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Treatment of the Metacarpals Fracture

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Abstract:

Background: Metacarpal fractures represent one of the most common injuries of the hand and may lead to significant deformity and permanent functional impairment if inadequately treated. Over recent decades, management strategies have evolved from predominantly conservative approaches to a wide spectrum of operative techniques driven by advances in fixation materials, biomechanical understanding, and the growing emphasis on early mobilization. Treatment selection depends on multiple factors including fracture pattern, stability, degree of deformity, soft-tissue involvement, and patient-related considerations. The primary goals remain restoration of anatomy, stable fixation, and preservation of hand function. This review summarizes current concepts in the non-operative and operative management of metacarpal fractures, highlighting indications, techniques, biomechanical principles, and rehabilitation considerations.

Keywords: Metacarpal fractures; Hand fractures; Internal fixation; Lag screw fixation; K-wire fixation; Non-operative management; Rehabilitation

Introduction:

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 **(1). Watson-Jones (2)** demonstrated that serious problems may 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 **(3)**.

Selection of the optimum treatment depends on a number of factors including: fracture location (intra-articular vs. 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 **(4)**.

The goals in treatment of metacarpal fractures remain the same regardless the method employed (5):

- Restoration of articular anatomy.
- Elimination of angular or rotational deformity.
- Stabilization of fractures.
- Surgically accepted wounds.
- Rapid mobilization.

Optimal treatment for metacarpal and phalangeal 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**.(6**, **7**).

Non- operative treatment:

The majority of metacarpal fractures can be treated non-operatively. Acceptance of mild deformity is often preferable to surgical treatment **(8, 9)**. 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 **(10-13).**

In the early decades of the twentieth century, metacarpal fractures were all managed non-operatively **(4)**. Conservative treatment was recommended if there is no joint displacement, no rotation failure, no angulation over 30 degrees and shortening less than 5 millimeters **(14)**.

• 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**.** 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 **(15)**.

• Closed reduction and immobilization:

Closed reduction and plaster of Paris (POP) fixation has been recommended by Bunnel **(16)**. This procedure, except in skilled hands, frequently results in finger and hand stiffness, malunion, necrotic skin areas and consequently great economic loss **(17,18)**.

Accurate anatomical reduction of the hand fractures is critical before application of the external immobilization cast or splint **(19).** 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 (**Fig. 1**). The period of immobilization should not exceed three weeks. These are called "**James principles**" **(20, 21)**.

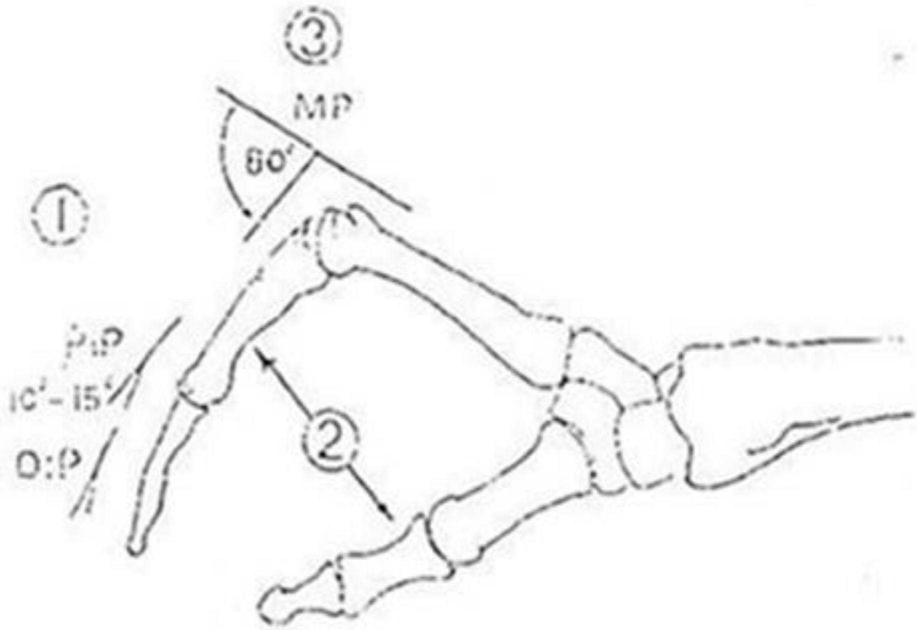

Fig. (1): The classic protective (safe) position **(22).**

(1) Interphalangeal joint extension.

(2) Palmar abduction and extension of the thumb.

(3) Finger metacarpophalangeal joint flexion.

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 (**10**,**23**).

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 **(24)**.

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 **(10).**

Closed reduction and internal fixation (CRIF):

Multiple options exist for operative fixation of metacarpal fractures. Percutaneous Kirschner wires (KW) remain an important technique to control and stabilize fracture fragments. Several pinning techniques can be used for metacarpal head, neck, shaft, and base fractures (**25**-**28**).

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 **(26-31).** 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 farther through the dorsal subchondral bone of the metacarpal bone **(32)**.

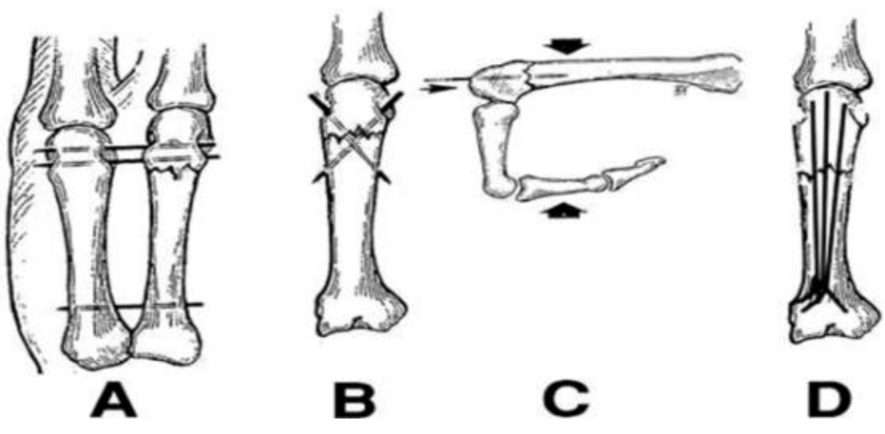

Fig.(2): Various pinning fixation techniques described for the management of metacarpal fractures. (A) Transfixion pinning. (B) Cross k-wires. (C) Retro grade intramedullary fixation. (D) Antegrade intramedullary fixation **(26).**

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**(33-35)**.

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 **(36-40)**.

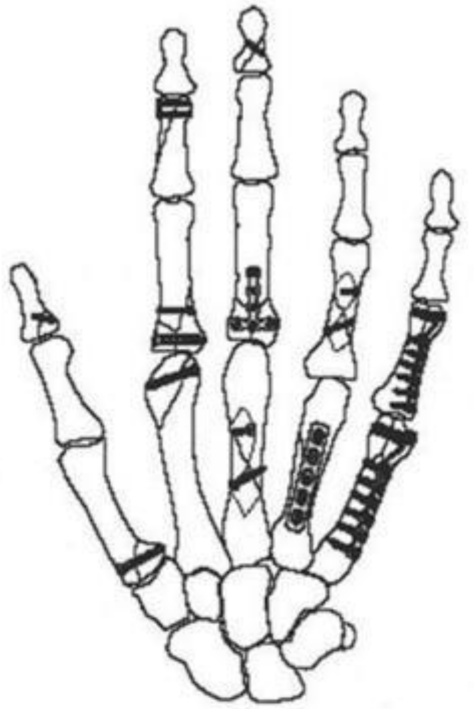

Fig. (3): Hand skeleton with useful available implants **(35).**

Tension band wiring 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 fracture site **(41)**.

Intraosseous wiring involves passing a 26 - gauge wire transversely across the fracture line dorsal to the mid axis and looping it around oblique K- wires to neutralize the rotational forces. Excellent success has been reported using this technique for transverse fractures **(41)**.

Lag screw fixation method:

Fixation of metacarpal fractures only with lag screws is a technique many surgeons employ because of the implants' low profile and biomechanical stability **(42)**.

Implant:

Screws with diameters of 1. 0, 1. 2, 1. 3 , 1. 5, 1.6, 1.7, 2. 0, 2.3, and 2.4 mm are now available depending on the manufacturer. The driving recess of screw heads and screwdriver bits have different designs, ranging from cross- head, square, and hexagonal to star- shaped. Knowledge of the screw diameter and the screw core diameter is necessary as this determines the size of the hole to be predrilled for a fixation screw or lag screw **(43).**

Biomechanics of lag screw:

Long oblique fractures with the fracture length more than the diameter of the bone or isolated corner articular fractures may be especially amenable to lag screw fixation. For fixation to be effective, the width of the fracture fragment should be at least 3 times as wide as the thread diameter of the screw. Important considerations regarding screws include outer diameter, inner diameter, and pitch. The pitch of the screw is the distance between the screw threads, which affects the compression. The outer diameter, which is represented by the maximal diameter of the shaft of the screw with the f lutes, has a direct effect on the pull-out strength, whereas the inner diameter directly affects the bending strength and tensile strength **(37)**.

Lag screw fixation involves drilling a hole in the near cortex that is the same diameter as the outer diameter of the screw. This practice causes the screw to engage only the far cortex and not the near cortex, increasing compression.

The most effective compression across the fracture site occurs with the placement of the screw perpendicular to the fracture line. However, because limited axial stability is provided by this construct alone, it is best to apply multiple lag screws at right angles to both the fracture line and the shaft of the bone. Two interfragmentary lag screws were significantly more rigid than crossed K wires, tension band wiring, or dorsal plate fixation in an oblique proximal phalanx apex volar bending model. The most stable construct included plate fixation with 2 interfragmentary lag screws **(37)**.

Surgical approaches:

Dorsal approach of metacarpals:

A straight or S- shaped skin incision is made on the extensor surface of the hand; a straight incision should run parallel to but not directly over the extensor tendons. The extensor tendons are retracted laterally. The interosseous muscles are exposed and detached partially; if possible, the intertendinous connections are preserved **(Fig. 4).** The approach to the base of the fifth metacarpal is through a dorsoulnar incision moved radially. The dorsal sensory branch of the ulnar nerve must be exposed and protected; the tendons of the little finger are retracted laterally **(43)**.

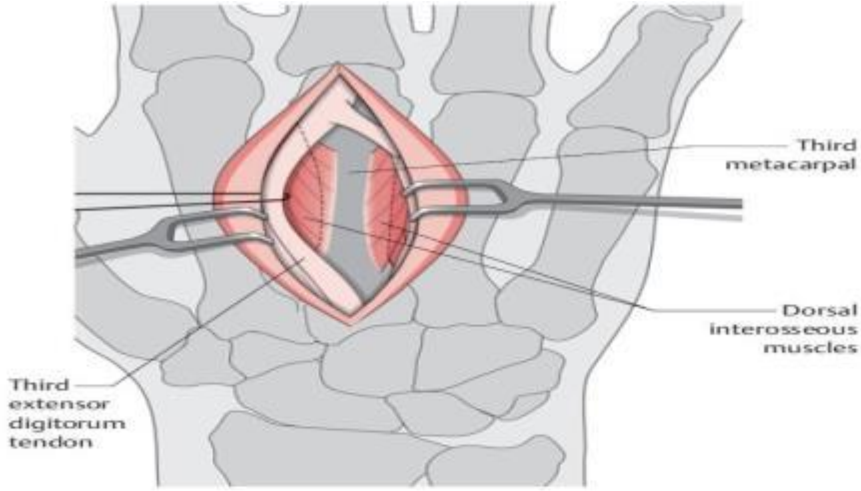

Fig. (4): Dorsal approach for metacarpals **(43).**

Technique of lag screw fixation:

Long oblique fractures are common and are usually best treated with lag screws. Two or more mini-screws may be spaced at intervals to stabilize long oblique fractures whose length equals or exceeds twice the diameter of the adjacent bone **(Fig.5).** In case of a shorter fracture line, a single lag screw and a neutralization plate are suitable to be used. (**44**)

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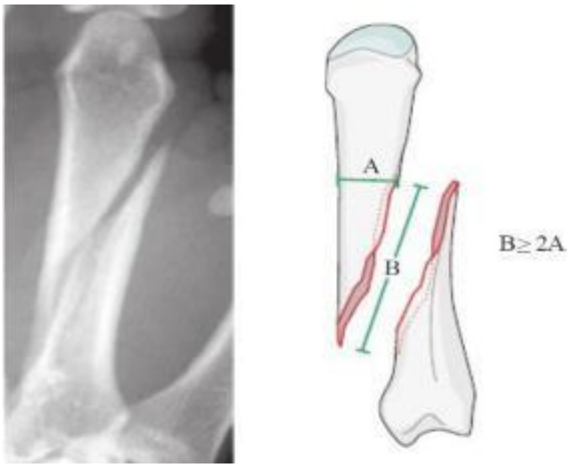

Fig. (5): Long oblique fracture geometry **(45).**

Reduction may be preliminary secured with one or two pointed reduction forceps. Making sure that the reduction forceps do not conflict with the planned screw positions is important. Confirming that the apex of each fracture fragment has been properly reduced is essential. Checking rotational alignment is achieved by passively flexing the fingers and looking for rotational malalignment of the finger in form of scissoring **(45)** **(Fig. 6)**.

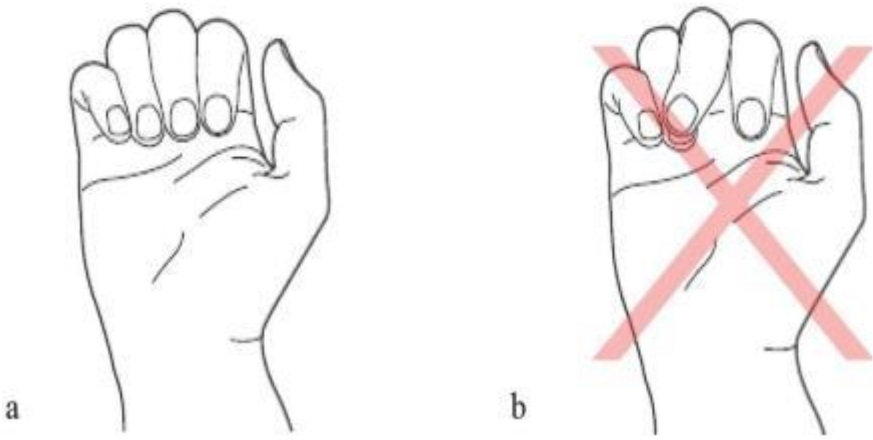

Fig. (6): Rotation assessment a) rotationally aligned, b) rotationally malaligned. **(45)**

For prober fixation, lag screws should be inserted perpendicularly to the fracture plane. Tightening a screw that is not perpendicular to the fracture plane risks fracture displacement. **(Fig.7)** Lag screws are inserted with a gliding hole in the near cortex, and a thread hole in the far cortex. Inserting a screw across a fracture plane that is threaded in both cortices will hold the fragment apart and apply no inter fragmentary compression. A minimal distance between the apex of the fracture and the screw head, equal to the screw head diameter, must be observed. Screws should not be inserted too close to the fracture apex. **(Fig.8).** There are two important reasons for countersinking. The risk of soft tissue irritation is greatly reduced. Countersinking ensures that the screw head has a maximal contact area with the bone, distributing the forces from the screw head more widely than a non sunk head **(45)**.

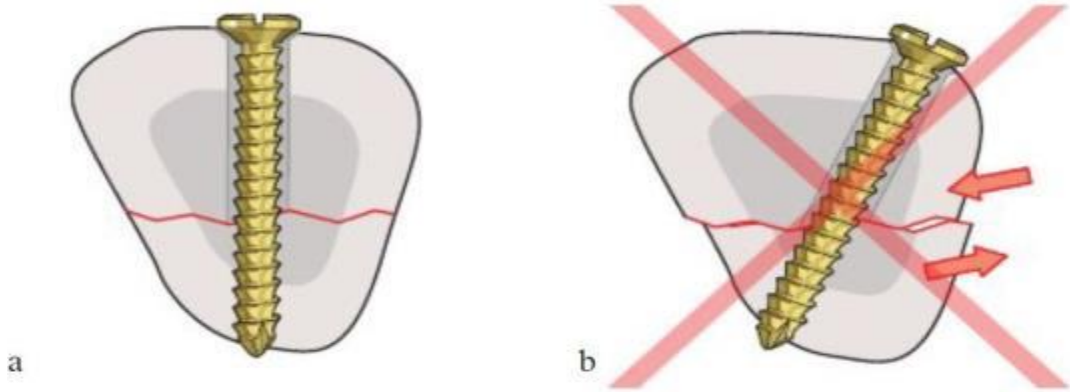

Fig.(7): Screw direction; A) perpendicular on fracture B) Not perpendicular on fracture. **(45)**

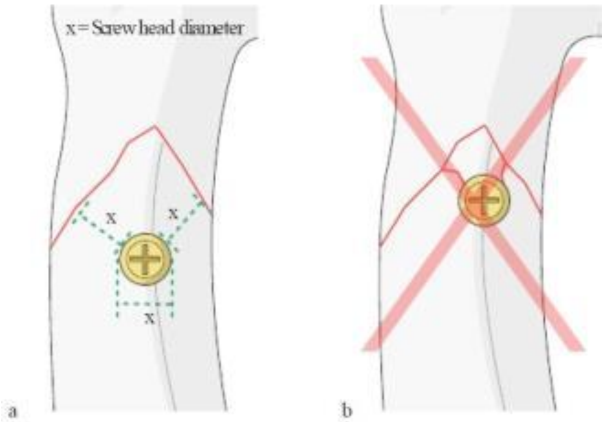

Fig.(8): Screw position; A) Far enough from fracture apex B) Near fracture apex. **(45)**

- **Tension band wiring (TBW)**

The use of tension band principles was introduced by **Segmuller (46)**. It was applied to fracture surgery by **Weber (44)** and further developed by **Meyer (47)**. 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 **(48) (Fig.9).**

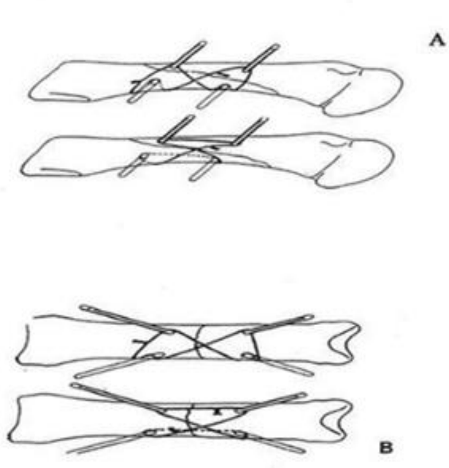

Fig. (9): Technique of tension band wiring.**(44),** A-Long oblique and spiral fractures, B-Transverse and short oblique fractures.

- **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 **(49)**, without jeopardizing bony union. Ideal indications are oblique or torsion fractures of the metacarpals **(50)**.

- **Expandable 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 **(51) (Fig.10)**.

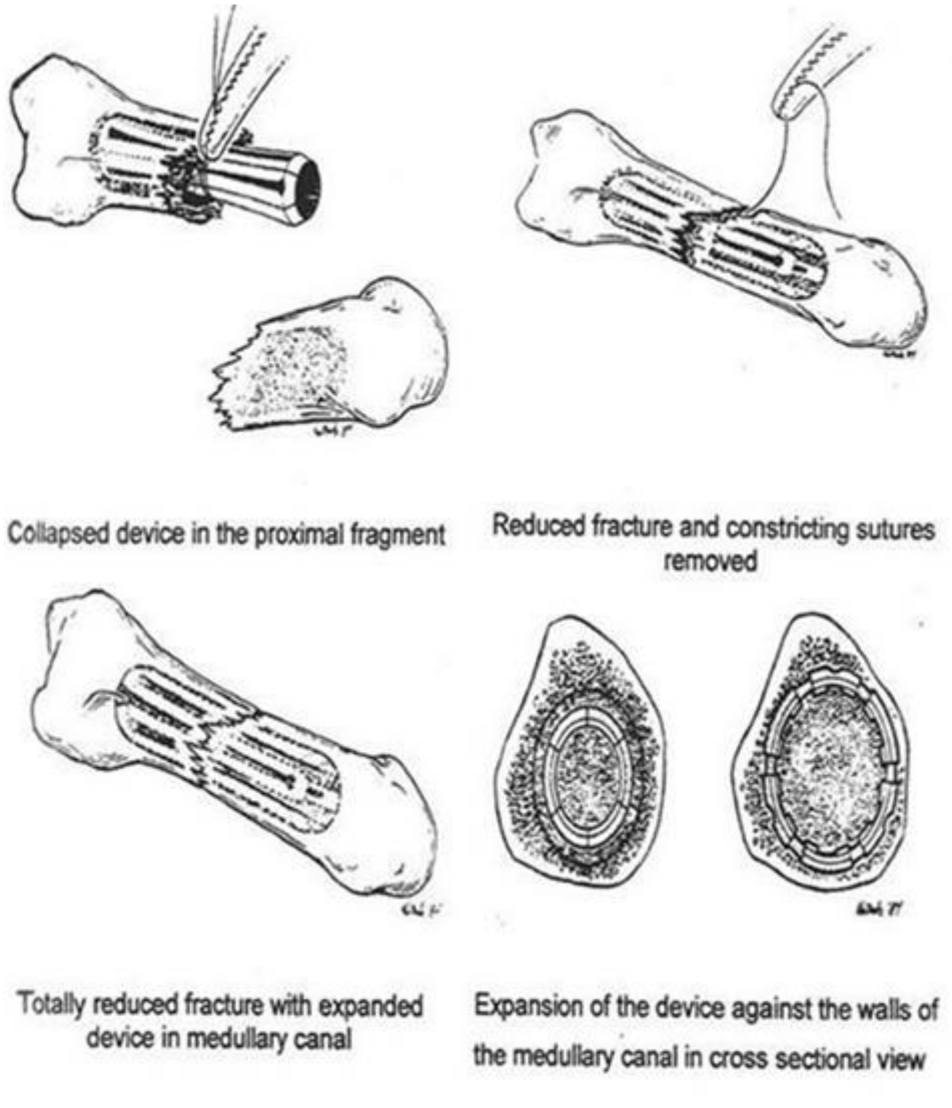

Fig. (10): Technique of fixation with expandable intramedullary device. **(52)**

External fixator:

External fixation with mini-external fixator, a technique originated by Jaquit, was developed for soft tissue and skeletal support in severe hand injuries **(53,54)**. Classical indications include the treatment of open fractures and osteomyelitis. Furthermore, fractures with considerable soft tissue damage and comminuted fractures may be included **(55)**.

Schuind et al. (56) believed that the indications of external mini-fixator could be enlarged to closed metacarpal bone fractures. It also plays an important role in stabilization of periarticular fractures with secure fixation after reduction **(57)**.

External stabilization with the mini-fixator combines the advantages of effective stabilization with a minimally invasive technique. With closed reduction of the fracture the key advantages of conservative fracture treatment is realized **(58)**.

Contraindications for the use of mini-fixators in hand fractures are the same as for external fixation in general. This includes severe osteoporosis, HIV infection and patients with poorly controlled diabetes. Patients with poor compliance are also not suitable for this method **(55)**.

Barton's axiom **"the best way to make the hand work is to make the hand work"** is achievable with this method **(59).**

Rehabilitation:

Functional recovery and minimizing morbidity are the fundamental goals of rehabilitation. Early digital motion and tendon gliding exercises are important. Elevation augments digital motion by diminishing and resolving swelling and edema and consequently decreasing resistance to tendon gliding and joint motion. Progress is guided by soft tissue response, fracture stability, and the patient's pain tolerance. Fracture stability limits pain and allows more rapid and intense implementation of exercises **(60)**.

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