Retrograde Headless Intramedullary Screw Fixation for Displaced Fifth Metacarpal Neck and Shaft Fractures: Short Term Results

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Abstract

Background This study aimed to evaluate the early clinical outcomes of retrograde headless intramedullary screw fixation for displaced fifth metacarpal neck and shaft fractures.

Methods We retrospectively reviewed nine patients treated with retrograde intramedullary screw fixation of fifth metacarpal neck and shaft fractures between 2011 and 2013. Patient demographics and outcomes including hand dominance, age, sex, type of injury, injury and postoperative radiographs, return to work, time to fracture union radiographically, complications, visual analog score, disabilities of the arm, shoulder, and hand scores, postoperative metacarpophalangeal joint range of motion, and grip strength were recorded.

Results Nine fractures in nine patients with a mean age of 32 years (19–54) were included. There were seven metacarpal neck and two metacarpal shaft fractures. All patients sustained injury by direct impact of fist against an object. No case involved worker's compensation. Patients had a mean follow-up of 36 weeks (6–57 weeks) and at the time of latest

follow-up had no pain. Mean radiographic healing was 49 days (28–85 days). Mean return to work was 6 weeks (4–10 weeks). Mean metacarpalphalangeal joint motion was 0° extension and 90° flexion. Mean disabilities of the arm, shoulder, and hand scores pre- and postoperatively improved from 43 to 0.7, respectively. The mean postoperative grip strength was measured of the injured hand (40 kg) and un-injured hand (41 kg). **Conclusions** Retrograde headless intramedullary screw fixation of fifth metacarpal neck and shaft fractures has overall favorable early outcomes and offers the benefit of stable fixation, early motion without cast immobilization, and the ability for early return to work. This technique is a viable surgical option for these fractures and may be considered in the appropriate patient population.

Keywords Metacarpal fracture · Retrograde intramedullary screw

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Introduction

Metacarpal neck and shaft fractures are common hand injuries. The mechanism of injury is usually an axial force on a flexed metacarpophalangeal (MP) joint. Metacarpal neck injuries most commonly occur by punching a person or an object hence the eponym, boxer fracture. The lifetime incidence of boxer fractures in the United States is estimated to be 2.5 % [9].

There are substantial costs associated with the treatment of metacarpal fractures including medical costs and loss of work productivity. Stable fracture patterns can be successfully treated with non-operative treatment [6, 9, 12]. Non-operative treatment options include splinting/casting with or without closed reduction and functional taping. The degree of acceptable angulation of metacarpal neck fractures is debatable and recommendations vary from 20° to 70°; published guidelines consist of 15° at the index finger, 20° at the middle finger, 30°

at the ring finger, and 40° to 50° at the small finger [10]. Ford et al. recommended that non-operative management was the optimal treatment for up to 70° of angulation for metacarpal neck fractures in the small finger [6]. Acceptable angulation for metacarpal shaft fractures is greater than 30° in the small finger, 20° in the ring finger, and any angulation for the index and middle fingers [10].

Unstable fractures require open or closed reduction with supplemental fixation to maintain reduction and rotation [8]. Surgical fixation techniques include closed reduction and percutaneous pinning with Kirschner wires, intraosseous wiring, intramedullary nailing, intramedullary screw, and open reduction internal fixation with plate-screw or screw-alone constructs [3, 7, 8].

Retrograde intramedullary metacarpal screw fixation is a newer technique, but has been shown to impart stable fixation that allows early range of motion and improved function [3]. Our hypothesis is that retrograde intramedullary screw fixation may provide stable fixation to allow early motion, return to work, and fracture union with a low rate of complications. The purpose of this study is to retrospectively review a case series of patients with fifth metacarpal neck and shaft fractures treated with retrograde intramedullary screw fixation in order to evaluate and report on the early clinical outcomes of this surgical technique.

Materials and methods

With institutional review board approval, a retrospective review was performed for all patients who underwent retrograde intramedullary screw fixation for fifth metacarpal fractures between 2011 and 2013 at two institutions. The following were used as inclusion criteria for this operative method: [9] patient in good health and skeletally mature; [12] diagnosis of fifth metacarpal neck or shaft fracture; [6] fracture angulation measured on lateral radiographs >70° for metacarpal neck, >30° or >4 mm shortening for metacarpal shaft, or malrotation of injured digit on clinical exam; and [10] all patients provided written informed consent of treatment. Patients that were excluded from this study were those with [9] open fractures, [12] polytrauma of ipsilateral wrist or extremity, [6] skeletally immature, [10] patients not coherent for informed consent, [8] follow-up less than 6 weeks, and [7] incomplete data for analysis.

The Disabilities of the Arm Shoulder and Hand (DASH) and Visual Analog Score (VAS) was administered preoperatively only in the outpatient setting. Some patients did not have preoperative DASH or VAS because they were originally seen in the emergency room and treated as an inpatient. Postoperative DASH was obtained in all patients. Injury and postoperative radiographs were compared to evaluate for loss of reduction and radiographic signs of healing, defined by three bridging cortices.

At follow-up appointments, patients were evaluated clinically on their range of motion with digital goniometer and normal range of motion was defined as 0–90°. Grip strength, VAS, and DASH were also evaluated. Grip strength was obtained in the injured and non-injured hands when fracture healing was present. Patients were evaluated at follow-up clinic appointments until clinical and radiographic healing of fracture was obtained. During follow-up, both minor (infection, stiffness, and pain) and major (nonunion, malunion, MP joint arthrosis, and need for revision surgery) complications were documented if present.

Surgical technique

The surgical technique utilized in the study was based on the case report by Boulton et al. [3]. Closed reduction of the fracture is performed usually via flexion at MP joint with direct pressure and rotation until anatomic position is verified under fluoroscopy. A 1-cm dorsal longitudinal incision is made over the distal MP joint. A single guide wire is placed radial to the extensor tendon across the fracture through the dorsal metacarpal head while maintaining fracture reduction and is verified fluoroscopically. A small transverse incision is made around the guide wire in the sagittal band, which is later repaired with nonabsorbable suture. Cannulated drilling is performed by hand over the guide wire and a 3.0-mm cannulated headless screw (Synthes: West Chester, PA) is then placed over the wire and buried into the subchondral bone. At all times the extensor tendon is protected with a soft tissue guide. The guide pin starting point and subsequent screw placement is dorsally in the metacarpal head in line with the medullary canal. In all cases the longest available length size screw (40 mm) was used. The long thread screw was used for metacarpal neck fractures and short thread screw for the metacarpal shaft fractures. This allowed for the threads to be within the proximal fragment and obtain compression of the fracture. Alignment, stability, rotation, and MP joint motion are then tested under fluoroscopic imaging to ensure position and that no block to motion or impingement is present. An ulnar gutter plaster splint is placed initially. Hand therapy is started within 5–7 days for a custom ulnar gutter resting orthosis, edema control, active, and passive range of motion. Patients are encouraged to remove for bathing and motion. The resting orthosis is discontinued once patients obtain full range of motion and radiographic healing is present (Fig. 1).

Results

Sixteen patients met surgical inclusion criteria and were evaluated clinically and radiographically at follow-up clinic appointments. Six patients were lost to follow-up after the first postoperative visit and one due to incomplete data for analysis leaving

Fig. 1 **a–b** Preoperative radiographs of a fifth metacarpal neck fracture, **c–d** 6-week postoperative radiographs with healing and anatomic alignment after placement of a 40-mm retrograde headless intramedullary screw

nine total patients for study review (Table 1). Each patient excluded for follow-up <6 weeks returned only for the first postoperative visit. The average age was 32 years (19–54), nine male, all right-hand dominant, and all patients with injury to the right hand. Two patients were smokers. There were seven metacarpal necks and two metacarpal shafts (Fig. 2). All patients

sustained low velocity injuries by direct impact of fist against an object, and no case was worker's compensation related. All fractures were found to be in a transverse or short oblique pattern on imaging with an average of 61° of angulation and all patients had malrotation on clinical exam. Patients had mean follow-up of 36 weeks (6–57 weeks). Mean time for radiographic healing was 49 days (28–85 days). Radiographic evaluation revealed anatomic reduction after fracture healing in all patients. Mean return to work was by 6 weeks (4–10 weeks). At the latest follow-up visit, mean MP joint range of motion was 0–90°. Mean DASH scores improved from 43 (preoperative) to 0.7 (postoperative). Postoperative mean Visual Analog Score was 0. Grip strength in most patients was equal to or better than their contra-lateral uninjured hand, injured hand (mean, 40 kg), and uninjured hand (mean, 41 kg). There were no complications observed.

Discussion

There are various methods for treating metacarpal neck and shaft fractures described in the literature, each with potential advantages and disadvantages [1–4, 7, 8, 11]. Kirschner wire fixation offers limited soft tissue disruption, but may delay the ability for early motion. In addition, pin tract infection can occur when pins are left extracutaneous. Intramedullary fixation of metacarpal fractures has been shown to have good outcomes. A recent meta-analysis looking at eight studies with antegrade fixation revealed equivalent or better outcomes than comparison groups, however, all studies in this analysis used IM K-wires (13). Antegrade intramedullary nailing has also been used successfully and offers limited soft tissue stripping, but the nail can migrate into the MP joint and has required removal of implants after fracture healing [7].

Retrograde intramedullary headless screw fixation has been described as an operative method for displaced, comminuted,

Table 1 Patient demographics and outcomes

Patient	Age	Occupation	Tobacco use	DASH Preop	DASH Postop	Angulation Preop	Return to work (weeks)	Union X-ray (days)	Grip Injured hand	Grip Uninjured hand	Follow-up (weeks)
1	54	Engineer	No	–	0	65 deg neck	6	85	51 kg	56 kg	57
2	31	Dentist	No	–	1.7	70 deg neck	6	67	47 kg	44 kg	9
3	31	Computers	Yes	–	0	55 deg neck	4	42	41 kg	46 kg	6
4	22	Unknown	No	49	0	30 deg shaft	4	69	20 kg	40 kg	10
5	27	US Marine	Yes	30	0	75 deg shaft	8	56	41 kg	35 kg	52
6	29	US Marine	No	40	0	80 deg neck	10	42	33 kg	28 kg	45
7	32	US Marine	No	35	0	70 deg neck	4	28	48 kg	46 kg	52
8	19	US Marine	No	50	0	60 deg neck	6	28	33 kg	28 kg	40
9	45	US Marine	No	55	5	45 deg neck	4	28	48 kg	45 kg	56
Mean	32			43	0.7	61 deg	6	49	40 kg	41 kg	36

DASH The Disabilities of the Arm Shoulder and Hand

Fig. 2 **a–b** Preoperative radiographs of a fifth metacarpal shaft fracture, **c–d** 7-week postoperative radiographs with healing and anatomic alignment after placement of a 40-mm retrograde headless intramedullary screw

subcapital fractures of the metacarpal neck [3]. As reported by Boulton et al. in their case report, the patient regained functional active range of motion without pain by 6 weeks postoperatively, maintained alignment, had radiographic union of fracture by 12 weeks, and at 1 year recovered full extension, but limited flexion to 80° at the MP joint [3]. The present case series results show similar outcomes, but with improved range of motion and earlier gain of functional range of motion. Early rehabilitation is essential for these fractures to avoid stiffness of the MP and proximal interphalangeal joints; a benefit of IM screw fixation is earlier therapy for these patients. In our series, all patients began active and passive range of motion within the first week postoperatively and all had full range of motion at latest follow-up. Other benefits of this fixation include burying the screw in subchondral bone, compression across the fracture site, proximal and distal fixation, and no need for routine implant removal [3]. Although this technique has been reported for comminuted,

sub-capital, metacarpal neck fractures, we have expanded to include all metacarpal neck and shaft fractures meeting our inclusion criteria. Our results in fifth metacarpal neck and shaft fractures showed that these patients did well with this mode of fixation and had early favorable outcomes.

A concern about this technique for metacarpal fractures is the placement of the screw through the dorsal surface of the metacarpal head and whether this will lead to MP joint arthritis. There have been no reports of this complication to date in the literature and we have not experienced any complications such as continued pain in the MP joint. However, no study exists with sufficient long-term follow-up to evaluate metacarpal head arthrosis. Three-dimensional CT evaluation revealed the dorsal starting point was in line with the medullary canal and did not engage the center of the proximal phalanx base articular surface during most of the sagittal plane arc [5]. Our thought is that the area where the screw is placed likely fills in with fibrocartilage such as in microfracture technique for osteochondral defects. Further studies and long-term follow-up will be required to evaluate for this potential problem.

Limitations of our study include the small number of patients. This can be accounted for because as mentioned, this is a newer technique and there are specific indications for treating metacarpal neck and shaft fractures with retrograde intramedullary screw fixation. Other limitations include the short-term follow-up and patients lost to follow-up. This study was performed in order to look at the short-term outcomes of retrograde intramedullary screw fixation, however, some of the patients had much shorter follow-up than desired by the treating surgeons. Multiple failed attempts were made to contact patients that did not return for follow-up past initial postoperative appointment. It is speculated that some patients did not return for follow-up likely because of a combination of factors including socioeconomic status and the majority being treated at a level 1 trauma center. It is also possible that some patients did not feel they needed longer follow-up because they were doing well and returned to normal function or could have been seen elsewhere. A final limitation could be the retrospective study design and lack of a comparative study group. Our future endeavors include longer follow-up on outcomes as well as a prospective study comparing retrograde intramedullary screw fixation against fixation methods including Kirschner wires or plate fixation. Given the lack of an interlocking mechanism, the intramedullary screw construct may be torsionally unstable. The screw threads within the proximal and distal fragments seem to provide rotational fracture stability and we have not found this to be a problem clinically. A biomechanical study of this construct is underway to evaluate torsional, axial, and bending stability compared to other current fixation methods.

In conclusion, retrograde intramedullary screw fixation in the treatment of fifth metacarpal shaft and neck fractures offers

stable fixation to allow early range of motion and return to work. Using this technique, we report overall satisfactory short-term outcomes.

All procedures in this study were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Conflict of interest disclosure Michael C. Doarn declares that he has no conflict of interest.

Jason A. Nydick declares that he has no conflict of interest.

Bailee D. Williams declares that she has no conflict of interest.

Michael J. Garcia is a consultant for Osteomed and Auxilium.

Statement of Human and Animal Rights The institutional and national guide for the care and use of laboratory animals was followed and no animals were included in this study.

Statement of Informed Consent Informed consent was obtained from all patients for surgery and for being included in the study written.

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References

1. Balfour GW. Minimally invasive intramedullary rod fixation of multiple metacarpal shaft fractures. *Tech Hand Upper Extrem Surg.* 2008 Mar;12(1):43–5. PMID: 18388754.
2. Blazar PE, Leven D. Intramedullary nail fixation for metacarpal fractures. *Hand Clin.* 2010;26(3):321–5. v. PMID: 20670797.
3. Boulton CL, Salzler M, Mudgal CS. Intramedullary cannulated headless screw fixation of a comminuted subcapital metacarpal fracture: case report. *J Hand Surg Am.* 2010;35(8):1260–3. Epub 2010 Jul 8. PMID: 20619555.
4. Chammaa RH, Thomas PB, Khalil A. Single retrograde intramedullary wire fixation of metacarpal shaft fractures. *Acta Orthop Belg.* 2010 Dec;76(6):751–7. PMID: 21302572.
5. Corkum JP, Davison PG, Lalonde DH. Systematic review of the best evidence in intramedullary fixation for metacarpal fractures. *Hand.* 2013;8:253–60. doi:10.1007/s11552-013-9531-8.
6. Ford D, Ali M, Steel WM. Fractures of the fifth metacarpal neck: is reduction or immobilization necessary? *J Hand Surg (Br).* 1989;14: 165. PMID: 2746115.
7. Jorge Orbay MD. Intramedullary nailing of metacarpal shaft fractures. *Tech Hand Upper Extrem Surg.* 2005;9(2):69–73. PMID: 16201247.
8. Kozin SH, Thoder JJ, Lieberman G. Operative treatment of metacarpal and phalangeal shaft fractures. *J Am Acad Orthop Surg.* 2000;8:111–21. PMID: 10799096.
9. Poolman RW, Goslings JC, Lee JB, Statius Muller M, Steller EP, Struijs PA. Conservative treatment for closed fifth (small finger) metacarpal neck fractures. *Cochrane Database Syst Rev.* 2005 Jul 20;3, CD003210. PMID: 16034891.
10. Stern PJ. Fractures of the metacarpals and phalanges. In: Green DP, Hotchkiss RN, Pederson WC, Wolfe SW, editors. *Operative hand surgery.* 5th ed. New York: Churchill Livingstone; 2005. p. 277–342.
11. ten Berg PWL, Mudgal CS, Leibman MI, Belsky MR, Ruchelsman DE. Quantitative 3-dimensional CT analyses of intramedullary headless screw fixation for metacarpal neck fractures. *J Hand Surg [Am].* 2013 Feb;38(2):322–30. PMID: 23200214.
12. Van Aaken J, Kämpfen S, Berli M, Fritschy D, Della Santa D, Fusetti C. Outcome of boxer's fractures treated by a soft wrap and buddy taping: a prospective study. *Hand.* 2007;2: 212–7. PMID: 18780055.