

Percutaneous Distraction Pinning for Metacarpophalangeal Joint Stabilization After Blast or Crush Injuries of the Hand

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Abstract

Background Unstable, severely comminuted fractures of the metacarpophalangeal (MCP) joint are difficult to treat. Closed treatment and casting of these fractures often fail to maintain proper alignment and impede wound care where concomitant open injuries such as gunshot wounds are present. Conventional pinning or plating techniques are not

feasible if extensive bone loss and comminution are present. A distraction pinning technique represents a potential alternative, but results with this approach, to our knowledge, have not been reported.

Questions/purposes The purposes of this study were (1) to evaluate the effectiveness (defined as osseous union and joint stability) of distraction pinning for comminuted fractures involving MCP joints after gunshot or crush injuries; (2) to report the short-term results in terms of pain and function in a small group of patients who underwent MCP distraction pinning; and (3) to evaluate complications and return to work status of these patients in the short term.

Methods We reviewed 10 patients with comminuted pilon-type fractures of the base of the proximal phalanx or metacarpal head treated with wire distraction fixation from 2005 and 2014. During that period, we used this technique to treat all patients whose fractures were deemed too comminuted for plating or pinning, and during that period, no other techniques (such as simple external fixation) were used for patients meeting those indications. The minimum followup was 6 months; eight of the 10 patients were accounted at a median of 10 months (range, 6–89 months). The median age was 47 years (range, 28–57 years), and seven of the eight were male. Kirschner wire fixation frames were removed 3.5 to 6 weeks after the index surgery when fracture consolidation was confirmed on radiography by the treating surgeon. Stability and range of motion of the MCP joint were assessed using physical examination, radiographs, and goniometer by the treating surgeon. Patients completed the Quick Disabilities of the Arm, Shoulder and Hand score at latest followup or by telephone, and complications were assessed by chart review.

Results All fractures were healed with stable MCP joints. Eight patients reported having no pain or minimal pain of

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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their injuries to the hand. The median finger and thumb MCP arc of motion were 80° (range, 70°–105°) and 30° (range, 0°–60°), respectively. The median Quick Disabilities of the Arm, Shoulder and Hand score was 3 (range, 0–41). One patient underwent a second surgical procedure for bone grafting and soft tissue coverage. Three patients developed pin site irritations and were treated with oral antibiotics. Six patients returned to their original job.

Conclusions The distraction pinning technique provides reliable osseous union and joint stability of comminuted pilon-type fractures of the base of the proximal phalanx or metacarpal head, even with associated open wounds. Future studies will need to evaluate these patients at longer term followup and compare this approach with other available techniques, because arthrosis, stiffness, and progressive loss of function seem likely to occur given the severity of these injuries.

Level of Evidence Level IV, therapeutic study.

Introduction

Complex hand injuries are common in war zones and civilian settings alike. Experience gained from World War II and the Vietnam conflict has helped guide the treatment of civilian gunshot wounds [17], and complex hand wounds caused by industrial crush injuries and motor vehicle accidents pose similar challenges for treating physicians. Rapid and effective bony stabilization are important for management of those complex hand injuries both in combat casualties and civilians.

Although the majority of hand fractures associated with bullet or crush injuries can be stabilized with conventional Kirschner wires or plating techniques, unstable comminuted fractures of the base of the proximal phalanx (P1) and the distal metacarpal are challenging injuries to treat for a number of reasons. The metacarpophalangeal (MCP) and proximal interphalangeal (PIP) joints are prone to pain and stiffness after injury [1, 4, 12, 13]. Closed treatment and casting of these fractures often inadequately maintain proper alignment and impede wound care in cases of concomitant open wounds. It is difficult to maintain length and stability using Kirschner wires when the MCP joint is severely comminuted with bone loss. Open reduction and internal fixation may not be a feasible option as a result of inadequate cortical purchase and the compromised state of the soft tissues in patients presenting with these injuries.

Distraction external fixation has been well described as a treatment option for pilon-type fractures about the PIP joint [14]. A technique using a similar distraction external fixation principle has also been described by Li and Cardoso for the treatment of pilon-type fractures of the base of

P1, especially after gunshot injuries [2, 9]. We have been using this technique for the treatment of pilon-type fractures of the MCP joint for the past 9 years; to our knowledge, no study has reported on the results of this approach in the management of this complex and difficult injury pattern.

We therefore sought to (1) evaluate the effectiveness (defined as osseous union and joint stability) of distraction pinning for comminuted fractures involving MCP joints after gunshot or crush injuries; (2) report the short-term results in terms of pain and function in a small group of patients who underwent after distraction pinning; and (3) evaluate complications and return to work status of these patients in the short term.

Patients and Methods

After obtaining institutional review board approval, we retrospectively reviewed a database of all patients with comminuted MCP joint fractures treated with wire external fixation. All patients included in this study were treated at our Level I trauma center by the senior author (ZL) from January 2005 to July 2014.

During that period, we used this technique to treat all patients whose fractures were deemed too comminuted for plating or pinning, and during that period, no other techniques (such as simple external fixation) were used for patients meeting those indications. Ten patients were identified who met the criteria for inclusion: comminuted pilon-type fractures of the base of the proximal phalanx or metacarpal head treated with the wire external fixation technique described previously at our institution. There were no exclusions. The minimum followup was 6 months; eight of the 10 patients were accounted for, five in person and three by telephone, at a median of 10 months (range, 6–89 months), although only three had followup beyond 1 year.

The institutional electronic medical record and telephone interview were used for information gathering. Information on pain, ROM, use of the affected hand, Quick Disabilities of the Arm, Shoulder and Hand (DASH) scores (0–100 with “0” for normal function and “100” the most severely impaired), limitations on hand use, and working status were recorded. Stability and ROM of the MCP joint were assessed using physical examination, radiographs, and goniometer by the treating surgeon. In terms of stability, all joints were stressed radially, ulnarly (in flexion and extension) as well as being stressed into extension. Patients completed the Quick DASH score at latest followup or by telephone, and complications were assessed by chart review as well as by telephone when necessary.

We used the distraction pinning technique as previously described [2, 9]. The procedure was done under regional or general anesthesia. An image intensifier was used for all cases. Once the wounds were thoroughly débrided, two 0.045-mm Kirschner wires were inserted longitudinally into the metacarpal starting at the neck, in the collateral recess when available, in a retrograde fashion. A third wire was placed transversely across the neck of the P1 distal to the zone of injury. This transphalangeal wire was bent 90° dorsally at both ends leaving enough space for potential finger swelling. The metacarpal wires were first bent 90° volarly approximately 1 cm distal to the MCP joint. The finger was then distracted manually to reduce the fracture and restore the length of the P1 with the MCP joint in 90° of flexion. The metacarpal wires were then bent dorsally at the level of the transphalangeal wires, and Jurgan Pin Balls® (Jurgan Development & Manufacturing, Madison, WI, USA) were applied to capture both the metacarpal and transphalangeal wires to maintain the MCP joint in a slightly distracted position. The wires were then cut flush to the Jurgan balls (Fig. 1). The patient was encouraged to

move the interphalangeal joints of the injured digital and the joints of adjacent digits. The device was removed in the office 4 to 6 weeks after surgery depending on fracture healing.

Of the eight included patients, seven were male. The median age was 47 years (range, 28–57 years). All eight of the injuries were to the left hand; five were documented as the nondominant hand with no distinction made in the other three in the notes regarding hand dominance. There were two long, two ring, one small, and one index finger and two thumbs involved. The mechanisms of injury included gunshot wound, crush, motor vehicle accident, and fall (Table 1).

All patients were followed at least until the fracture consolidated. Three patients were also able to be reached for a telephone interview. Kirschner wire fixation frames were removed 3.5 to 6 weeks after the index surgery with fracture consolidation confirmed on radiographs. On the final followup visits, all fractures were healed with stable MCP joints.

Results

Seven of the eight patients achieved osseous union without further surgery, and one achieved union after a second procedure for bone grafting and soft tissue coverage. There was no evidence of laxity in any of the treated joints on physical examination.

Eight patients reported having no pain (four patients) or minimal to mild pain (four patients) of their hand injuries. The median finger and thumb MCP arc of motion were 80° (range, 70°–105°) and 30° (range, 0°–60°), respectively. The median QuickDASH score was 3 (range, 0–41).

As noted earlier, one patient underwent a second surgery including bone graft, adipofascial turndown flap, and skin graft for extensive soft tissue loss [3]. At the latest followup, 8 months after initial injury, that patient was noted to have scar adhesions, and we had scheduled the patient for occupational therapy to begin to address the adhesions. However, the patient never followed up for this and has been lost to followup since. Three patients developed pin site irritations and were treated with oral antibiotics. Six of the eight patients were released to unrestricted activities as of their most recent followup, and they all had returned to their original job. The other two were to slowly increase activities with weight restrictions and followup before being advanced to no restriction; however, they did not return for followup visits nor were they able to be reached by telephone. One of these patients was last seen at 7 months after initial injury, the other patient was last seen at 8 months after initial injury.

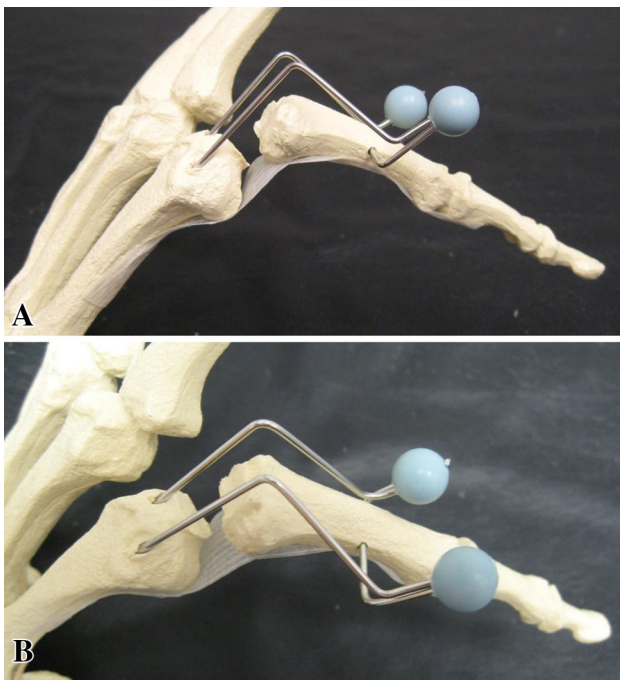


Fig. 1A–B (A) This lateral view of a sawbones model demonstrates the distraction external fixation construct for base of proximal phalanx or distal metacarpal fractures. The metacarpal wires are bent dorsally just distal to the phalangeal wires. When the Jurgan balls are applied, a distraction force is applied across the joint. Reprinted with permission from Koman LA, ed. *Orthopaedic Manual*. Winston-Salem, NC, USA: Orthopaedic Press; 2009:6–7. (B) This oblique view of a sawbones model demonstrates the distraction external fixation construct for base of proximal phalanx or distal metacarpal fractures. Reprinted with permission from Koman LA, ed. *Orthopaedic Manual*. Winston-Salem, NC, USA: Orthopaedic Press; 2009:6–7.

Table 1. Patient demographics

Patient number	Sex	Age (years)	Side	Digit	Type of injury	Concomitant injury	Followup (months)	MCP ROM (degrees)
1	M	42	Left	Long	GSW	Dorsal soft tissue loss, 75% loss base P1, 75% loss extensor tendon	8	N/A
2	F	50	Left	Ring	Fall	None	89	0/75
3	M	18	Left	Small	GSW	Open wound dorsoulnar MCP	11	0/90
4	M	50	Left	Ring	Crush	Open fracture	53 (by phone)/5 (in person)	-20/85
5	M	28	Left	Thumb	Crush	Open fracture volar and dorsal, 50%–60% FPL laceration	8	0/60
6	M	49	Left	Thumb	Crush	Open radial and ulnar MC shaft/base P1 fractures	41 (by phone)/3 (in person)	0/0
7	M	24	Left	Index	MVA	Left distal radius fracture	7	0/80
8	M	45	Left	Long	GSW	Open wound dorsal with less than 50% extensor tendon injury, Open left index MC fracture	6 (by phone)/ 4 (in person)	10/80

M = male; F = female; MCP = metacarpophalangeal; GSW = gunshot wound; MVA = motor vehicle accident; FPL = flexor pollicis longus; MC = metacarpal; N/A = not available.

Discussion

Rapid and effective bony stabilization is important after a blast injury to the hand in a war zone or civilian setting. Although conventional pinning or plating techniques are effective for most hand injuries, the management of comminuted MCP, base of P1, or distal metacarpal head and fractures can be difficult, especially in conjunction with open wounds. Percutaneous pinning and splinting may fail to provide adequate stability, lead to stiffness, and impede local wound care. Although open reduction and internal fixation facilitates direct reduction of the articular surface, this technique is not always possible in the presence of severe comminution or bone loss. In the setting of open fractures resulting from blast or crush injuries, the soft tissues and the vascularity of the fracture fragments may be further compromised by placement of a plate and screws. We therefore evaluated a novel distraction pinning technique, which, to our knowledge, has not been reported before. We found reliable osseous union and joint stability at short-term followup, satisfactory patient-reported outcomes scores using the QuickDASH, and few reoperations in a small group of patients who presented with a complex and challenging set of injuries. We are unable, however, to comment on longer term issues that we expect may arise in this patient population such as stiffness or arthrosis.

This study had several limitations. The most important of these is its relatively short and incomplete followup. Only eight of the 10 patients in whom we did this procedure had followup beyond 6 months, and only three had followup beyond 1 year. Because of this, we can only demonstrate with confidence osseous union, soft tissue healing, and early reoperations; other studies with longer

term and more complete followup are needed to compare this technique with other available approaches in terms of stiffness, arthrosis, and late reoperations. In addition, the number of patients is limited. This is the result of the relatively infrequent nature of these specific injuries. However, when these injuries do present, they are difficult injuries to adequately treat. Finally, the retrospective study design is associated with particular sources of bias such as selection bias; however, during the period in question, we exclusively used this technique in our patients with injuries that were not amenable to plating or simple pinning.

We found reliable osseous union and joint stability with this technique despite the complex and difficult injury pattern. Other techniques have reported on these parameters in complex phalangeal and metacarpal fractures. Omokawa et al. [11] prospectively studied 51 patients with periarticular phalangeal and metacarpal fractures treated with titanium plating. Thirty-one patients presented with fractures about the MCP joint, although it is unclear how many were pilon-type fractures. They reported successful union in all fractures. Similarly, Ouellette and Freeland [12] showed successful union with open reduction and internal fixation of phalangeal and metacarpal fractures with minicondylar plates. Klein and Belsole [8] suggest percutaneous pinning of displaced articular fractures of the base of the P1 similar to Bennett fractures of the thumb. Their described technique places one pin across the MCP joint and an additional more transverse pin from the fragment to the shaft. Although this approach seems appropriate for minimally comminuted fractures, it may not provide adequate stability for pilon-type fractures. Ebinger et al. [5] suggested a combination of transcutaneous pinning and dynamic splinting for such fractures.

Drenth and Klasen [4] used a mini-Hoffmann external fixator (Stryker, Kalamazoo, MI, USA) to treat 36 phalangeal and metacarpal fractures, one of which was intraarticular. The pins were bent dorsally 40° to 60° to avoid interference with adjacent digits. Shehadi [15] reports a series of 26 metacarpal and phalangeal fractures successfully treated with external fixation. Three of these were comminuted intraarticular fractures of the base of the P1. His design involved an external fixator constructed with Kirschner wires linked externally with a methylmethacrylate bar.

We found satisfactory ROM and QuickDASH scores at short term in our small series on distraction pinning for complex fractures of the MCP joint. A number of investigators have shown successful results with treatment of fractures about the PIP joint with external fixation [6–8, 10, 11, 14–16]. Some investigators have shown superior results with regard to stability and joint ROM when compared with open reduction and internal fixation. However, less has been published on distraction external fixation of comminuted distal metacarpal and intraarticular base of P1 fractures. Omokawa et al. [11] reported good-to-excellent ROM in 43 of 51 patients. Margic [10] devised a “simple” external fixation device for treatment of phalangeal and metacarpal fractures. The device necessitates the use of “a thin, shaped connecting element with 2 perpendicular holes secured with screws.” He published results on 100 patients and showed good functional outcomes in 76% of isolated phalangeal fractures and 89% of multiple finger fractures. Fahmy [6] published good outcomes with the use of a flexible miniexternal fixator using serpentine springs.

Despite the severity of these injuries, we were gratified to see relatively few complications, and only one patient underwent an early reoperation. Other studies have shown results that vary from poor to excellent [1, 4, 12, 13]. Omokawa et al. [11] reported that 30 of their patients underwent removal of hardware and 20 patients required tenolysis. Ouellette and Freeland [12] noted a 57% complication rate in 51 patients. They concluded that the severity of soft tissue injury is most influential on the development of complications after open reduction and internal fixation.

The distraction pinning technique provides reliable osseous union and joint stability of comminuted distal metacarpal and pilon-type fractures of the base of P1, even in patients presenting with associated open wounds. However, future studies will need to evaluate these patients at longer term followup and compare this approach with other available techniques, because arthrosis, stiffness, and

progressive loss of function seem likely to occur given the severity of these injuries.

References

1. Badia A, Riano F, Ravikoff J, Khouri R, Gonzalez-Hernandez E, Orbay JL. Dynamic intradigital external fixation for proximal interphalangeal joint fracture dislocations. *J Hand Surg Am.* 2005;30:154–160.
2. Cardoso R, Li Z. Novel wire external fixation technique for proximal phalanx pilon fractures: technique and 2 case reports. *Tech Hand Up Extrem Surg.* 2011;15:162–165.
3. Deal DN, Barnwell J, Li Z. Soft-tissue coverage of complex dorsal hand and finger defects using the turnover adipofascial flap. *J Reconstr Microsurg.* 2011;27:133–138.
4. Drenth DJ, Klasen HJ. External fixation for phalangeal and metacarpal fractures. *J Bone Joint Surg Br.* 1998;80:227–230.
5. Ebinger T, Erhard N, Kinzl L, Mentzel M. Dynamic treatment of displaced proximal phalangeal fractures. *J Hand Surg Am.* 1999;24:1254–1262.
6. Fahmy NR. The Stockport Serpentine Spring System for the treatment of displaced comminuted intra-articular phalangeal fractures. *J Hand Surg Br.* 1990;15:303–311.
7. Johnson D, Tiernan E, Richards AM, Cole RP. Dynamic external fixation for complex intraarticular phalangeal fractures. *J Hand Surg Br.* 2004;29:76–81.
8. Klein DM, Belsole RJ. Percutaneous treatment of carpal, metacarpal, and phalangeal injuries. *Clin Orthop Relat Res.* 2000;375:116–125.
9. Li Z, Cardoso R. Distraction external fixation for comminuted fractures of the base of the proximal phalanx. *J Hand Surg Eur Vol.* 2010;35:508–509.
10. Margic K. External fixation of closed metacarpal and phalangeal fractures of digits. A prospective study of one hundred consecutive patients. *J Hand Surg Br.* 2006;31:30–40.
11. 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;33:857–863.
12. Ouellette EA, Freeland AE. Use of the minicondylar plate in metacarpal and phalangeal fractures. *Clin Orthop Relat Res.* 1996;327:38–46.
13. Pun WK, Chow SP, So YC, Luk KD, Ngai WK, Ip FK, Peng WH, Ng C, Crosby C. Unstable phalangeal fractures: treatment by AO screw and plate fixation. *J Hand Surg Am.* 1991;16:113–117.
14. Ruland RT, Hogan CJ, Cannon DL, Slade JF. Use of dynamic distraction external fixation for unstable fracture-dislocations of the proximal interphalangeal joint. *J Hand Surg Am.* 2008;33:19–25.
15. Shehadi SI. External fixation of metacarpal and phalangeal fractures. *J Hand Surg Am.* 1991;16:544–550.
16. Stern PJ, Roman RJ, Kiefhaber TR, McDonough JJ. Pilon fractures of the proximal interphalangeal joint. *J Hand Surg Am.* 1991;16:844–850.
17. Turker T, Capdarest-Arest N. Management of gunshot wounds to the hand: a literature review. *J Hand Surg Am.* 2013;38:1641–1650.