Metacarpal shaft fractures: A review
C McCarthy¹, JB Samora¹, HM Awan*¹

Abstract
Introduction
Fractures of the hand cause significant disability and may lead to long-term loss of function. Metacarpal fractures represent 30-50% of all hand fractures. Not all metacarpal fractures require surgical intervention, as good outcomes have been reported with conservative care. Our aim is thus to review the available literature to help guide treatment of these common injuries.

Discussion
Anatomy
The metacarpals bridge the carpus to the phalanges allowing for normal hand function, including flexion and extension of the digits as well as grip strength.² The index and long finger metacarpals allow little motion at the carpometacarpal (CMC) joint whereas the ring and small finger metacarpals have a significant amount more CMC motion.²

Fractures are described based on their location in the metacarpal shaft, and can be either intra-articular, metaphyseal or diaphyseal. Diaphyseal fractures often have dorsal angulation, the amount of which varies depending on which metacarpal is involved, and is directly related to the amount of CMC motion for the affected digit.² Kozin et al.³ highlight that the intricate hand anatomy can easily account for this dorsal angulation, as the lumbricals and interossei originate from the proximal third of the metacarpal shaft and insert distally to the anterolateral proximal phalanges, and are volar to the metacarpophalangeal (MP) joint. This anatomical arrangement creates the deforming force of metacarpal diaphyseal shaft fractures, and explains the apex dorsal angulation.

Fractures of the metacarpal shaft can limit hand range of motion (ROM) and grip strength, can lead to an extensor lag from shortening, and often cause rotational deformity of the digit.³ Extensor lag is a function of shortening and has been shown through cadaveric studies that every 2mm of shortening up to 10mm creates a 7 degree extensor lag.⁴ Grip strength is also affected by shortening and a separate cadaveric study demonstrated that at full flexion of the digit, shortening more than 5mm resulted in a statistically significant decrease in flexion force and the same results occurred at 7.5mm shortening with 50% flexion of the digit.⁵ These biomechanical changes can negatively affect both quality of life and functional abilities.

Indications
Many metacarpal shaft fractures can be treated non-operatively with closed reduction and immobilization. However, indications for conservative vs. surgical treatment of metacarpal fractures are not well defined in the literature. Indications for surgery are generally based on those fracture characteristics likely to result in significant hand disability or cosmetic issues. Creating stability in an unstable fracture is the primary indication, although no concrete definition of unstable MC shaft fractures exists.

Some agreed upon indications include open fractures, multiple metacarpal fractures in the same hand, MC fractures associated with flexor tendon injury, irreducible fractures, and MC fractures which are associated with rotational deformity and shortening.⁶,⁷ Additional, patient specific indications for surgery exist, such as metacarpal fractures in athletes, as fixation may provide earlier return to competition and rehabilitation.⁸

Index and long finger metacarpals can tolerate approximately 10-15 degrees more than the CMC motion at their respective digit, which equates to an allowable 10-15 degrees dorsal angulation for fractures of those digits. Ring finger metacarpal fractures have an allowable 30-35 degrees allowable angulation and up to 50 degrees in small finger metacarpal fracture.²

In a survey of 161 hand surgeons in the United Kingdom, 39% “would contemplate intervention” of metacarpal shaft fractures in the small finger exceeding 30 degrees of angulation.⁹ Shortening of greater than 5mm is an...
fractures require more fixation to control the deformities.\textsuperscript{15}
Plate and screw fixation does appear to lead to good functional results.\textsuperscript{20,27}
Varying plating methods can be used from non-locking to locking. A recent study found that double-row non-locking plating was stronger than double row locking plates, which was stronger than single-row locked plating.\textsuperscript{28}

Biomechanically, plate and screw constructs have proven to be no different in maximum bending moment strength, bending rigidity than K-wire fixation, although torsional strength was less for plate and screws.\textsuperscript{29}
Studies have also compared the need for bicortical versus unicortical fixation of screws, with a cadaveric study finding no difference.\textsuperscript{30}
Some fractures, particularly long oblique fractures, may be amenable to simple screw fixation in lag technique.
One study compared lag technique strength to standard cortical purchase technique in 48 cadaver specimens and demonstrated no difference in strength of fixation.\textsuperscript{31}

There was no difference between the 1.5mm and 2.0 mm size screws. Non-locked plates are the standard treatment for metacarpal fractures although there are some potential indications to consider locking technology including metaphyseal comminution, bone loss, highly comminuted diaphyseal fractures, or pathologic fractures.\textsuperscript{32}

New implant materials have been developed, including polyethyl-etherketone (PEEK) implants. In a comparison with unicortical locking plates using PEEK compared to bicortical non-locking plates in a biomechanical study, there was no difference in strength.\textsuperscript{33}
Absorbable implants have also been utilized for metacarpal fractures although in one study,\textsuperscript{34} four of ten patients experienced foreign body reaction requiring operative debridement and removal. A case report\textsuperscript{30} using poly-L-lactic acid and polyglycolic acid copolymer plates and screws in a ring finger oblique metacarpal shaft fracture showed plate failure with screws intact to the bone.

Outcomes
Outcomes are generally positive with various reporting methods, including the Disabilities of the Arm, Shoulder, and Hand (DASH) scoring system. Reported excellent or good outcomes range from 78% to 94%.\textsuperscript{20,27,35,36} There does appear to be predictable healing of these fractures with rates as high as 90 to 100%\textsuperscript{(19)}.

Osseous union typically occurs between five and eight weeks.\textsuperscript{2,13}
Nonoperative treatment results in predictable healing rates as well with one study\textsuperscript{37} showing 100% union of 54 fractures in a retrospective review of treatment with palmar wrist splints and mobilization of all fingers.

Percutaneous pinning has good outcomes with up to 100% bony union rates.\textsuperscript{3,6,13,14,15,16,17,18,19,21,24,25} One study of retrograde K-wire fixation in 105 patients with 10 month follow-up showed the same ROM as non-injured side.\textsuperscript{38}

Plate and screw fixation leads to 78-85% acceptable to excellent function.\textsuperscript{20,27}

Complications
Despite predictable healing and excellent or good outcomes, surgical procedures can lead to complications.
The most common complications include superficial infections, extensor tenosynovitis, stiffness, hardware failure, and sensory disturbances (cold intolerance as well as complex regional pain syndrome).\textsuperscript{3,16,23,36,39}
Superficial infections occurred primarily in patients where fixation included pinning wherein the pins remained to some extent external to the skin.
Superficial infections occur anywhere from 12-15% of the time.\textsuperscript{5,14,35} Deep infections are relatively rare, with reports ranging from 1-9%.\textsuperscript{23,35} Some authors recommend burying wires to avoid the complication of superficial infection.\textsuperscript{5}

One author reported 29% cold intolerance after pinning and 39% skin sensory impairment of varying degrees.\textsuperscript{5} A Turkish retrospective study of 50 metacarpal fractures in 43 patients 3 of which were open injuries had an incidence of 23% “major” complications including extensor tenosynovitis.\textsuperscript{24} They found 9% of patients had plate irritation requiring
removal of hardware, and 14% with < 180 degrees range of motion. In a larger U.S. study, 35% of patients had one or more complication including difficulty with fracture healing, stiffness, plate loosening or breakage, complex regional pain syndrome and one deep infection.23 A separate U.S. review of 38 fractures treated with plate fixation specifically found 42% complication rate to include stiffness, malunion, nonunion, and tendon rupture.39

Interestingly, one study of 335 patients with metacarpal shaft fractures noted that missed follow up appointments were associated with unmarried, uninsured, unemployed and disabled patients. This should be taken into account when considering treatment methods especially with regards to method specific potential complications40. It is clear that surgical intervention for metacarpal fractures is not benign and regardless of technique, complications can and do occur.

Conclusion

Metacarpal fractures of the hand are common injuries and can cause significant disability if not treated properly. Not all fractures require surgical intervention, as good outcomes have been reported with conservative care. Kirschner wire fixation as well as open reduction and internal fixation are acceptable methods to treat MC shaft fractures.

Lag screws for long oblique fractures provide good fixation. Outcomes appear to be good regardless of surgical technique, with high rates of union. Nonetheless, surgical treatment is not without complications and these should be elucidated to patients before proceeding with any treatment option. Until foreign body reactions can be eliminated, we recommend against the use of absorbable implants at this time. Randomized prospective studies are needed to help determine appropriate indications for the surgical treatment of metacarpal shaft fractures, as well as guide best treatment options.

References


Licensee OAPL (UK) 2014. Creative Commons Attribution License (CC-BY)


Competing interests: None declared.

All authors abide by the Association for Medical Ethics (AME) ethical rules of disclosure.