HAND (2014) 9:16–23
DOI 10.1007/s11552-013-9562-1

REVIEW

Metacarpal fractures: treatment and complications

**Kathleen M. Kollitz · Warren C. Hammert ·
Nicholas B. Vedder · Jerry I. Huang**

Published online: 16 October 2013

Abstract Metacarpal fractures comprise between 18–44 % of all hand fractures. Non-thumb metacarpals account for around 88 % of all metacarpal fractures, with the fifth finger most commonly involved [19]. The majority of metacarpal fractures are isolated injuries, which are simple, closed, and stable. While many metacarpal fractures do well without surgery, there is a paucity of literature and persistent controversy to guide the treating physician on the best treatment algorithm. The purpose of this article is to review non-thumb metacarpal anatomy and treatment protocols for nonoperative management of stable fractures, and compare existing literature on surgical techniques for treatment of acute fractures and complications.

Keywords Metacarpals · Fractures · Hand · Trauma

Introduction

Metacarpal fractures comprise between 18–44 % of all hand fractures [10, 21]. Non-thumb metacarpals account for around 88 % of all metacarpal fractures, with the fifth finger most commonly involved [21]. The majority of metacarpal fractures are isolated injuries, simple, closed, and stable. While many metacarpal fractures have excellent outcomes without surgery, there is a paucity of literature and persistent controversy to guide the treating physician on the best treatment algorithm. The purpose of this article is to review non-thumb metacarpal anatomy and treatment protocols for nonoperative management of stable fractures, and compare existing literature on surgical techniques for treatment of acute fractures and complications.

K. M. Kollitz · N. B. Vedder · J. I. Huang (✉)
Department of Orthopaedics and Sports Medicine,
University of Washington Medical Center, 4245 Roosevelt Way
N.E., Box 354740, Seattle, WA 98105, USA
e-mail: jihuang@uw.edu

K. M. Kollitz
Duke University School of Medicine, DUMC 2927, Durham,
NC 27710, USA

W. C. Hammert
Department of Orthopaedic Surgery, University of Rochester
Medical Center, 601 Elmwood Avenue, Box 665, Rochester,
NY 14642, USA

Anatomy

The four finger metacarpals are concave on the palmar aspect. Taken together, they form a transverse arch supporting the palm. The index and middle finger metacarpals are fixed relative to the carpus, while the ring and small finger metacarpals are mobile with a flexion-extension arc of motion of 15–25° at the carpometacarpal (CMC) joint [8]. The metacarpal head is cam-shaped and forms a condyloid joint with the proximal phalanx. In extension, the collateral ligaments are lax and thus the joints may deviate radially and ulnarly. In flexion, the cam structure puts the collateral ligaments under tension which stabilizes the joint allowing minimal motion to radial and ulnar directed forces. The increased stability in flexion allows for more effective lateral key-pinch and grip strength. The volar plate resists hyperextension and provides stability to the metcarpophalangeal (MCP) joint, while the intermetacarpal ligament stabilizes the fingers, minimizing proximal migration and rotation of the fractured bone.

The dorsal and palmar interossei arise from the metacarpals and insert into the extensor expansion and proximal phalanx. Proximally, the extensor carpi ulnaris attaches to the base of the small finger metacarpal, while the extensor carpi radialis longus and brevis attach to the middle and index finger metacarpal bases, respectively. The ring finger is the only metacarpal without a proximal tendon attachment. These tendons exert deforming forces on fractured metacarpals.

Pathoanatomy and Diagnosis

Metacarpal fractures follow the same descriptive classification patterns as other long bone fractures. They may be open or closed, and intra- or extra-articular. Fracture lines may be oblique, transverse, spiral, or comminuted. Metacarpal fractures tend to have apex dorsal angulation due to the force exerted by the intrinsic and extrinsic flexors on the distal fragment.

On examination, there may be loss of knuckle contour from shortening and more proximal dorsal bony prominence secondary to excessive angulation. Shortening is usually detected radiographically. Shortening is more common at the border digits or with multiple fractures, as the intermetacarpal ligament helps to prevent shortening more than 3–4 mm in the central digits [45]. Shortening is potentially problematic as the extensor mechanism is attached at the level of the metacarpal head, through the sagittal bands, and therefore, the shortening will create a tendon imbalance resulting in an extension lag. Every 2 mm of shortening will result in 7° of extension lag [45]. As the MCP joints naturally hyperextend by about 20°, shortening of up to 6 mm is tolerable with neutral MCP extension.

Angulation is also best assessed radiographically. Most commonly, metacarpal fractures have apex dorsal angulation. Most authors recommend nonoperative management for up to 40°–50° of apex dorsal angulation in the small finger, 30° at the ring finger, 20° at the middle finger, and 15° at the index finger [8, 12]. Acceptable results can be expected for small finger metacarpal neck fractures with angulation as high as 70° [25, 27, 42, 47]. However, more than 30° of dorsal angulation can lead to weakness of grip [2].

Metacarpal shaft fractures are less forgiving. Mobility at the CMC joint allows the patient to adapt appropriately to 10°–15° of apex dorsal angulation in the ring and small fingers, respectively, without functional impairment [12, 33]. Conversely, the index and middles finger can tolerate only minimal apex dorsal angulation, and reduction should be attempted with greater than 10° of angulation [12, 28, 33]. Although the MCP joint can hyperextend to accommodate flexion deformity in the metacarpal, this compensation can result in inadequate force at the proximal interphalangeal (PIP) joint, leading to extensor lag, a phenomenon known as pseudoclawing. Careful attention on exam must be paid to the ability to extend the PIP in both MCP flexion and extension. Angulation in the coronal plane is less common but may occur in border digits, leading to divergence of the digit in both flexion and extension.

Rotational deformity is poorly tolerated in finger fractures. Malrotation may not be apparent with finger extension other than mild nail malalignment, but becomes pronounced with flexion. Each degree of rotation at the metacarpal results in 5° of rotation at the finger tip, leading to 1.5 cm of digital overlap in the closed fist [15]. Symptomatic scissoring can be quite disabling. To assess rotation, the examiner should compare the affected and contralateral hands. Normally, all fingers point to scaphoid tubercle, and deviation from this alignment may indicate a rotated fracture fragment.

Intra-articular fractures deserve special consideration. A step off of >1 mm or involvement of more than 25 % of the articular surface are indications for operative fixation to align the joint and minimize the risk of subsequent arthrosis.

In general, three radiographic views (posterior-anterior or anterior posterior, lateral and oblique) will suffice for diagnosis. Semi-pronation oblique views should be obtained to evaluate the index and middle finger metacarpals, while semi-supination will allow for evaluation of the small and ring finger metacarpals. Brewerton views may be obtained to evaluate the metacarpal heads and involve placing the hand with dorsum of fingers flat against the X-ray plate, with the elbow extended and the wrist in neutral. The MP joints are then flexed at about 65° and the X-ray beam is angled 15° ulnar-to-radial [30]. Computed tomography (CT) is indicated only in complex fractures or CMC fracture-dislocation.

Nonoperative Treatment

The majority of metacarpal fractures can be treated nonoperatively. Acceptance of mild deformity is often preferable to surgical treatment. Fractures of the 5th metacarpal appear to do particularly well when treated conservatively (Table 1) [37].

A retrospective review performed by Westbrook et al. examined patients with isolated small finger metacarpal neck or

Table 1 Nonoperative treatment recommendations for simple closed, isolated non-thumb metacarpal fractures

Fracture type	Recommended Treatment	Comments
5th Metacarpal neck or shaft	No reduction needed; Buddy tape with immediate mobilization or splint/ cast immobilization for 4 weeks (Level of evidence: III)	Fingers may be splinted in neutral or flexion (Level of evidence: I)
Index, middle, and ring finger metacarpal shaft fractures	Palmar wrist splint with immediate moblization or splint/ cast immobilization for 4 weeks (Level of evidence: III)	Initial extension lag may be seen with palmar wrist splint, which will likely resolve

shaft fractures with at least 2 years of follow-up [49]. Nonoperatively treated patients were compared to those treated surgically with plates or K-wires; in the nonoperative group, there was no attempt at reduction, and the investigators found that virtually all had normal DASH scores and aesthetic scores at 2 years [49]. For patients with metacarpal neck fractures, there was no statistically significant difference between nonoperative and operatively treated patients though the data trended towards favoring the nonoperative treatment group [49]. In the case of metacarpal shaft fractures, the DASH, SportsDASH, and aesthetic scores were significantly better in the nonoperative group ($p = .001$, $p = .009$, and $p = .013$, respectively) [49]. The retrospective nature of the trial made it difficult to control for patient selection, however, and it is possible that those treated nonoperatively had less severe injuries. The investigators found no difference in mean angulation between groups at the time of injury, however, and essentially normal function and aesthetics were achieved in patients with angulation up to 40° even without attempts at reduction.

The fifth metacarpal neck fractures are usually stable, with apex dorsal angulation and shortening. Traction reduction and cast immobilization demonstrated good results, with 81 % improvement in angulation and average height loss of 1 % at healing [23]. Reduction may not be necessary, however, as Strub et al. also found that splinting without a reduction attempt provided satisfactory results in the small finger metacarpal neck [46]. The authors performed a prospective pseudorandomized trial compare splinting without reduction to closed reduction with bouquet pinning for closed fifth metacarpal neck fractures with 30°–70° of palmar angulation. While pinning led to greater patient satisfaction, there was no difference in range of motion, strength, or rotation [46].

No immobilization method for conservative management of the 5th metacarpal neck has been shown to be superior. Options include buddy taping to the ring finger with immediate motion or 4 weeks of immobilization in a splint or cast. The length of immobilization should be based on tenderness on clinical exam since X-rays will lag behind clinical healing. Positioning of the MCP joints during immobilization does not appear to affect the outcome. One randomized controlled trial of ulnar gutter casting of 5th metacarpal fractures for 4 weeks compared positioning the MCP joints in flexion to positioning the MCP joints in neutral, and demonstrated no difference in range of motion, grip strength or aesthetics at 3 months [24]. Other metacarpal fractures may also be treated conservatively with good results. One case series of 42 patients with 54 oblique fractures of non-thumb metacarpals reported that treatment with a palmar wrist splint and immediate mobilization produced 100 % union [3]. Though initially, extension lag was seen in all fingers, all regained full range of motion [3]. The investigators also found excellent grip strength, with injured hand strength equal to 94 % of the contralateral hand at 1 year [3].

Operative Treatment

Indications for operative treatment include displaced intra-articular fractures, polytrauma, severe soft tissue injury, unstable open fractures, segmental bone loss, and multiple hand or wrist fractures [43]. Irreducible fractures that re-displace following reduction or those which are subacute (greater than 3–4 weeks from injury) are also indications for operative treatment. For isolated, closed metacarpal fractures, surgery is indicated for failure to achieve successful closed reduction with residual malrotation and substantial shortening. Some fractures are irreducible as they re-displace following reduction, or are not reducible due to interval healing in subacute fractures (3–4 weeks out from injury). A summary of operative techniques, indications, and possible complications is found in Table 2.

For the small finger metacarpal, intramedullary (IM) pinning has been shown to produce results superior to transverse pinning. Winter et al. performed a prospective, randomized, controlled trial comparing the "bouquet" IM pinning technique with transverse pinning to the small finger metacarpal [50]. At all time points up to 90 days, patients demonstrated better total active motion and better range of motion at the MCP joint when treated with the bouquet technique [50]. Another prospective cohort trial of IM pinning and transverse pinning found no significant difference between the two techniques in terms of outcome or complications [51]. Finally, a retrospective review of retrograde crossed pinning compared to antegrade IM splinting demonstrated better motion after IM splinting and fewer patients with shortening of the digit [40]. There were no differences in grip strength, complications, operative time or DASH score between the two techniques [40]. Due to the improved motion and less shortening, the authors conclude that antegrade IM pinning performed slightly better and recommend this method [40]. In sum, these three studies find that while all are acceptable means of fixation, antegrade IM fixation (bouquet method or IM splinting) was superior to crossed pins or transverse pinning for fifth metacarpal neck fractures.

Most metacarpal head fractures have articular involvement and are often comminuted and, therefore, are best treated operatively. When the articular surface is not amenable to repair, replacement arthroplasty or arthrodesis can be considered.

Indications for surgery of metacarpal shaft fractures include greater than 10° of angulation in the index or middle finger metacarpal, or greater than 30°–40° of angulation in the ring or small finger. In addition, open and multiple metacarpal fractures are often best treated surgically. Any rotational malalignment must be corrected. This is assessed clinically by examining for rotation, scissoring or overlap of the fingers in flexion. The MCP joint is very stable in flexion, and the surgeon can take advantage of this stability to aid correction of rotational alignment.

Table 2 Recommended treatment, operative indications, and possible complications for closed metacarpal fracture types

Fracture type	Operative fixation technique	Operative indications	Possible complications
Metacarpal shaft	Long oblique fractures: lag screws Oblique or transverse fractures: plates or IM pinning Multiple fractures: plates	Displaced, irreducible fractures Shortening >6 mm Residual angulation >30–40° in small/ring fingers or >10° in middle or index finger Malrotation Segmental fractures	Pseudoclawing Extension lag Malrotation Stiffness
Metacarpal neck	Intramedullary/Bouquet pinning Transverse pinning Crossed pins	Malrotation Unstable fractures	Loss of knuckle prominence Extension lag Stiffness
Metacarpal head	K-wire fixation Lag screw	Intra-articular fractures with step-off >1 mm, or >25 % articular surface involvement	Joint arthrosis Stiffness

Metacarpal shaft fractures may be treated with K-wires, intra-osseous wires, lag screws, or plates, depending on the morphology of the fracture line. K-wires have the lowest bending strength and are best for reconstruction of the articular surface, neck, or base fracture fixation where plates or screws may be difficult to place, and to maintain reduction of dislocated metacarpals. Due to lack of rigidity, protected range of motion is recommended when K-wires are used for surgical treatment. As exposed pins may be prone to infection, some surgeons prefer to bury all pins. Intra-osseous wires with 90–90 fixation are more rigid than K-wires, and are another option for low profile fixation that is useful for transverse fracture patterns and replants. Lag screws may provide strong fixation in long oblique fractures and allow for early motion but should only be used when the fracture length is at least two times the width of the metacarpal [28]. Plates provide the most rigid fixation and are of varying thickness and strength including mini (2–2.4-mm high), micro (0.8–1.7-mm high), or absorbable.

When comparing IM nailing to plate and screw fixation for closed, displaced, extra-articular metacarpal shaft fractures, Ozer et al. found no difference in total active motion or DASH scores [35]. IM nailing required hardware removal and loss of fixation was more common; however, the two treatment groups were not of equal sizes and definitive conclusions regarding complication rates could not be drawn [35]. Facca et al. prospectively compared locking plates to IM K-wire fixation of closed, isolated, displaced fifth metacarpal fractures [14]. Patients treated with locking plates followed an early mobilization protocol, while those treated with IM K-wires were immobilized for 6 weeks. Mean follow-up was 4.8 months for locking plates and 3.3 for K-wires. Active flexion was significantly better in the K-wire group with mobility of 97.7 % of the contralateral side compared to 58.7 % in the locking plate group despite the increased period of immobilization in the K-wire patients (p =.001) [14]. There was no significant difference in grip strength, pain, DASH score, or complication rates [14]. Plate fixation is also associated with avascular necrosis, and surgeons must be wary of periosteal stripping [7].

There appears to be no difference between miniplates (1.3-mm thick) and microplates (0.6 mm plates) in terms of outcome or failure rate. A case–control study of 40 metacarpal and phalangeal fractures demonstrated no failures in either group, and no difference in rates of removal of hardware, stiffness, total active motion and no difference in OR staff reported ease-of-use [1]. For non-thumb metacarpals, total arc of motion for the micro plates ranged from 105°–258° with an average of 211°, with one patient lost to follow-up and no reported complications. Patients treated with the miniplate for non-thumb metacarpal fractures had a total arc of motion (TAM) ranging from 100°–245° with an average of 205°, with one reported poor functional outcome and one good functional outcome complicated by reflex sympathetic dystrophy [1]. Another prospective cohort study of microplates for periarticular, comminuted fractures of the metacarpals and phalanges resulted in good range of motion in 43 out of 51 patients [34]. For metacarpal fractures, TAM was 91 % of the contralateral side and for all fractures combined, grip strength averaged 87 % of the uninjured side [34]. Though technically demanding, microplates can appropriately treat comminuted intra-articular fractures [34]. Plates have also been shown to be an effective means of stabilization of multiple ipsilateral metacarpal fractures [41].

Bioabsorbable plates provide adequate fixation to obtain boney union [48]. Dumont et al. reported on 12 patients treated with bioabsorbable plates with an average total active motion of 234° [13]. Two patients suffered a loss of reduction, however, and were revised with metal plates and screws. These two complications notwithstanding, the authors conclude that bioabsorbable plates are suitable for the treatment of metacarpal fractures [13]. Another consecutive series of bioabsorbable plates compared to titanium plates for metacarpal fractures found no significant difference between groups in total active motion or grip strength [39]. All fractures united and there were no reported complications with a minimum of 6-month follow-up [39]. Prospective, randomized controlled trials of absorbable plates are lacking, however, and delayed foreign body reactions have been described up to 2 years after fracture fixation [17]. Bioabsorbable plates are also more expensive, and one cost-benefit analysis found that a hardware removal of at least 19 % would be required to break even as compared to use of metal plates [6].

Fractures at the carpometacarpal joint are frequently comminuted due to deforming forces of the wrist extensors as previously described. Treatment options include closed reduction and percutaneous pinning and open reduction with internal fixation. As the index and middle CMC joints are relatively immobile, primary CMC fusion should be considered in multiple CMC fracture-dislocations, especially those with significant articular comminution and instability [22].

Complications

Plate fixation of metacarpal fractures complication rates vary between 32–36 % [16, 36]. A 1998 review of 66 metacarpal fractures treated with plates and screws revealed a 36 % complication rate [36]. Stiffness was the most commonly reported complication, with 76 % of patients studied reported to have total active motion less than 220° [36]. Sixteen percent of complications reported involved a minor extensor lag, while 7.9 % had contractures, followed by major extensor lag in 6.3 % of complications [36]. More serious complications are rare, with nonunion, infection and tendon rupture each comprising 1.6 % of complications reported. Fusetti et al. reviewed 105 non-thumb metacarpal fractures in 2002, and found a 32 % complication rate [16]. The most common complication was poor healing, with 15 % of patients split evenly between malunion and nonunion [16]. Ten percent of complications were related to stiffness, while 8 % of patients experienced hardware failure [16]. Only 1 % of those studied had a deep infection [16]. Revision surgery due to hardware complication has been reported at rates of 4.6–32 % [4, 5, 35, 44].

Infection rates in metacarpal fractures are low. Open fracture infection rates have been reported between 2–11 % with operative treatment, whereas closed fractures have an infection rate close to 0.5 % [9, 32]. Poor outcomes are directly correlated to the higher degrees of soft tissue injury and contamination [9]. Incision and drainage or operative washouts are urgent but not emergent for open metacarpal fractures. A consecutive review of 146 open fractures in the hand found no difference in infection rate between those treated emergently as compared to those whose treatments were delayed beyond 12 h [32]. Gonzalez et al. reported a treatment algorithm for open fractures of the hand is based on the modified Gustillo-Anderson classification in 1999, summarized in Table 3 [18].

Osteomyelitis in the hand is rare but serious: in one series, 39 % of patients with osteomyelitis went on to amputation [38]. Diagnosis is made from exam and X-rays, with one retrospective study reporting abnormal X-ray findings in 37 of 38 available radiographs [38]. Magnetic resonance imaging, computed tomography, and bone scan are slightly better than plain radiographs for the detection of osteomyelitis; however, all have poor sensitivity and specificity [28]. Combined with the high costs, advanced imaging is not recommended. There is little benefit to ESR and CRP for diagnosis [26, 38]. If values are obtained initially and found to be elevated, they may be helpful in monitoring response to therapy; however [26], if osteomyelitis is suspected, intraoperative biopsy and cultures are recommended. Implants should be removed and involved soft tissue and bone debrided. Antibiotic beads may be placed and internal or external fixation applied to manage pain and prevent further soft tissue damage. Antibiotics should be administered for 4–6 weeks. Osteomyelitis may be considered to be resolved if the patient is free of symptoms with normal ESR and CRP at least 4 weeks after the last dose of antibiotics [4]. At that time, a second stage operation can be performed with intraoperative cultures and fresh frozen section. If both are negative, bone grafting with internal fixation can be performed [38].

Nonunion is defined as no clinical or radiographic healing 4 months after fixation, or a radiographic fracture line at 14 months [29]. Hypertrophic nonunion lacks stability and is caused by inadequate immobilization. For closed fractures treated without surgery, the possibility of soft tissue interposition must be considered. Union can usually be attained with debridement of the fibrous tissue and application of a rigid fixation [4]. Atrophic nonunion is due to bone loss or loss of blood supply, which may be caused by open injuries and infection. Atrophic nonunion is treated with debridement of interposed soft tissue or infected bone, application of bone graft where needed, and application of stable fixation. Plates and screws are preferred over K-wires due to their rigidity. Early range of motion is recommended to prevent stiffness, and tenolysis is often required [4]. Bone grafting is not indicated in cases of extensive soft tissue loss or over an insensate area, as the graft represents a liability [4]. In these cases, amputation is likely preferable.

Nonunion in closed metacarpal fractures is more common in transverse fracture patterns. Fusetti et al. found 29.6 % incidence of nonunion in transverse fractures, whereas only 7.4 % of other fractures failed to unite [16]. It appears like this because there is less apposition of bone in transverse shaft fractures. Nonunion/delayed union is more common in

Table 3 Algorithm for the treatment of open fractures of the hand

Gustillo–Anderson class	Description	Treatment recommendation	Antibiotics
Type 1	Clean laceration <1 cm No contamination, crush injury, or comminution	I&D plus immediate definitive fixation and closure	Cefazolin 48 h
Type 2	Clean laceration >1 cm No contamination, crush injury, or comminution	Controversial; - I&D with wound left open for second look in 24–72 h; clean wounds may be definitively treated or - I&D with immediate fixation for clean-appearing injuries and closure	Cefazolin 3–5 days
Type 3	Laceration >10 cm or soft tissue crush, periosteal stripping, comminution, blast, contamination or farm injury	- Aggressive I&D with preliminary fixation with K-wires and/or external fixator - Repeat I&D every 24–72 h until quantitative cultures have $<10^5$ bacterial count - Soft tissue or flap coverage within 1 week where possible	Cefazolin plus an aminoglycoside; add penicillin for soil contamination

Treatment algorithm as recommended by Gonzolez et al. 1999

I&D incision and drainage, *cm* centimeter

manual workers with a rate of 28.1 % compared to 6.0 % in nonmanual workers [16].

Acceptable limits of deformity for malunion are summarized in Table 4. Angulation of the metacarpal shaft in the sagittal plane is better tolerated than angulation in the coronal plane. The small and ring finger have more CMC mobility, which allows for greater tolerance of angulation without loss of function. The metacarpal neck may tolerate higher degrees of angulation than the metacarpal shaft. As previously mentioned, the examiner should look for pseudoclawing in angulated metacarpal fractures. A hyperextended MCP joint can accommodate metacarpal angulation and achieve neutral extension, but this may lead to inadequate force at the PIP, thus the examiner should test PIP extension with the MCP in flexion and in neutral.

In contrast to angulation, rotation is poorly tolerated. Rotation transmits down the entire finger shaft and is exaggerated in flexion. Derotational osteotomy may be performed at original fracture site or base of metacarpal, though better healing is achieved at metaphysis. Fixation with plates will allow for earlier range of motion as compared to K-wire fixation, which must be protected with a splint or cast for several weeks. An osteotomy at the proximal metaphysis of the metacarpal can correct 18°–20° of rotation [20]. The step-cut osteotomy allows for more boney apposition and lag screw fixation, which leads to fewer adhesions. In a step-cut osteotomy, an oscillating saw is used to make hemi-transverse cuts in the proximal and distal metacarpal shaft. Two dorsal parallel cuts are then made longitudinally between the hemi-transverse cuts, leaving the volar cortex intact. Removal of

Table 4 Limits of acceptable deformities in metacarpal shaft fractures, diagnosis of displaced metacarpal fractures, and possible resulting complications

Deformity	Tolerable limit of deformity	Exam findings	Possible complications
Apex dorsal angulation	Neck: Index and middle fingers 10–15° Ring finger: 30° Small finger 50–70° Shaft: Index and middle fingers 10° Ring and small fingers 20°–30°	Dorsal prominence	Pseudoclawing, grip weakness, malunion
Shortening	Up to 6 mm	Loss of prominence of the MCP joint in closed fist Extension lag	Extension lag, grip weakness
Rotation	No tolerable limit	Malaligned nail beds Finger overlap/scissoring in closed fist	Scissoring, grip weakness

mm millimeters, *MCP* metacarpophalangeal

1 mm of bone from the dorsal cortex allows for derotation and correction of approximately 1 cm of overlap from the fingertip [31]. If the malunion is angulated and rotated, then the osteotomy must be performed at the original fracture site. Angulation can be corrected with an opening or closing wedge osteotomy, and care must be taken to avoid overshortening.

Joint stiffness is common with metacarpal fractures, and may require a second surgery with results varying and multiple complications reported. In 1979, Gould and Nicholson reported a series of 105 MCP capsulectomies [19]. On average, patients gained 13°–18° of motion, which led to functional change [19]. Creighton and Steichen reported results of a series of extensor tenolysis with and without dorsal capsulotomy in 612 patients with fractures of the hand [11]. A capsulotomy was performed if patients were found to be limited in passive flexion. For patients who underwent tenolysis only, total active motion improved from 173° to 227° and extensor lag improved from 16° to 8° [11]. Patients who underwent tenolysis and dorsal capsulotomy improved total active motion from 164° to 194°; however, extension lag worsened from an average of 24° to an average of 28°. Finally, Page and Stern reported on tenolysis alone of 15 digits in 1998 [36]. Only 3 out of the 15 improved their range of motion. Tendon rupture has also rarely been reported as a complication of metacarpal fractures [43].

Conclusions

Metacarpal fractures are common injuries in the hand. Most metacarpal fractures have a good outcome with nonoperative treatment because there is substantial tolerance to angulation and shortening, particularly fractures of the small finger metacarpal shaft and neck. Rotation is poorly tolerated as it is magnified with flexion and often results in scissoring, which interferes with grip. Complication rates are reported between 32–36 %, with stiffness and malunion as the two most common. Malunion including angulation, rotation, and shortening may be treated effectively with surgery; however, surgery to alleviate stiffness has less predictable success. The surgeon must be well versed in the variety of treatment options available and choose the most appropriate treatment according to each patient's presentation.

Statement of Human and Animal Rights This article does not contain any original research with human or animal subjects.

Statement of Informed Consent This article does not contain any patient identifying details, and no alterations have been made to data to protect patient privacy.

Conflict of interest Author KK declares that she has no conflicts of interest. Author WH declares that he has no conflicts of interest. Author NV declares that he has no conflicts of interest. Author JH declares the following conflicts of interest: Consultant for Arthrex, Inc for education and product development; Grants from Arthrex, Inc, for Fellowship Education; Honoraria from AO North America as course faculty; payment for service on speakers' bureau for Auxilium; and travel and accommodation expense from Arthrex and Auxilium.

References

1. Agarwal AK, Pickford MA. Experience with a new ultralow-profile osteosynthesis system for fractures of the metacarpals and phalanges. Ann Plast Surg. 2006;57:206–12.
2. Ali A, Hamman J, Mass DP. The biomechanical effects of angulated boxer's fractures. J Hand Surg [Am]. 1999;24:835–44.
3. Al-Qattan MM. Outcome of conservative management of spiral/long oblique fractures of the metacarpal shaft of the fingers using a palmar wrist splint and immediate mobilisation of the fingers. J Hand Surg Eur. 2008;33:723–7.
4. Balaram AK, Bednar MS. Complications after the fractures of metacarpal and phalanges. Hand Clin. 2010;26:169–77.
5. Bannasch H, Heerman AK, Iblher N, et al. Ten years stable internal fixation of metacarpal and phalangeal hand fractures. J Trauma. 2010;68:624–8.
6. Bostman OM. Metallic or absorbable fracture fixation devices: A cost minimization analysis. Clin Orthop Relat Res. 1996;329:233–9.
7. Buchler U, Fischer T. Use of a minicondylar plate for metacarpal and phalangeal periarticular injuries. *Clin Orthop Relat Res*. 1987;214:53–8.
8. Chin SH, Vedder NB. MOC-PSSM CME article: Metacarpal fractures. Plast Reconstr Surg. 2008;121:1–13.
9. Chow SP, Pun WK, So YC, et al. A prospective study of 245 open digital fractures of the hand. J Hand Surg (Br). 1991;16:137–40.
10. Chung KC, Spilson SV. The frequency and epidemiology of hand and forearm fractures in the United States. J Hand Surg [Am]. 2001;26:908–15.
11. Creighton Jr JJ, Steichen JB. Complications in phalangeal and metacarpal fracture management. Results of extensor tenolysis. Hand Clin. 1994;10:111–6.
12. Day CS, Stern PJ. Fractures of the Metacarpals and Phalanges. In: Wolf SW, editor. Green's operative hand surgery. Philadelphia: Elsevier Churchill Livingstone; 2011.
13. Dumont C, Fuchs M, Burchhardt H, et al. Clinical results of absorbable plates for displaced metacarpal fractures. J Hand Surg [Am]. 2007;32:491–6.
14. Facca S, Ramdhian R, Pelissier A, et al. Fifth metacarpal neck fracture fixation: Locking plate versus K-wire? Orthop Traumatol Surg Res. 2010;96:506–12.
15. Freeland AE. Hand fractures: repair reconstruction and rehabilitation. New York: Churchill Livingstone; 2000.
16. Fusetti C, Meyer H, Borisch N, et al. Complications of plate fixation in metacarpal fractures. J Trauma. 2002;52:535–9.
17. Givissis PK, Stavridis SI, Papagelopoulos PJ, et al. Delayed foreign-body reaction to absorbable implants in metacarpal fracture treatment. Clin Orthop Relat Res. 2010;468:3377–83.
18. Gonzalez MH, Jablon M, Weinzweig N. Open fractures of the hand. J South Orthop Assoc. 1999;8:193–202.
19. Gould JS, Nicholson BG. Capsulectomy of the metacarpophalangeal and proximal interphalangeal joints. J Hand Surg [Am]. 1979;4:482–6.

20. Gross MS, Gelberman RH. Metacarpal rotational osteotomy. J Hand Surg [Am]. 1985;10:105–8.
21. Gudmundsen TE, Borgen L. Fractures of the fifth metacarpal. Acta Radiol. 2009;50:296–300.
22. Hanel DP. Primary fusion of fracture dislocations of central carpometacarpal joints. *Clin Orthop Relat Res*. 1996;327:85–93.
23. Harris AR, Beckenbaugh RD, Nettrour JF, et al. Metacarpal neck fractures: results of treatment with traction reduction and cast immobilization. Hand. 2009;4:161–4.
24. Hofmeister EP, Kim J, Shin AY. Comparison of 2 methods of immobilization of fifth metacarpal neck fractures: a prospective randomized study. J Hand Surg [Am]. 2008;33:1362–8.
25. Holst-nielsen F. Subcapital fractures of the four ulnar metacarpal bones. Hand. 1976;8:290–3.
26. Honda H, McDonald JR. Current recommendations in the management of osteomyelitis of the hand and wrist. J Hand Surg [Am]. 2009;34:1135–6.
27. Hunter JM, Cowen NJ. Fifth metacarpal fractures in a compensation clinic population. A report on one hundred and thirty-three cases. J Bone Joint Surg Am. 1970;52:1159–65.
28. Jones NF, Jupiter JB, Lalonde DH. Common fractures and dislocations of the hand. Plast Reconstr Surg. 2012;130:722e–36.
29. Jupiter JB, Koniuch MP, Smith RJ. The management of delayed union and nonunion of the metacarpals and phalanges. J Hand Surg [Am]. 1985;10:457–66.
30. Lane CS. Detecting occult fractures of the metacarpal head: the Brewerton view. J Hand Surg [Am]. 1977;2:131–3.
31. Manktelow RT, Mahoney JL. Step osteotomy: a precise rotation osteotomy to correct scissoring deformities of the fingers. Plast Reconstr Surg. 1981;68:571–6.
32. McLain RF, Steyers C, Stoddard M. Infections in open fractures of the hand. J Hand Surg [Am]. 1991;16:108–12.
33. McNemar TB, Howell JW, Chang E. Management of metacarpal fractures. J Hand Ther. 2003;16:143–51.
34. Omokawa S, Fujitani R, Dohi Y, et al. Prospective outcomes of comminuted periarticular metacarpal and phalangeal fractures treated using a titanium plate system. J Hand Surg [Am]. 2008;33:857–63.
35. Ozer K, Gillani S, Williams A, et al. Comparison of intramedullary nailing versus plate-screw fixation of extra-articular metacarpal fractures. J Hand Surg [Am]. 2008;33:1724–31.
36. Page SM, Stern PJ. Complications and range of motion following plate fixation of metacarpal and phalangeal fractures. J Hand Surg [Am]. 1998;23:827–32.
37. Poolman RW, Goslings JC, Lee JB et al. Conservative treatment for closed fifth (small finger) metacarpal neck fractures. *Cochrane Database Syst Rev*. 2005:CD003210.
38. Reilly KE, Linz JC, Stern PJ, et al. Osteomyelitis of the tubular bones of the hand. J Hand Surg [Am]. 1997;22:644–9.
39. Sakai A, Oshige T, Zenke Y, et al. Mechanical comparison of novel bioabsorbable plates with titanium plates and small-series clinical comparisons for metacarpal fractures. J Bone Joint Surg Am. 2012;94:1597–604.
40. Schadel-Hopfner M, Wild M, Windolf J, et al. Antegrade intramedullary splinting or percutaneous retrograde crossed pinning for displaced neck fractures of the fifth metacarpal? Arch Orthop Trauma Surg. 2007;127:435–40.
41. Souer JS, Mudgal CS. Plate fixation in closed ipsilateral multiple metacarpal fractures. J Hand Surg Eur Vol. 2008;33:740–4.
42. Statius Muller MG, Poolman RW, van Hoogstraten MJ, et al. Immediate mobilization gives good results in boxer's fractures with volar angulation up to 70 degrees: a prospective randomized trial comparing immediate mobilization with cast immobilization. Arch Orthop Trauma Surg. 2003;123:534–7.
43. Stern PJ. Management of fractures of the hand over the last 25 years. J Hand Surg [Am]. 2000;25:817–23.
44. Stern PJ, Weiser MJ, Reilly DG. Complications of plate fixation in the hand skeleton. Clin Orthop Relat Res. 1987;214:59–65.
45. Strauch RJ, Rosenwasser MP, Lunt JG. Metacarpal shaft fractures: the effect of shortening on the extensor tendon mechanism. J Hand Surg [Am]. 1998;23:519–23.
46. Strub B, Schindele S, Sonderegger J, et al. Intramedullary splinting or conservative treatment for displaced fractures of the little finger metacarpal neck? A prospective study. J Hand Surg Eur Vol. 2010;35:725–9.
47. Theeuwen GA, Lemmens JA, van Niekerk JL. Conservative treatment of boxer's fracture: a retrospective analysis. Injury. 1991;22:394–6.
48. Waris E, Ashammakhi N, Happonen H et al. Bioabsorbable miniplating versus metallic fixation for metacarpal fractures. *Clin Orthop Relat Res*. 2003;410:310–9.
49. Westbrook AP, Davis TR, Armstrong D, et al. The clinical significance of malunion of fractures of the neck and shaft of the little finger metacarpal. J Hand Surg Eur Vol. 2008;33:732–9.
50. Winter M, Balaguer T, Bessiere C, et al. Surgical treatment of the boxer's fracture: transverse pinning versus intramedullary pinning. J Hand Surg Eur Vol. 2007;32:709–13.
51. Wong TC, Ip FK, Yeung SH. Comparison between percutaneous transverse fixation and intramedullary K-wires in treating closed fractures of the metacarpal neck of the little finger. J Hand Surg (Br). 2006;31:61–5.