Dual Antegrade Intramedullary Headless Screw Fixation for Treatment of Unstable Proximal Phalanx Fractures

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Abstract

Background: Although intramedullary headless screw (IMHS) fixation is a promising minimally invasive surgical treatment option for unstable proximal phalanx fractures, a single IMHS may provide inadequate fixation for certain fracture patterns. The purpose of this study was to evaluate the short-term clinical outcomes in a pilot series of patients with proximal phalanx fractures treated with dual antegrade IMHS fixation. **Methods:** We performed a retrospective chart review of proximal phalanx fractures treated with dual antegrade IMHS fixation with a minimum 1 year of follow-up. Demographic information including patient age, sex, occupation, workers' compensation status, mechanism of injury, hand dominance, and injured digit were obtained. Postoperative outcomes measured included range of motion, grip strength, Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) outcome scores, return to full-duty work interval, and complications. **Results:** Ten fractures in 10 patients (4 male, 6 female) satisfied study inclusion. The mean age of patients was 39 years (range, 20-62), and average follow-up duration was 84 weeks (range, 61-106). Final postoperative total active motion was 258° (range, 245°-270°), mean grip strength was 97% (range, 84%-104%) of the uninjured side, and QuickDASH score was 3.9 (range, 0-13.6). No complications occurred, and no patients required additional intervention. **Conclusions:** Dual antegrade IMHS fixation of proximal phalanx fractures resulted in excellent postoperative motion, near-normal grip strength, positive self-reported patient outcomes, and no complications with follow-up of at least 1 year. Further study in a larger number of patients is warranted to determine if this promising technique is superior to other modes of fixation.

Keywords: proximal phalanx fracture, intramedullary headless screw, dual compression screw, antegrade approach, finger, minimally invasive

Introduction

Phalangeal fractures are among the most commonly occurring of all upper extremity fractures, of which the proximal phalanx is most often injured.^{3,11,17} For unstable proximal phalanx fractures not amenable to conservative treatment, the optimal operative intervention remains unclear despite a plethora of available surgical options. Plate fixation is purported to provide near-anatomic reduction and optimal stability allowing for early rehabilitation, although the clinical results have been mixed.^{13,14,18} Complications, most notably stiffness, fixed flexion contractures of the proximal interphalangeal (PIP) joint, and extensor lag, are often reported to necessitate secondary surgery.^{13,14}

Minimally invasive techniques may provide suitable alternatives to plate fixation of phalangeal fractures, thus circumventing their inherent extensive soft tissue dissection. Such options include percutaneous pinning, cerclage wiring, lag screw, or external fixation.^{1,6,12,16} However,

these options often carry their own inherent drawbacks related to inadequate fixation, planned or unplanned hardware removal, and prolonged immobilization.^{6,9,10,12}

Intramedullary headless screws (IMHS) are among the newest options for treatment of unstable proximal phalanx fractures. Positive outcomes following IMHS fixation for metacarpals and phalanges with minimal complications are reported in a small number of recent studies.^{4,5,8,15} However, for fractures with notable comminution, IMHS fixation is thought to be a relative contraindication due to the potential

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for compression of the fragments and shortening of the bone.⁴ To address this problem in subcapital metacarpal fractures, del Piñal and colleagues described a technique termed “Y-strutting,” whereby a second retrograde IMHS was placed in an offset plane with the first screw.⁴ To our knowledge, an analogous technique has not been described through an antegrade approach and/or for diaphyseal phalanx fractures. The purpose of this study is to report our preliminary results from a pilot series of patients with unstable extra-articular proximal phalanx fractures treated with dual antegrade IMHS fixation.

Materials and Methods

This retrospective chart review was approved by our institutional review (ethics) board. We queried our departmental billing database for Current Procedural Terminology ([CPT]; American Medical Association, Chicago, Illinois) code 26735 (open treatment of phalangeal shaft fracture, proximal or middle phalanx) performed between October 2014 through March 2016. From this data set, operative notes were reviewed to determine which patients underwent dual antegrade IMHS fixation for proximal phalangeal fractures, while all others were excluded.

Surgical Technique and Postoperative Protocol

After the operative arm was sterilely prepped and a pneumatic tourniquet was inflated to 250 mm Hg on the upper arm, manual reduction was performed under fluoroscopy. A transverse nick incision of no more than 0.5 cm in length was made over the metacarpophalangeal (MP) joint, which was then flexed 60° to 75° while the proximal end of the phalanx was pressed dorsally to facilitate insertion of the first 1.0 mm guide wire under fluoroscopic guidance.⁸ Because a second screw was used, the first wire can be placed in a slightly oblique trajectory to the long axis of the phalanx. Depending on the fracture configuration, the second 1.0 mm guide wire can be inserted into the base of the proximal phalanx either via its radial or its ulnar side to create a triangular construct with the first wire in multiple planes. With the wires in place holding the fracture reduced, a longitudinal nick incision was made in the extensor mechanism to accommodate the cannulated drill. After drilling over the guide wires, a screw was placed over the first wire until it was countersunk and the first wire was removed. The second screw, which was generally more oblique in orientation and thus shorter than the first, was then placed until the head was countersunk and the corresponding guide wire was removed. Depending on the size of the phalanx, we used either a 2.4-mm or 3.0-mm headless compression screw for the first screw (DePuy Synthes, West Chester, Pennsylvania), while a 2.4 mm was consistently used for the second screw (Figures 1-3). The skin was closed with

4-0 nylon suture, and the patient was placed in a bulky volar splint with the hand in the intrinsic plus position. Patients with fractures of the small or ring fingers were transitioned to a forearm-based ulnar gutter splint in 2 to 3 days, while those with long or index finger fractures were placed in custom forearm-based ulnar/radial gutter splints at that time. Formal therapy began within 1 week of surgery within range-of-motion exercises and was advanced to strengthening as tolerated. Rehabilitation was accelerated for elite athletes wishing to return to sport in-season, as they were permitted to return to competition as soon as tolerated with a hard playing cast.

Results

Demographics and Injury Characteristics

Ten fractures in 10 patients (4 male, 6 female) with at least 1-year follow-up (mean 84 weeks; range, 61-106) were included in this study (Table 1). The average patient age at the time of surgery was 39 years (range, 20-62). The mean interval from the initial injury to surgery was 6 days (range, 1-18). Two patients had associated workers' compensation claims, and 2 patients were elite athletes (1 professional hockey player, 1 college football player) who were injured during in-season game play. Seven of 10 cases involved the nondominant extremity, and the small finger was the most commonly affected digit (4 small vs 2 each for other fingers). One patient who was a practicing occupational therapist sustained a metacarpal fracture on the same small finger as her phalanx fracture and was treated with a retrograde IMHS during the same operation.

Postoperative Outcomes

Final postoperative total active motion (TAM) was 258° (range, 245°-270°), MP joint motion was 86° (range, 80°-90°), and PIP joint motion was 96° (range, 95°-100°). Mean postoperative grip strength of the operative side was 97% (range, 84%-104%) of the contralateral uninjured side. Mean postoperative QuickDASH score was 3.9 (range, 0-13.6) for the full cohort. For those seven patients who had preoperative QuickDASH scores available, the median QuickDASH improved significantly from 50 preoperatively to 2.3 postoperatively (Mann-Whitney *U* test statistic = 77.0; *P* = .002).

All 10 patients returned to full-duty work or athletic activity at a mean of 6.4 weeks (range, 0.9-16.7) from surgery, including both high-level athletes who returned to full in-season play with a hard-shell playing cast within 1.5 weeks of surgery. The 2 patients who took the longest to return to full-duty work both had workers' compensation claims, including one patient who was involved in ongoing litigation throughout her postoperative treatment course and

Table 1. Demographic Data, Injury History, and Outcomes for Study Cohort.

Patient	Age (years)	Sex	Affect side	Digit	Fracture pattern	Occupation	Injury mechanism	WC interval (days)	Injury to surgery	Return to full-duty work/ sport (weeks)	Pre-op Quick DASH	Final Quick DASH	Follow-up (weeks)	Grip injured (pounds)	Grip uninjured (pounds)	Grip injured: Uninjured, %	MPI motion (degrees)	PIPI motion (degrees)	TAM (degrees)	Opp. TAM (degrees)
1 ^a	62	F	L, ND	Small	Small	Occupational therapist	Ground-level fall	N	4	8.9	NR	4.5	76	40	43	93	80	95	245	265
2	24	F	L, ND	Index	Index	Consultant	Ground-level fall	N	5	4.7	50	2.3	81	50	50	100	90	100	270	270
3	57	F	R, D	Small	Small	Package handler	Ground-level fall	Y	18	16.7	82	13.6	61	42	50	84	80	95	255	270
4	36	M	L, ND	Ring	Ring	Consultant	Bicycle vs MVA	N	6	2.6	56	0	97	105	110	95	85	100	265	270
5	56	F	L, ND	Small	Small	Dental assistant	Caught on purse-strap	N	10	7.9	46	0	90	43	45	96	85	90	255	260
6	52	F	L, ND	Ring	Ring	Lab technician	Ground-level fall	Y	3	11.3	70	11.4	95	60	60	100	85	90	245	270
7	20	M	R, D	Long	Long	College football player	Tackled	N	1	1.9	NR	0	92	150	145	103	90	100	270	270
8	26	M	L, ND	Small	Small	Tax collector	Crushed by wood	N	6	3.7	36	2.3	63	105	105	100	90	90	255	255
9	33	F	R, D	Long	Long	Branch manager	Ground-level fall	N	4	6.0	34	4.5	106	52	50	104	90	100	265	265
10	24	M	L, ND	Index	Index	Professional hockey player	Hit by hockey puck	N	1	0.9	NR	0	74	140	146	96	85	95	255	255
Mean	39							6	6.4	51	3.9	3.9	84			97	86	96	258	257

Note. WC = Workers' Compensation; QuickDASH = Quick Disabilities of the Arm, Shoulder and Hand; MPI = metacarpophalangeal joint; PIPJ = proximal interphalangeal joint; TAM = total active motion of same digit on contralateral hand; M = male; F = female; L = left; R = right; D = dominant; ND = nondominant; MVA = motor vehicle accident; NR = not recorded.

^aPatient 1 also had a small finger metacarpal fracture that was treated with retrograde IMHS.

Figure 1. Preoperative (a) posteroanterior and (b) oblique radiographs demonstrating proximal third fracture of the small finger proximal phalanx with concomitant metacarpal neck fracture (Table I, Patient 1). Postoperative (c) posteroanterior and (d) oblique radiographs following dual antegrade intramedullary headless screw (IMHS) fixation of the proximal phalanx and retrograde IMHS for the metacarpal fracture.

Figure 2. Preoperative (a) posteroanterior and (b) lateral radiographs demonstrating comminuted metaphyseal fracture of the ring finger proximal phalanx (Table I, Patient 4). Postoperative (c) posteroanterior and (d) lateral radiographs following dual antegrade intramedullary headless screw fixation of the proximal phalanx.

returned to work at 16.7 weeks postoperatively. Of note, that patient had surgery 18 days following her injury after she was initially treated conservatively at another institution and came to our center for a second opinion. The 2 workers' compensation patients also had the highest final QuickDASH scores, with all other patient QuickDASH scores below 5. No complications occurred, and no patients required additional intervention.

Discussion

While surgical treatment options for proximal phalanx fractures are vast, results following operative fixation are often suboptimal. Surgeons are often faced with the difficult deci-

sion of selecting more stable constructs at the expense of extensive soft tissue dissection, as is often the case with plate fixation. This can in turn lead to stiffness, restricted motion, and other complications that require additional surgery.^{13,14} On the contrary, while less invasive options minimize the soft tissue insult that leads to those complications, they may lack the stability necessary in complex fracture patterns.⁷

Fixation of metacarpals and phalanges with IMHS has gained traction in recent years due to its minimally invasive nature that also obviates the need for a second planned procedure, as is generally needed for percutaneous pinning or external fixation. In the largest series of antegrade IMHS for proximal phalanx fractures (24) to date, Giesen et al reported a reasonable mean postoperative

Figure 3. Preoperative (a) posteroanterior, (b) oblique, and (c) lateral radiographs demonstrating transverse metaphyseal fracture of the index finger proximal phalanx with dorsal angulation (Table 1, Patient 2). Postoperative (d) posteroanterior, (e) oblique, and (f) lateral radiographs following dual antegrade intramedullary headless screw fixation of the proximal phalanx.

TAM of 222° .⁸ In that study, 1 patient with a long oblique fracture required IMHS removal and revision lag screw fixation at 9 days due to fracture re-displacement. A second underwent IMHS removal due to mild protrusion into the MP joint, although that patient was asymptomatic.⁸ Also of note was that 7 of the 24 fractures involved the proximal third of the phalanx and required use of a trans-articular fixation technique, whereby a guide wire was inserted through the head of the metacarpal to ensure optimal placement in the dorsal central lip of the phalanx.⁸ In a follow-up cadaveric study, Borbas et al reported qualitatively, the defect on the palmar metacarpal head

appeared to be similar in size to that on the proximal articular surface of the proximal phalanx, although this was not measured quantitatively.² In a study including 19 proximal phalanx fractures treated with retrograde IMHS, del Piñal et al demonstrated excellent outcomes with TAM of 243° .⁴ Although it was not used in the phalanges, the authors also described the “Y-strutting” technique in subcapital metacarpal fractures that would be prone to collapse with a single retrograde IMHS.

The dual antegrade IMHS fixation method we describe in this report utilizes advantageous elements of both of these aforementioned studies. To avoid insult to the articular

surface of the metacarpal head, we avoided the transarticular technique in favor of the intra-articular method, regardless of fracture pattern.⁸ Because a second screw was placed providing an additional plane of fixation, it was not critical to orient the first screw exactly parallel to the long axis of the phalanx. Another advantage, as was the case in the first patient we treated with this method, is that concomitant metacarpal fractures of the affected digit may be treated with a retrograde IMHS through the incision.

This study has a number of noteworthy limitations, including its small cohort size and the lack of a comparison or control group. There are also inherent biases associated with the retrospective design. Although our follow-up interval of at least 1 year was reasonable, there is certainly the possibility that complications occurred after this time that we are unaware of. In addition, because of variability in short-term follow-up intervals, we did not attempt to determine the time to bony union.

Despite these limitations, we feel that this small series may provide valuable information for surgeons faced with unstable proximal phalanx fractures in need of fixation, who wish to avoid the drawbacks associated with plate fixation. Further prospective evaluation of this method is warranted in a larger number of patients in comparison with single antegrade IMHS and other modes of fixation.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

This retrospective study involved human subjects and was approved by our university's institutional review board.

Statement of Informed Consent

Informed consent was not necessary due to this study's retrospective nature.

Declaration of Conflicting Interests

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