Lateral Versus Dorsal Plating for Treating Metacarpal and Phalanx Fractures: A Retrospective Cohort Study

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Abstract

Background: The purpose of this study was to investigate the differences between the dorsal and lateral plate position for metacarpal and phalanx fractures.

Methods: We conducted a retrospective review of prospectively collected patient data for 186 fractures treated by a single surgeon between 2009 and 2011. Rates of plate removal, total arc of postoperative motion (TAM), and patient and injury demographics were tested for association with plating position.

Results: Increasing age, larger plates, and dorsal plating were found in univariate analysis to be associated with decreased TAM and increased plate removal in phalanx but not in metacarpal fractures.

Conclusions: These data suggest that dorsal plating results in decreased TAM and increased rates of plate removal in some fractures. TAM was greater in phalanx fractures treated with lateral plating and therefore this plating technique should be considered when treating these fractures.

Introduction

Despite the widespread use of locked plating for metacarpal and phalanx fractures, surgeons still debate the proper plate placement between the dorsal and lateral position. Early pioneers of hand surgery, including Alan Freeland, advocated for lateral plating to avoid interference with the extensor tendons.[1] However, early biomechanical studies of plating suggested the use of dorsal plating for hand fractures because the dorsal side of the bone experiences the highest tension forces, leading many surgeons to abandon lateral plating.[2] This debate has recently arisen again because modern biomechanical studies have shown equivalent biomechanical strength between lateral and dorsal locked plating.[3]

Proper plate placement remains a mystery, particularly for treating fractures of the proximal phalanx. It seems intuitive that placement of plates on the side of the proximal phalanx has the inherent benefit of reducing the interaction between the plate and extensor tendon. Yet little evidence exists examining this key relationship. Current treatment options of hand fractures include plating,[4,5] screws alone,[6] intramedullary fixation,[7,8] Kirschner wires,[9] or external fixation,[10] all of which have range-of-motion deficits after operative procedure.[11,12] Therefore, it is essential to examine ways to minimize these considerable side effects.

This study was designed to assess the difference between dorsal and lateral plating for treating metacarpal and phalanx fractures of patients with hand trauma, treated by a single surgeon. We hypothesized that lateral plating would increase postoperative range of motion and decrease the need for plate removal owing to less irritation on the extensor tendons of the hand in both metacarpal and phalanx fractures.

Methods

This study was approved by our institutional review board (IRB #15-031). A retrospective cohort study was conducted of patients treated by a single surgeon. Between 2009 and 2011, patients with metacarpal or phalanx fractures treated with open reduction and internal fixation, using locking plates, were identified (Figures 1A and 1B). Patients who had a minimum 1-year follow-up were included. Those with prior injuries and pathological fractures were excluded from the study. In total, 140 patients (186 fractures) were selected for inclusion in the study. All patients were treated with the use of low-profile, locked plates from the A.L.P.S Hand Fracture System (Zimmer-Biomet, Indiana, USA).

All patients were allowed to perform range of motion and weight bearing as tolerated immediately after operative treatment. At the last routine follow-up visit, the surgeon recorded the total arc of postoperative motion (TAM).

Figure 1. Preoperative, intraoperative, and postoperative imaging for (A) lateral and (B) dorsal plating.

The average age of the study population was 38.66 years (SD, 13.46). One hundred fifty (81%) fractures occurred in men. A total of 104 patients had isolated fractures, 30 sustained two fractures, five sustained three fractures, and one sustained five fractures. Patients had a wide variety of presenting injury types and were treated with either straight-, T-, or Y-configured plates in a dorsal or lateral position on the basis of the surgeon's discretion. One hundred eight (60%) fractures were treated with dorsal plates, and 73 (40%) with lateral plates.

Rate of plate removal and TAM were selected as the two primary outcome measures of the study. Secondary outcome measures included the need for a secondary tenolysis procedure, a postoperative infection, and postoperative complications. Patient and injury covariates included: age (< 35, 35-49, > 50); gender; mechanism of injury (low energy, high energy, or crush injury); location of injury (metacarpal or phalanx); type of plate (straight-, T-, or Y-configured plate); plate location (dorsal or lateral); soft-tissue injury (open or closed); other injuries (soft-tissue repair or tendon repair); and use of postoperative hand-therapy techniques (yes or no).

All patient and injury covariates were first tested in univariate analysis for association with rate of plate removal and TAM with the use of chi-squared test, Fisher exact test, t-tests, analysis of variance (known as ANOVA), point viserial correlation, and the Pearson correlation, as appropriate. Covariates that were significantly associated with either primary outcome variable were selected for inclusion in multivariate modeling (significance determined at $\alpha = 0.05$). Secondary outcome variables were described with descriptive statistics.

Multivariate modeling of the primary outcome variables was performed with the use of generalized linear mixed modeling. A mixed-model approach was chosen to account for clustering in the data. Some patients in the study sustained multiple fractures and therefore had multiple inclusions in the dataset. This tiered sampling structure had the potential to bias the results because patients who required one plate removal may have required multiple plate removal for various reasons (ie, infection). To account for this, mixed modeling was used to model fractures and patients as two separate clusters in a hierarchical design.

A multivariate model was run for each primary outcome variable. First, rate of plate removal was tested for association with study covariates with the use of generalized linear mixed modeling with a Poisson distribution and robust error variance. A Poisson distribution was used to directly estimate the relative risk of study variables.[13,14] Next, a generalized linear mixed model was used to test the association of TAM with study covariates.

Results

Univariate Analysis

Age, plate type, and plate position were the only variables significantly associated with an increased rate of plate removal. Patients older than 50 years required plate removal more often than patients aged 35 to 49 years or less than 35 years (25% vs 16% vs 5%; $P = 0.002$). Fractures treated with larger T- or Y-type plates required removal more often than straight-type plates in phalanx fractures (28% vs 4.2%; = 0.005), but not in metacarpal fractures (12% vs 9.5%; $P = 0.753$). Dorsal plates were found to have significantly higher rates of removal compared to lateral plates in phalanx fractures (32% vs 5%; $P = 0.014$), but not in metacarpal fractures (14% vs 10%; $P = 0.746$; Figure 2).

Age, plate type, and plate position were the only variables significantly associated with a decreased TAM. Patients older than 50 years had decreased TAM compared to patients aged 35 to 49 years or less than 35 years. (211° vs 221° vs 235°; $P = 0.008$). Fractures treated with larger T- or Y-type plates had significantly decreased TAM as compared to straight-type plates in phalanx fractures (195° vs 222°; $P = 0.023$), but not in metacarpal fractures (232° vs 218°; $P = 0.145$). Likewise, dorsal plates were associated with a significant decrease in TAM compared to lateral plates in phalanx fractures (192° vs 222°; $P = 0.027$), but not in metacarpal fractures (226° vs 231°; $P = 0.811$; Figure 3).

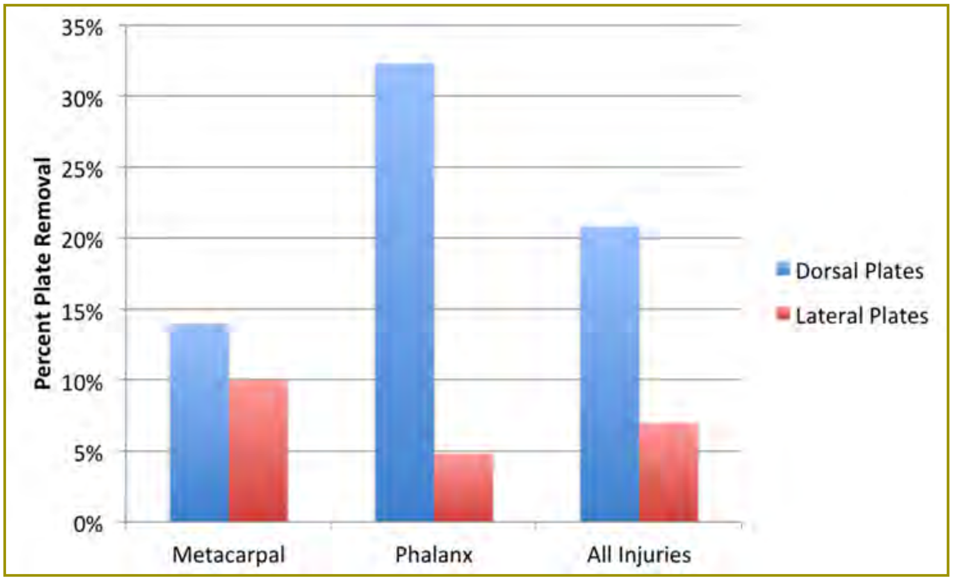

Figure 2. Rate of plate removal by fracture type and plate location.

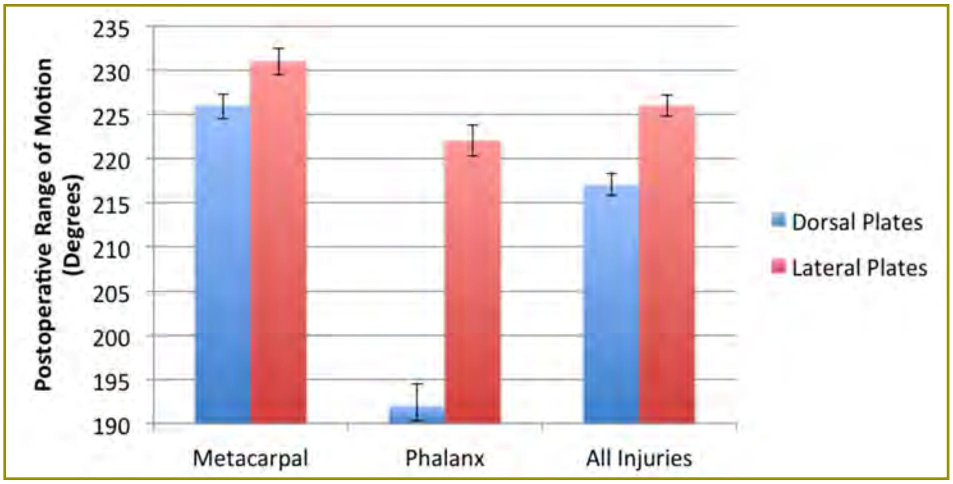

Figure 3. Postoperative total arc of motion by fracture type and plate location.

Multivariate Analysis

The two primary outcome measures (ie, plate removal and TAM) were significantly associated with study variables in phalanx fractures only. Therefore, a multivariate analysis was performed only for phalanx fractures. In a multivariate analysis of plate removal in phalanx fractures, dorsal plating was associated with a significant increase in relative risk of plate removal as compared to lateral plating (relative risk [RR], 3.89; 95% CI: 1.01-14.92; $P = 0.04$). Both increasing age (RR, 3.33; 95% CI: 0.78-14.11; $P = 0.19$) and larger T-type or Y-type plates (RR, 3.81; 95% CI: 0.94-15.43; $P = 0.06$) were associated with a non-significant increase in relative risk of plate removal.

In a multivariate model of TAM, lateral plating in phalanx fractures was significantly associated with an increase in TAM (increased motion of 26°; $P = 0.04$). Straight plates had a non-significant increase in TAM compared to larger T- and Y-type plates (increased TAM of 19°; $P = 0.134$). Patients younger than 35 years had a non-significant increased TAM compared to patients aged 35 to 49 years (increase TAM of 12°; $P = 0.430$) and patients older than 50 years (increase TAM of 30°; $P = 0.06$).

Complications

One patient of 140 (0.7%) developed a deep surgical-site infection; one patient (0.7%) developed a nonunion, and nine patients (6.4%) returned to the operating room for treating soft-tissue defects associated with trauma. Sixteen of 140 (11%) patients returned to the operating room for an additional tenolysis procedure (Table 1). Patients treated with dorsal plating underwent tenolysis more often than those treated with lateral plates in both phalanx (81% vs 19%; $P < 0.001$) and metacarpal fractures (100% versus 0%; $P < 0.001$; Figure 4). After tenolysis, postoperative TAM in dorsal plating was not statistically different than TAM in lateral plating for both phalanx (216 vs 223; $P = 0.477$) and metacarpal fractures (228 vs 231; $P = 0.706$).

Table 1. Primary and secondary outcomes of study cohort by fracture location and treatment

Outcome	Metacarpal		Phalanx	
	Dorsal	Lateral	Dorsal	Lateral
Plate removal, percent	12	9.5	24	4.6
Total Arc of Motion, degrees	227	229	197	223
Secondary tenolysis	5	0	9	2

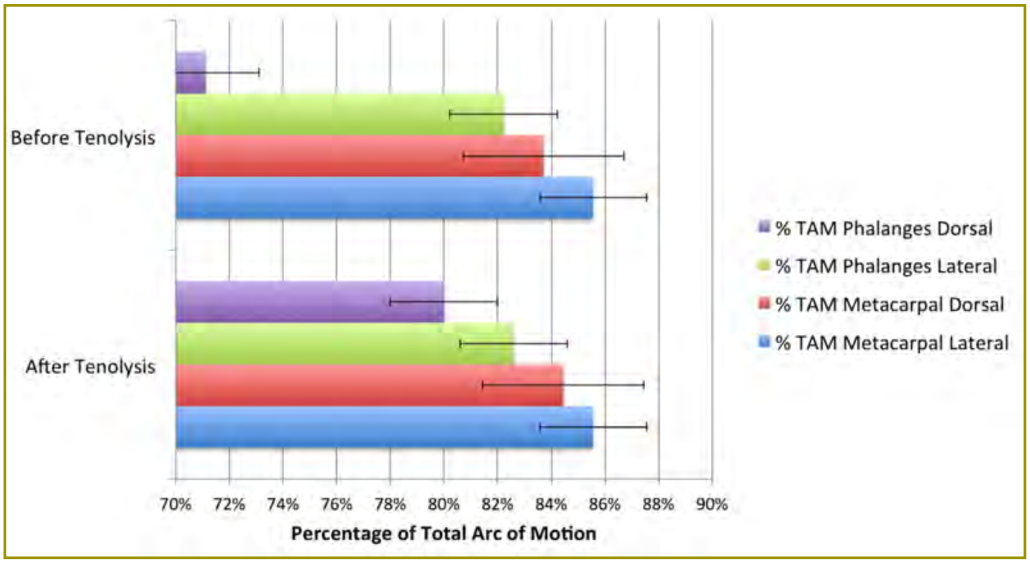

Figure 4. Comparison of postoperative total arc of motion (TAM) before and after tenolysis procedures.

Discussion

This study is one of the largest case series assessing the results of lateral versus dorsal plating in treating metacarpal and phalanx fractures. A retrospective review of patient outcomes found that patients treated with lateral plating had increased range of motion and decreased need for plate removal in proximal phalanx fractures. A similar trend was seen in metacarpal fractures; however, it was not statistically significant.

Placement of plates on the side of the proximal phalanx and not under the tendon would theoretically reduce tendon adhesions. To date, only Omokawa et al[15] showed an association between lateral plating and improved outcomes, although the study lacked the power to examine these effects in a multivariate fashion. Data in this study provided strong evidence that lateral plating significantly reduces need for plate removal and increases postoperative range of motion in phalanx fractures. This is likely owing to the decrease in irritation and adhesions to the extensor tendons.

Despite these findings, most fractures continue to be treated using a dorsal approach, probably because early plating systems in the hand were difficult to contour and therefore sat poorly in a lateral position. In our experience, lateral plating sometimes requires plate contouring and finesse in placement. The lateral side of the phalanx has large variations in profile that requires axial, sagittal, and coronal bends in the plate to allow the plate to lie cleanly on the bone. These difficulties are more easily overcome with new generation plating systems. These plating systems overcome the difficulty with lateral plating by providing locked fixation on plates that are easily contorted to align with the proximal phalanx.

In addition to tendon irritation and adhesion, scar formation and tissue trauma from the surgical approach also may affect postoperative motion. Although most surgeons prefer a dorsal midline approach owing to the excellent visualization of the fracture site, this approach requires considerable tissue dissection. The method may cause inadvertent tissue injury around the extensor tendon sub-sheath and further affect tendon adhesion.

In the current study, lateral plating was performed from a dorsal approach and a direct lateral approach. Compared to a dorsal approach for dorsal plating, this approach provided inferior visualization of the cortex and makes placement of the plate and drilling and insertion of the screws more difficult. In addition, lateral plating requires a pre-contoured bend to avoid “fracture gapping” and angular deformity at the far cortex. Alternatively, a direct lateral approach offers the potential benefit of no interaction or generation of scar between the bone and extensor-tendon interface during dissection, reduction, or plate placement. This is particularly true of the distal part of the proximal phalanx, in which minimal dissection occurs between the skin incision and bone. The only sensitive structure is the dorsal branch of the digital nerve, which can be sacrificed when necessary. In the proximal portion of the proximal phalanx, the lateral bands are encountered, which requires elevation or partial excision to aid in exposure.

Despite the difficulties of lateral plating, the authors believe that the procedure offers an obvious benefit to the digit's ultimate total range of motion. Despite our findings that indicate improved use of lateral plate placement, we were unable to recommend one surgical approach over the other owing to limitations of the study design. This study was conducted as a retrospective analysis of a heterogeneous trauma population. Although data were collected on plate location, no data were collected on surgical approach, which limited the ability to specifically examine the direct effect of surgical approach on overall outcomes. Further studies may choose to examine surgical approaches, in addition to plate placement, in a prospective randomized fashion.

Our findings agree with those of other authors who have reported difficulty in need for plate removal and decreased postoperative range of motion after plating of fractures in the hand.[16-19] Studies have suggested that up to 20% of plates will need removal, and up to 89% of patients will experience decreased postoperative range of motion after hand plating.[5,20] This is often worse in the phalanges where less soft tissue surrounds the tendon-bone interface than in the metacarpals.[1]

The current study has limitations. Although designed to limit potential bias, this study was performed retrospectively in a heterogeneous trauma population, including a wide range of patients and injuries. We found no significant relationship between study outcomes and many patient and injury characteristics, including the severity of fractures and open or closed injuries. However, other authors have found such characteristics to be significant.[1,15,21] Our may have been underpowered to determine specific effects. Additionally, we used a database of patients with traumatic injuries treated by a single surgeon. Patients with 1 year of follow-up were included because plate removal commonly occurs between 4 and 6 months after injury.[20] However, it is plausible that additional plate removal may occur later in some patients. In that case, these findings would be an underestimation of the actual rate of plate removal.

Overall, our results confirm that a main complication of plating for treating metacarpal and phalanx fractures is the need for an additional operative procedure for plate removal or tenolysis. When clinically feasible, plating in the lateral position may decrease the need for future plate removal and increase postoperative range of motion, especially in phalanx fractures. Lateral plating, therefore, may prove to mitigate some of the negative side effects of fracture fixation with plates and screws and increase outcomes for patients with fractures of the hand.

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Conflict of Interest

The authors report no conflicts of interest.

References

1. Ouellette EA, Freeland AE. Use of the minicondylar plate in metacarpal and phalangeal fractures. Clin Orthop Relat Res 1996;(327):38-46.
2. Courtiss EH, reviewer. Plast Reconstr Surg 1979;64(4):557. Review of: Gottfried S. Konstam P, trans-ed. Surgical Stabilization of the Skeleton of the Hand. Baltimore, ML: Williams & Wilkins; 1977.
3. Shanmugam R, Ernst M, Stoffel K, et al. Angular stable lateral plating is a valid alternative to conventional plate fixation in the proximal phalanx: a biomechanical study. Clin Biomech (Bristol, Avon) 2015;30(5):405-10. doi: 10.1016/j.clinbiomech.2015.03.019.
4. Kurzen P, Fusetti C, Bonaccio M, Nagy L. Complications after plate fixation of phalangeal fractures. J Trauma. 2006;60(4):841-3.
5. Page SM, Stern PJ. Complications and range of motion following plate fixation of metacarpal and phalangeal fractures. J Hand Surg Am 1998;23(5):827-32.
6. Crawford GP. Screw fixation for certain fractures of the phalanges and metacarpals. J Bone Joint Surg Am 1976;58(4):487-92.
7. Orbay JL, Touhami A. The treatment of unstable metacarpal and phalangeal shaft fractures with flexible nonlocking and locking intramedullary nails. Hand Clin 2006;22(3):279-86.
8. Ozer K, Gillani S, Williams A, Peterson SL, Morgan S. Comparison of intramedullary nailing versus plate-screw fixation of extra-articular metacarpal fractures. J Hand Surg Am 2008;33(10):1724-31. doi: 10.1016/j.jhsa.2008.07.011.
9. Botte MJ, Davis JL, Rose BA, et al. Complications of smooth pin fixation of fractures and dislocations in the

hand and wrist. Clin Orthop Relat Res 1992;(276):194-201.
10. Margić K. External fixation of closed metacarpal and phalangeal fractures of digits: a prospective study of one hundred consecutive patients. J Hand Surg Br 2006;31(1):30-40.
11. Henry MH. Fractures of the proximal phalanx and metacarpals in the hand: preferred methods of stabilization. J Am Acad Orthop Surg 200816(10):586-95.
12. Kamath JB, Harshvardhan, Naik DM, Bansal A. Current concepts in managing fractures of metacarpal and phalangess. Indian J Plast Surg 2011;44(2):203-11. doi: 10.4103/0970-0358.85341.
13. Bohl DD, Basques BA, Golinvaux NS, Miller CP, Baumgaertner MR, Grauer JN. Extramedullary compared with intramedullary implants for intertrochanteric hip fractures: thirty-day outcomes of 4432s procedures from the ACS NSQIP database. J Bone Joint Surg Am 2014;96(22):1871-7. doi: 10.2106/JBJS.N.00041.
14. Zou G. A modified poisson regression approach to prospective studies with binary data. Am J Epidemiol 2004;159(7):702-6.
15. Omokawa S, Fujitani R, Dohi Y, Okawa T, Yajima H. Prospective outcomes of comminuted periarticular metacarpal and phalangeal fractures treated using a titanium plate system. J Hand Surg Am 2008;33(6):857-63. doi: 10.1016/j.jhsa.2008.01.040.
16. Doht S, Meffert RH, Raschke MJ, Blunk T, Ochman S. Biomechanical analysis of the efficacy of locking plates during cyclic loading in metacarpal fractures. ScientificWorldJournal 2014;2014:648787. doi: 10.1155/2014/648787.
17. Fusetti C, Meyer H, Borisch N, Stern R, Santa DD, Papaloïzos M. Complications of plate fixation in metacarpal fractures. J Trauma 2002;52(3):535-9.
18. Gajendran VK, Szabo RM, Myo GK, Curtiss SB. Biomechanical comparison of double-row locking plates versus single- and double-row non-locking plates in a comminuted metacarpal fracture model. J Hand Surg Am 2009;34(10):1851-8. doi: 10.1016/j.jhsa.2009.07.005.
19. Ruchelsman DE, Mudgal CS, Jupiter JB. The role of locking technology in the hand. Hand Clin 2010;26(3): 307-19; v. doi: 10.1016/j.hcl.2010.04.001.
20. Syed S, Mohammed R, Hussain S, Waldram M, Power D, Tan S. Re-operation for tendon adhesions following open reduction and internal fixation of metacarpal fractures [abstract]. Inj Extra 2010;41(12):160. doi: 10.1016/j.injury.2010.07.482
21. Shimizu T, Omokawa S, Akahane M, et al. Predictors of the postoperative range of finger motion for comminuted periarticular metacarpal and phalangeal fractures treated with a titanium plate. Injury 2012;43(6):940-5. doi: 10.1016/j.injury.2012.02.011.