An Insight of Management of Metacarpal Fractures

Mohammed Almukhtar Dougdoug, Adel Mohammad Salama, Amr Mohamed El Adawy, and Ahmed Mashhour Gaber
Orthopedic Surgery Department, Faculty of Medicine - Zagazig University
Corresponding author: Mohammed Almukhtar Dougdoug
E-mail: Mohammeddougdoug@gmail.com

Abstract

Background: The metacarpals shape a transverse arch to which the rigid row of distal carpal bones is fixed. The peripheral metacarpals (those of the little and thumb finger) form the sides of the cup of the palmar gutter and as they form together to deepen this concavity. The index metacarpal is the mainly firmly fixed, while the thumb metacarpal articulates with the trapezium and acts separately from the others. The middle metacarpals are strongly unite to the carpus. The ring metacarpal shapes a transitional part of the semi-independent last metacarpal. Metacarpal fractures are common, accounting for 18% of all fractures of the hand and forearm. Selection of the optimum treatment depends on a number of factors including: fracture location (intra-articular versus extra- articular), deformity (angulation, rotation, shortening), open or closed fracture, associated osseous and soft tissue injuries and fracture stability. Additional considerations include patient’s age, occupation, socioeconomic state, presence of systemic illness, the surgeon’s skills and the patient’s ability to co-operate in the implementation of treatment.

Keywords: Metacarpal Fractures

Introduction

Metacarpal fractures are common, accounting for 18% of all fractures of the hand and forearm **(1)**; the peak incidence of metacarpal shaft fractures is between 20 and 40 years **(2)**.

Incorrect diagnosis and management of metacarpal and phalangeal fractures can have catastrophic consequences for patients, as much morbidity and disability can be prevented by establishing proper management at initial evaluation 3).

Management of fractures to the metacarpal bones of the hand is decided on both the clinical examination and radiological findings. The reasons behind this are that the hand's long-term function is often dependent on the fracture's angulation and rotation. The key parts of the clinical examination are to assess the degree of rotational deformity, and whether there is any soft tissue compromise, including evidence of open fractures with or without the involvement of a 'fight bite.' This term relates to the high incidence of hand fractures secondary to punches and that a number of these involve a punch to an individual's mouth and thus an accidental 'bite' to the skin. Inability to extend at the metacarpo-phalangeal joint also correlates to increased need of operative fixation **(4)**.

Rotation of the digit impacts greatly on functional grip, and can be a source of chronic pain. It is best assessed by asking the patient to make a fist.

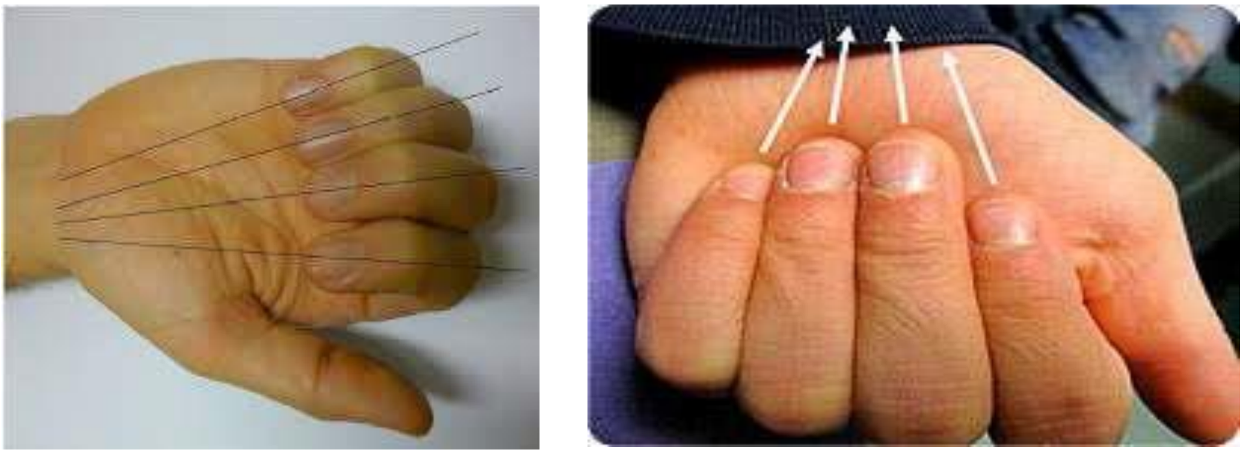

Fig. (1): The direction of the fingers when flexing to make a fist: pointing towards the area of the scaphoid tubercle. These lines are disrupted when the finger is rotated with the rotated finger lying under neighbouring digits **(3)**.

should point towards the scaphoid tubercle, without overlapping with the MCPJ and Proximal interphalangeal joint (PIPJ) flexed. Also, the nail should appear parallel to the hand and neighboring digits when looking end-on. the digits should then tuck in as the Distal Interphalangeal Joint (DIPJ) is flexed, although pain often restricts a degree of the flexion of all these joints. Comparison should be made to the other hand, but there is now a feeling that both digit overlap and nail alignment vary greatly within the population, making the clinical examination more difficult **(3)**.

Clinical examination:

Problems associated with metacarpal shaft fractures relate to shortening, rotation, and dorsal apex angulation. Of these, malrotation is the most critical. Minor rotational deformities can cause the fingers to overlap when the hand is made into a fist. Rotational abnormalities are best judged clinically by comparing the injured and uninjured digits through a full Range of Motion (ROM). With flexion, each digit should point toward the scaphoid tuberosity. The plane of the nail should be similar between the injured digit and the contralateral corresponding finger when evaluated in an intrinsic plus position. Like shaft fractures, metacarpal neck fractures usually are easily diagnosed by localized tenderness and swelling with loss of dorsal knuckle contour. The ring and small metacarpals are most commonly fractured **(5)**.

Dorsal dislocations of the metacarpo-phalangeal joint are readily identified by a hyperextension posture of the digit with loss of joint flexion, dimpling of the skin dorsally may also be observed **(6)**.

1.

Imaging:

a)

Plain radiography:

Plain radiography is the primary means of evaluating hand injuries beyond the history and physical examination. Any significant injury to the hand should be assessed with Postero- anterior (PA), lateral, and oblique views. A 30° pronated lateral view for 2nd and 3rd metacarpal fractures and a 30° supinated lateral view for 4th and 5th metacarpal fractures are helpful. The tubular skeleton of the hand requires three radiographic views-Antero Posterior (AP), lateral, and oblique-to accurately assess the position and integrity of these small skeletal units and their articulations. The phalanges

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must be seen in a true lateral projection, and the injured digit should be isolated to avoid superimposition of the skeletal units of the adjacent digits.

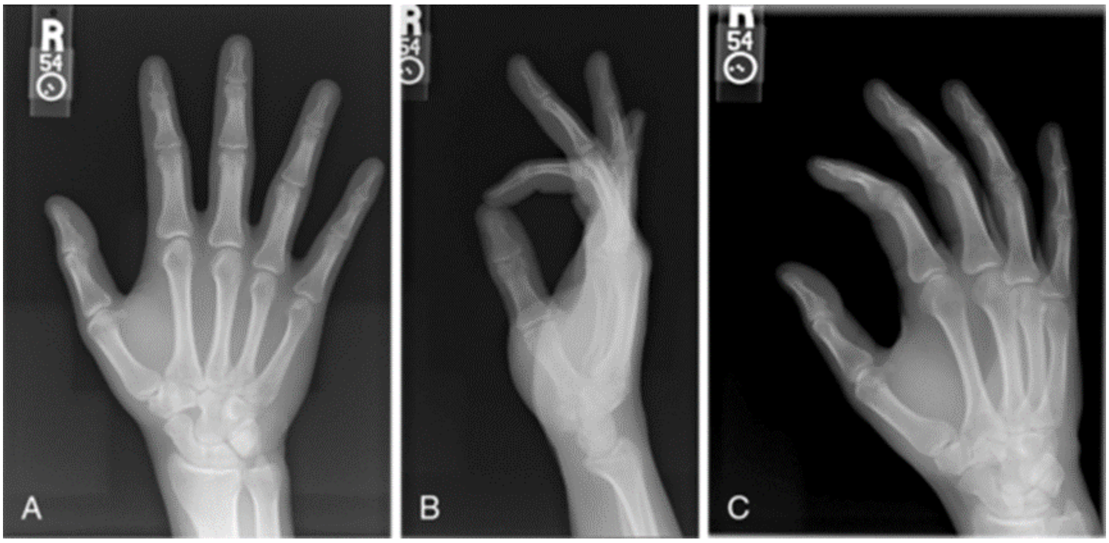

Fig. (2): A: Posteroanterior, B: lateral, and C: oblique views of hand imaging (8).

Carpo-metacarpal injuries:

CMC fractures and dislocations are frequently difficult to visualize or fully characterize with standard radiographic projections. Additional oblique views, fluoroscopy, or computed tomography may be necessary. Additionally, traction radiographs can sometimes best demonstrate the bony and ligamentous injuries and their severity. This is accomplished by distracting the involved digits and obtaining multiple radiographic views. CMC dislocation results in subtle loss of joint space as viewed on the AP projection. Often, this is seen as a '**broken saw tooth**' sign at the CMC joint. This sign may be accompanied by displacement noted on lateral or oblique views. Assessing closely for other additional injuries is important. Because significant force is required to disrupt the strong CMC ligaments, fracture-dislocation of one CMC

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joint is often accompanied by an injury to one or more of its neighbours **(3)** .

Fig. (3): Postero -anterior and lateral radiographs (A and B) of the left carpus demonstrating dorsal dislocations of the index, middle, ring and small carpo-metacarpal joint. The fractures of the third metacarpal and trapezium are also visible **(9)**.

Metacarpo-phalangeal dislocations*:*

Most commonly, lateral radiographs reveal the dorsal displacement of the proximal phalanx. In more severe and complex dislocations, there may also coexist a metacarpal head fracture **(10)**.

Fig.(4): 2nd metacarpo-phalangeal (MCP) joint dislocation in skeletally immature patient; note position of finger and dimpling of skin on volar hand (11).

Fig. (5): Radiograph of 2nd metacarpo-phalangeal (MCP) dislocation in skeletally immature patient (11).

CT scanning:

CT scans may also aid in evaluating CMC fracture-dislocations , injuries to the central digits, and injury to the fifth digit (reverse Bennett's fracture). With subtle injuries of the CMC joints, CT scanning may be required to aid the clinician in determining the diagnosis and in making management decisions **(12)**.

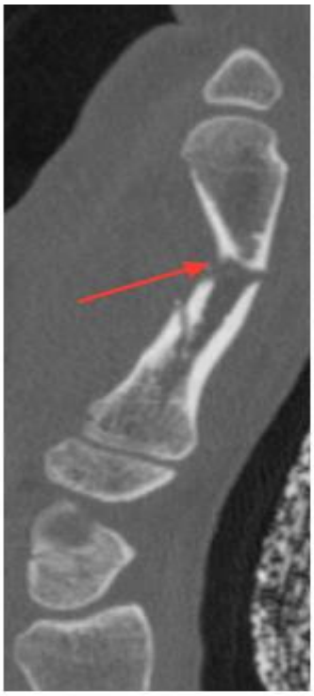

Fig. (6): CT of Boxer's fracture (13).

TREATMENT

Fractures of the metacarpals are among the most common fractures of the skeletal system. Unfortunately, these fractures are often neglected or regarded as trivial injuries **(14)**. **Watson-Jones (15)** demonstrated that serious problems maybe develop as considerable deformity and permanent functional disability.

Management of fractures in the hand has undergone dramatic changes in the last quarter of the last century **(16)**.

* **(17)**.

The goals in treatment of metacarpal fractures remain the same regardless the method employed **(18,19)**:

•Restoration of articular anatomy.

•Elimination of angular or rotational deformity.

•Stabilization of fractures.

•Surgically accepted wounds.

Rapid mobilization.

Optimal treatment for metacarpal fractures remains to be debated. Closed reduction and immobilization or functional bracing is reported, but requires careful selection of patients with fracture patterns amenable to non-operative treatment. In those patients requiring surgical fixation, treatment options are variable and include: closed or open reduction and fixation with percutaneous pinning, extra-or intra- osseous wiring, lag screws, intramedullary devices, plates or external fixation **(20,21)**.

I.Non- operative treatment:

The majority of metacarpal fractures can be treated non-operatively. Acceptance of mild deformity is often preferable to surgical treatment **(22,3)**. Closed reduction of shaft fractures often can be obtained by downward pressure on the dorsal apex of the fracture and upward pressure through the flexed MCP joint. **Burkhalter** advocated closed treatment for fractures that showed no rotational malalignment on clinical examination. He used a short arm cast with the wrist in 30-40 degrees of extension and added a dorsal extension block to hold the MCP joints flexed 80-90 degrees and the interphalangeal (IP) joints extended and the cast was maintained for 4 weeks. This position limits joint contractures and maintains the intrinsics in a relaxed position **(23,24)**.

In the early decades of the twentieth century, metacarpal fractures were all managed non-operatively **(17)**. Conservative treatment was recommended if there is no joint displacement, no rotation failure, no angulation over 30 degrees and shortening less than 5 millimeters **(25)**.

•Dynamic splinting:

Patient with stable non -displaced fractures should begin early protected range of motion when the pain resolves; usually within 3 to 5 days **(26)** . Metacarpal fractures that show little displacement being well splinted by adjacent metacarpals and the interossei tend to settle into stable position requiring no reduction and no immobilization and immediate active motion is the only treatment required **(27)** .

•Closed reduction and immobilization:

Closed reduction and plaster of Paris (POP) fixation has been recommended by Bunnel **(28)**. This procedure, except in skilled hands, frequently results in finger and hand stiffness, malunion, necrotic skin areas and consequently great economic loss **(29,30)**.

Accurate anatomical reduction of the hand fractures is critical before application of the external immobilization cast or splint **(31)**. If the hand had to be immobilized, care must be taken about the position. MP joints are flexed at 70-90 degrees while PIP and DIP joints are flexed at 15-20 degrees. This is called the **safe position of the hand** (position of function or intrinsic plus position) which prevents the stiffness of both MP and IP joints.

The period of immobilization should not exceed three weeks. These are called "**James principles**" **(32,33)**.

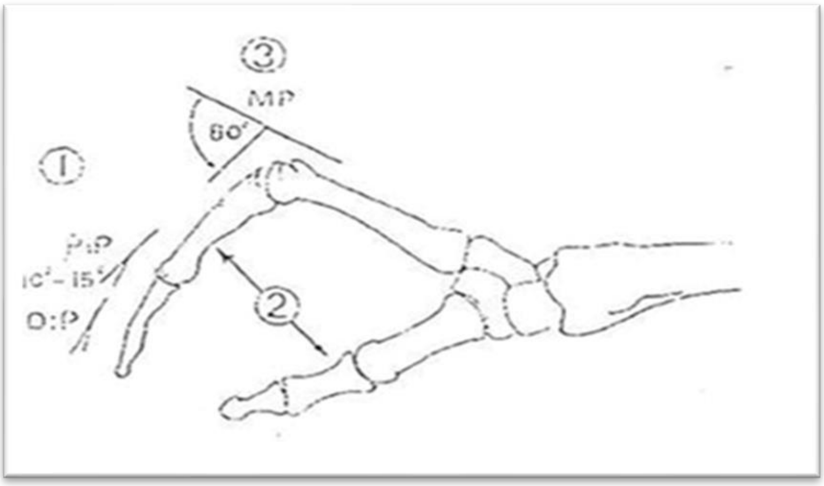

Fig. (7) The classic protective (safe) position **(34)**.

(1) Interphalangeal joint extension.
(2) Palmar abduction and extension of the thumb.
(3) Finger metacarpophalangeal joint flexion.

II.Operative treatment:

Over the past three decades, operative fixation of hand fractures has gained increasing popularity due to; improved materials,implant designs, instrumentation, better understanding of the biomechanical principles of internal fixation, more demanding public expectations, availability of specialists in hand surgery and hand therapists.Numerous indications for operative treatment include: malrotation, angulation or longitudinal shortening. Also, irreducible fractures, intra- articular fractures, open fractures, segmental bone loss, polytrauma with hand fractures, multiple hand or wrist fractures or fractures with soft tissue injury are indications of operative treatment for metacarpal and phalangeal fractures **(35,1)** .

Operative management aims to restore sufficient skeletal stability to achieve fracture union without loss of function. Such stability must be sufficient to allow for early mobilization **(36)**.

Prolonged immobilization should be avoided because of the risk of permanent stiffness; however, overly aggressive attempts at internal fixation may lead to soft tissue damage, tendon adhesions, infection, and the necessity for a secondary procedure for implant removal. Operative fixation must be used judiciously and with the expectation that the ultimate outcome will be as good as, and optimally better than the outcome after non-operative management **(37)**.

Closed reduction and internal fixation (CRIF):

Multiple options exist for operative fixation of metacarpal fractures. **Percutaneous Kirschner wires (K-W)** remain an important technique to control and stabilize fracture fragments. Several pinning techniques can be used for metacarpal head, neck, shaft, and base fracture **(38,39)**.

The easiest technique is transfixation pinning of the fractured metacarpal to an intact adjacent metacarpal. A second pinning technique uses K- wires to cross near the fracture site. These can be placed antegrade or retrograde. In antegrade method a prebended K- wires is inserted intramedullary in the metacarpal bone passing the fracture under fluoroscopy. The divergent tips of the wires in the metacarpal head resemble the stems of flowers, and thus the term " **bouquet**" osteosynthesis was used for this technique **(40,41).**

In retrograde method a K- wire is inserted through the metacarpal head in the retrograde direction. The wire is advanced to the proximal end of the metacarpal with the use of a hammer.Then, the wrist is maintained into a fully flexed position, and the wires are sequentially advanced further through the dorsal subchondral bone of the metacarpal bone **(42)**.

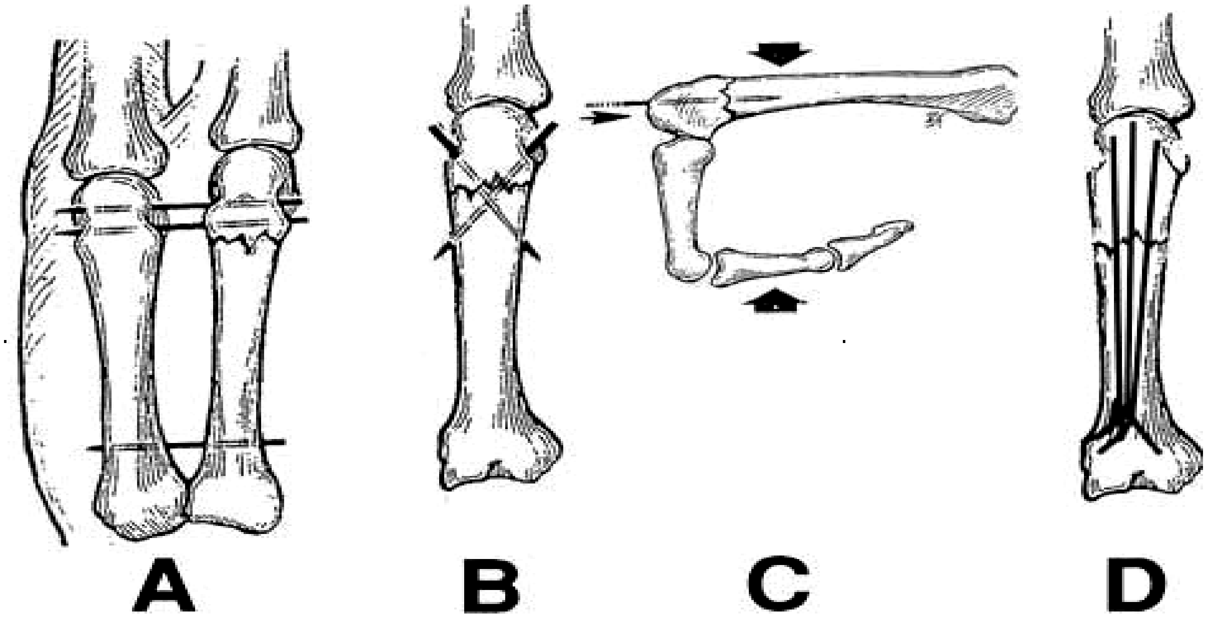

Fig.(8): Various pinning fixation techniques described for the management of metacarpal fractures. (A)Transfixion pinning. (B)Cross k-wires. (C)Retro grade intramedullary fixation. (D)Antegrade intramedullary fixation **(40).**

Headless compression screw fixation for metacarpal neck and shaft fractures has been shown to be a reliable option for axially stable fractures. The advantages of headless compression screws are relatively fast insertion and the minimally invasive insertion technique, decreasing risks associated with more extensive soft tissue dissection, stability allowing early range of motion, and that it is an intramedullary implant, which eliminates the risk of hardware irritation **(42)**.

IMHS Fixation method:

Intramedullary headless compression screw fixation has been performed in a retrograde manner in which a guidewire and then a cannulated headless screw are placed through a skin excision, a split in the sagittal band or extensor tendon, and the dorsal central articular cartilage surface of the metacarpal head.

Implant

The Headless Compression Screws, offer different diameters and lengths covering a wide range of indications for fracture management. The special head design minimizes soft tissue irritation and enables a minimally invasive method.
Various diameters for a wide range of indications:
2.0, 2.5, 3.0, 3.5, 4 mm.

Open reduction and internal fixation (ORIF):
Mini- plate and screws provides a rigid fixation. These implants neutralize rotational, torsional and shearing forces at the fracture area, thus enabling earlier, and stronger rehabilitation. A rigid fixation enabling bone healing and early active finger motion is important in surgical treatment. After the recent development of mini-plate and screw, their use in metacarpal and phalangeal fractures has increased **(43,44)** .
Tension band wiring the use of tension band principles was introduced by **Pauwels (45)**. It was applied to fracture surgery by **Weber (46)**, and further developed by **ASIF (34)**. This technique has been described by **Greene** and co-workers and used for secure fixation of any long bone fracture in the hand even. It allows for early active motion and return to full activity within four to six weeks **(47)**.
Entails inserting K- wires across the fracture site and using supplemental 26 - gauge wire looped around the protruding K- wire ends to create a compressive force at the f racture site **(48)**.
Intraosseous wiring involves passing a 26 - gauge wire transversely across the fracture line dorsal to the midaxis and looping it around oblique K- wires to neutralize the rotational forces. Excellent success has been reported using this technique for transverse fractures **(21)**.
Lag screw fixation fixation of metacarpal fractures only with lag screws is a technique many surgeons employ because of the implants' low profile and biomechanical stability **(49)**.
Biodegradable hemicirculage sutures bruser et al reviewed the use of biodegradable hemicirulage sutures in the treatment of metacarpal fractures. The polyglycolic acid hemicirculages achieved sufficient fracture fixation to permit early motion exercises **(50)**, without jeopardizing bony union. Ideal indications are oblique or torsion fractures of the metacarpals **(51)**.
Epandable intramedullary device the device consists of cylindrical apparatus made of titanium that allows for collapse in the circumferential diameter. It is introduced into the medullary canal in its collapsed state and then is released to allow re- expansion to its normal diameter in the canal with the fracture reduced over it. It gives excellent

fixation and affords stability approaching that of normal bone. Minimal post-operative immobilization is needed and early restoration of motion is possible **(52)**.

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