (55)	23 (61)	1 (17)	
Treatment, n (%)				
Open reduction and internal fixation	28 (64)	25 (66)	3 (50)	0.080
Percutaneous pinning	9 (20)	8 (21)	1 (17)	
Hemihamate	4 (9.1)	4 (11)	0	
Static external fixation	1 (2.3)	1 (2.6)	0	
Extension block pinning	1 (2.3)	0	1 (17)	
Volar plate arthroplasty	1 (2.3)	0	1 (17)	

(continued)

Table 1 (continued)

Characteristics	All volar base fractures	Postoperative subluxation		p-Value
		No	Yes	
	(n = 44)	(n = 38)	(n = 6)	
Preoperative subluxation, n (%)				
Yes	40 (91)	34 (89)	6 (100)	<0.001 ^b
No	4 (9.1)	4 (11)	0	

Abbreviations: BMI, body mass index; IQR, interquartile range; SD, standard deviation.

^aIncomplete data.

^bMcNemar’s chi-squared test (with 1 degree of freedom) = 34.

significant association with postoperative subluxation. Postoperative subluxated joints had an articular involvement of 53% on average, compared with 41% in the other group. Furthermore, comminution was more common in the postoperative subluxated joints (83 vs. 39%; ► **Table 1**).

Two of six patients with postoperative subluxation had revision surgery: in one patient (Patient 6), silicone arthroplasty was done after 9 months and in the second patient (Patient 4), volar plate arthroplasty with percutaneous pinning. These six patients had different demographic characteristics. Five of six fractures were comminuted (► **Supplementary Appendix A**, available in the online version).

None of the joints had preoperative arthritis. Eleven joints (25%) had postoperative arthritis. In bivariate analysis, none of the predictors was significantly associated with arthritis. Seven of 16 ring fingers (44%) had postoperative arthritis, compared with either a couple cases in other fingers. Seven of 23 (30%) fractures of the dominant side had postoperative arthritis, while this was 12% in the nondominant hand (► **Supplementary Appendix B**, available in the online version). Fifty per cent of the joints with postoperative arthritis had postoperative subluxation compared with 21% of joints without postoperative subluxation ($p = 0.15$; ► **Table 2**).

Discussion

The purpose of this study was to gain insights into postoperative dorsal PIP joint subluxation after operative treatment of volar base middle phalanx fractures. We found that 14% of volar base middle phalanx fractures had postoperative PIP joint subluxation. A large percentage of persistently subluxated joints demonstrated early arthritis. Not all patients with subluxated joints opted for reoperation.

This study has some limitations. (1) Any coding search depends on coding accuracy. However, since the codes are

fairly inclusive and all codes were verified by reviewing the medical record, we believe that we minimized these potential errors. (2) Seventy-six per cent of the volar fractures had adequate preoperative radiographs for quantitative measurements. We chose not to include inadequate radiographs because rotational artifact can substantially affect quantitative measurements. Unfortunately, we did not have a large enough cohort to show differences in bivariate analysis. (3) The assessment of subluxation is subjective; however, we mitigated this problem by having three independent hand surgeons assess subluxation. (4) Radiographic arthrosis may be dependent on the length of follow-up, and this outcome may change over the course of a longer time interval. Also, there is not always a correlation between X-ray appearance and clinical symptoms. (5) There were a large number of surgeons included with varying degrees of experience. Some complications may be attributable to technical limitations, but on the contrary, the findings are more generalizable to all hand surgery practices than a study focused on the results of a limited number of highly experienced surgeons.

The rate of persistent subluxation was relatively high. Subluxation is a well-described complication that occurs with dorsal blocking techniques,⁷ volar plate arthroplasty,⁵ hemihamate arthroplasty,⁸ and ORIF,⁹ but in these smaller series, postoperative subluxation is infrequently reported. However, subluxation may be more common. In a recent study looking at the outcome of extension block pinning, Waris et al found recurrent subluxation was noted in 29% (12 of 41) of the cases.⁴ Our rate of subluxation is similar to Deitch et al who reported three subluxations of 33 patients (9.1%) treated with ORIF and three subluxations of 23 patients (16%) treated with volar plate arthroplasty.³

In our study, joints with postoperative subluxation had a larger per cent articular surface involvement (53%) relative

Table 2 Association between postoperative dorsal PIP subluxation and arthritis

Characteristics	All volar base fractures	Postoperative arthritis		p-Value
		No	Yes	
	(n = 44)	(n = 38)	(n = 6)	
Postoperative arthritis, n (%)				
Yes	11 (25)	8 (21)	3 (50)	0.15
No	33 (75)	30 (79)	3 (50)	

Abbreviation: PIP, proximal interphalangeal.

to congruent joints (41%) and comminution was associated with postoperative dorsal subluxation. However, neither of these variables was statistically associated with subluxation. This is consistent with findings by Deitch et al who found patients with more than 50% joint surface involvement were at risk of persistent subluxation.³ Only two of six patients with postoperative subluxation underwent reoperation. There were not enough reoperation events in this subgroup for meaningful statistical analysis.

It is theorized that joint incongruity and subluxation contribute to arthrosis in the tibia,^{10,11} distal radius, femoral condyle,^{12,13} and acetabulum.^{14,15} We found that the association of postoperative arthritis and joint subluxation somewhat approached significance. Although an association does not establish causality, it supports the concept that malalignment of chondral surfaces and joint incongruence may lead to early arthrosis. Considering the variable length of follow-up in our series, these rates of arthrosis may be higher over time. Waris et al reported that 59% of all injured PIP joints had some degree of postoperative radiographic arthritis after fracture.⁴ Although we did not find a statistical association between arthritis and reduction ($p = 0.06$), there is a reasonable probability that a study involving a larger cohort would find an association.

Not all patients with joint subluxation progressed to reoperation, emphasizing that some degree of subluxation and PIP joint stiffness may be clinically tolerated. Most clinical series reporting on PIP joint fracture dislocations report a high prevalence of radiographic arthrosis. Assessment of the same patient series at a future time point may also give insight in whether the reoperation rate increases over time or remains stable.^{3,16} It is possible that patients with stiff but congruent joints underwent reoperation because they had a chance to improve, while patients with stiff but incongruent joints were primarily observed because it was unclear if an operation for stiffness would be beneficial because the joint incongruity would dictate range of motion.

The association of persistent subluxation and early arthrosis in dorsal PIP joint fracture dislocations needs further study; at this time, it is unclear in what ways persistent subluxation or arthrosis affects the rate of reoperation.

Note

This work was performed at the Hand and Upper Extremity Service, Department of Orthopedic Surgery, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts, United States.

Ethical Approval

The Institutional Review Board of our institution approved this study under protocol #2009P001019/MGH.

Conflict of Interest

All the authors certify that they have no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) or financial remunerations that might pose a conflict of interest in connection with the submitted article. D.R. reports grants from Skeletal Dynamics, other from Wright Medical and

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