FUNCTIONAL OUTCOME OF CLOSED METACARPAL FRACTURES TREATED WITH MINI FRAGMENT PLATES AND SCREWS

A PROSPECTIVE STUDY

DISSERTATION SUBMITTED FOR

MASTER OF SURGERY DEGREE EXAMINATION

BRANCH II – ORTHOPAEDIC SURGERY

2014

THE TAMIL NADU

DR. MGR MEDICAL UNIVERSITY

CHENNAI, TAMIL NADU

CERTIFICATE

This is to certify that the work entitled **Functional Outcome Of Closed Metacarpal Fractures Treated With Mini Fragment Plates And Screws - A Prospective Study** which is being submitted for M.S. Orthopaedics, is a bonafide work of **Dr.V.MOHANAKRISHNAN**, PostGraduate Student at Department of Orthopaedics, Madurai Medical College, Madurai.

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Madurai Medical College

Madurai

CERTIFICATE

This is to certify that the work entitled **FUNCTIONAL OUTCOME OF CLOSED METACARPAL FRACTURES TREATED WITH MINI FRAGMENT PLATES AND SCREWS - A PROSPECTIVE STUDY** which is being submitted for M.S. Orthopaedics, is a bonafide work of **Dr.V.Mohanakrishnan**, Post Graduate Student at Department of Orthopaedics, Madurai Medical College,Madurai.

He has completed the necessary period of stay in the Department and has fulfilled the conditions required for the submission of this thesis according to the University regulations. The study was undertaken by the candidate himself and the observations recorded have been periodically checked by us.

Recommended and forwarded

Prof. V. PUGALENTHI
Prof. & HOD, Dept. Of Orthopaedics,
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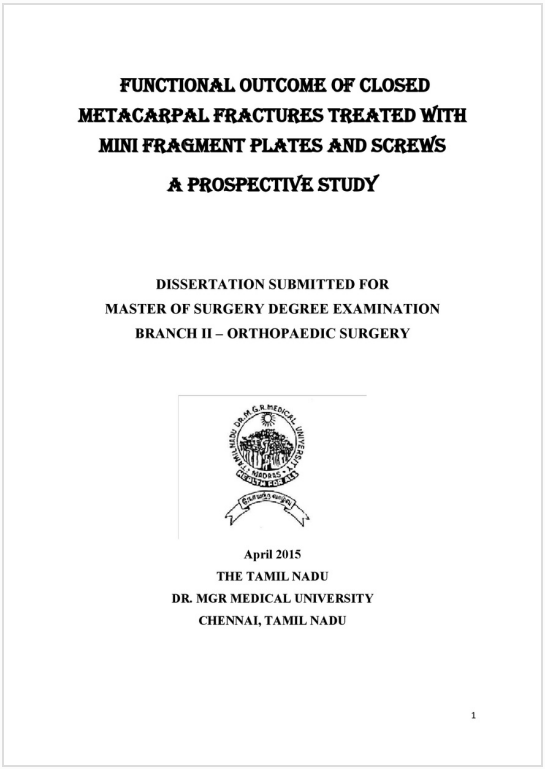

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FUNCTIONAL OUTCOME OF CLOSED METACARPAL FRACTURES TREATED WITH MINI FRAGMENT PLATES AND SCREWS - A PROSPECTIVE STUDY

Abstract:

Background: Accurate open reduction and internal fixation of metacarpal fractures are required in unstable fractures where closed treatment technique yield poor functional outcome which usually is less than 5% of hand fractures. Minifragment plates and screws when used in properly selected cases provide rigid fixation allowing early mobilisation of joints and hence good functional outcome.

Patients and methods: In 20 patients with closed unstable metacarpal fractures treated with minifragment plates and screws , functional outcome was assessed using American society for surgery of the hand (ASSH) total active flexion (TAF) score over a period of two years in prospective manner.

Results: In our study of unstable metacarpal fractures treated with plate osteosynthesis all the cases showed bone union (100%). The functional result is excellent in 80% of the patients (16 of 20 cases), good in 10% of cases (2 of 20 cases), poor in 10% of cases(2 of 20 cases). 2 patients developed superficial wound infection which settled with daily dressing and antibiotics and this does not affect the final outcome.

Conclusions: Plate and screw fixation is a good option for treating closed unstable metacarpal fractures, where other modalities of fixation are less effective, the rigid stable fixation provided by plating withstands load without failure allowed early mobilization and achieved good functional results.

Key words: metacarpal fracture, minifragment plate and screws, internal fixation.

ACKNOWLEDGEMENT

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I take this opportunity to express my deep sense of gratitude although I find words inadequate to express the greatness of **Prof. V. PUGALENTHI**, Prof. and Head of the Department of Orthopaedics, Madurai Medical College who has been a pillar of discipline, courage and immense kindness and who was instrumental in guiding me throughout the course of this thesis. I consider myself fortunate and privileged to work under his affectionate guidance, superb supervision and sustained support.

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Last, but not the least, I extend my thankfulness to all the patients who have participated in this study. But for their co-operation this exercise would have been futile.

PART A

PART B

ABBREVATIONS

ASSH	American Society for Surgery of the Hand
DIPJ	Distal Inter Phanlangeal Joint
IPJ	Inter Phalangeal Joint
K wire	Kirschner wire
PIPJ	Proximal Inter Phalangeal Joint
POSTOP	Post – Operative
PREOP	Pre – operative
ROM	Range Of Movements
RTA	Road Traffic Accident
TAF	Total Active Flexion

PART A

INTRODUCTION

Fractures of bones of the hand are among the commonest fractures in humans, but their management varies widely in the different regions of the world. This variability is due to many reasons, including availability of resources, social factors, geographic constraints, surgeon preference and experience, and local practice patterns. Developing countries are more likely to apply less expensive methods of managing hand fractures**.**

Fractures of the metacarpal bones of the hand constitutes between 14-28% of all visits to the hospital following trauma by various means like assault, road traffic accidents, industrial accidents, agricultural accidents etc[(1)].

Too often these metacarpal fractures are neglected or treated as minor injuries and results in major disability and deformity with permanent disability and handicap [(2, 3)].

Hand fractures can be complicated by deformity from no treatment, stiffness from over treatment and both deformity and stiffness from poor treatment [(4)]. Fracture healing in the hand is not an isolated goal rather the functional result is of paramount importance [(5)].

Recent studies have shown good functional results with surgical treatment of metacarpal fractures using miniplates and screws as compared to the

conservative treatment or K –wire fixation. This study involves evaluating functional outcome of metacarpal fractures treated with miniplates and screws [6].

ANATOMY OF METACARPALS [7]

Metacarpals are 5 miniature cylindrical long bones of hand. They are numbered from lateral to medial side. Parts of metacarpal are 1. Base or carpal extremity, 2. Body or shaft , 3. Head or digital extremity

Base of metacarpal:

It is cuboid. Its dorsal and volar surfaces are rough for attachment of ligaments. It articulates with distal carpal bones and adjacent metacarpals.

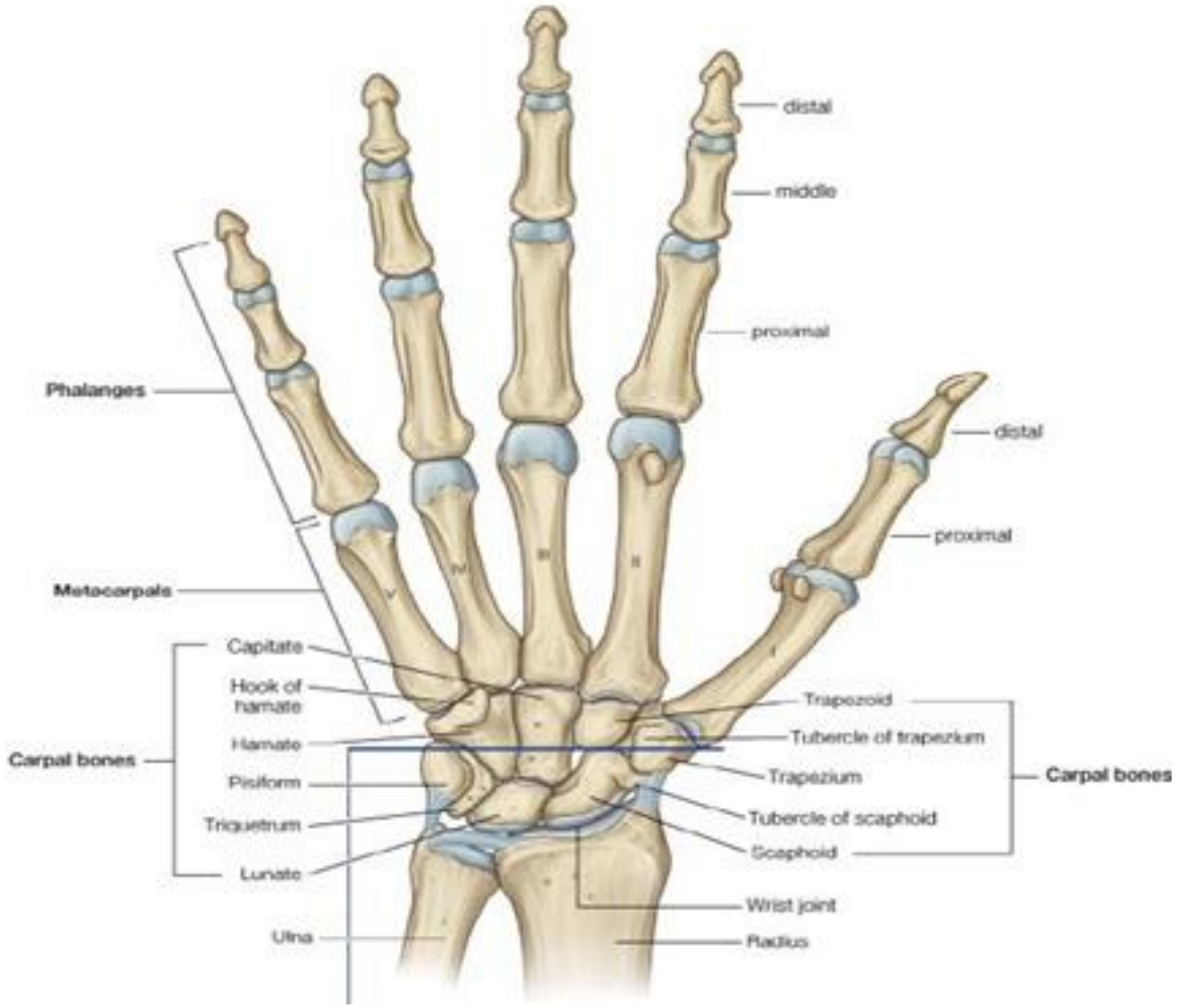
Body:

It is prismoid and longitudinally curved with dorsal surface is convex palmar surface is concave, it has three surface – medial, lateral and dorsal surface. Medial & lateral surfaces are concave where interossei muscles are attached and separated by anterior ridge which is prominent. Dorsal surface is smooth and convex. It is covered by tendons of extensor muscle.

Head :

It is oblong, broader extends upward on volar aspect than on dorsal aspect. The tubercle on either side gives attachment to collateral ligaments of metacarpo-phalangeal ligaments. Dorsal surface is smooth and support extensor tendons, volar surface is grooved for flexor tendons. It articulates with base of proximal phalanx.

Characteristics of individual metacarpals:



Anatomy Of Metacarpals

First metacarpal /metacarpal of thumb:

Short and stout, diverges from carpal bones, rotated 90 degree medially relative to other metacarpal bones thus helps in opposition. It does not articulate with other metacarpals. Opponens pollicis is inserted to its lateral side. Medial border gives attachment to lateral head of first dorsal interossei.

Second metacarpal/metacarpal of index finger:

Longest and has larger base than other metacarpals. Flexor carpi radialis is attached to its volar surface of the base. Extensor carpi radialis longus is inserted to its dorsal surface of the base.

Third metacarpal /metacarpal of middle finger

A little shorter than second. Extensor carpi radialis brevis is attached to dorsal surface of its base.

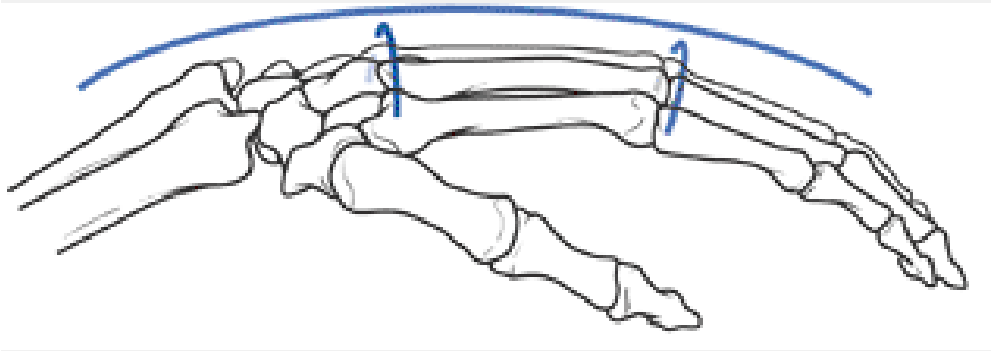
Fourth metacarpal/metacarpal of ring finger:

It is shorter than third. Its base articulates with hamate and capitates proximaly, lateral side for third metacarpal and medial side for fifth metacarpal.

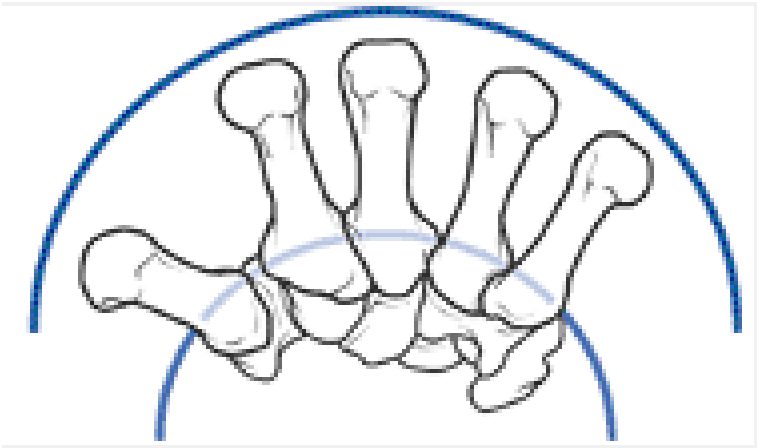
Fifth metacarpal/metacarpal of little finger:

Base has elongated articular side for fourth metacarpal. Medial side is non articular and bears tubercle.

Metacarpals are key elements in forming three arches of hand. These are two transverse arches one at carpo-metacarpal joint level, other at metacarpo-phalangeal level. Third is longitudinal arch with broad convex dorsal surface formed by the metacarpals themselves.



LONGITUDINAL ARCH OF METACARPAL



TRANSVERSE ARCH AT CARPOMETACARPAL AND METACARPOPHALANGEAL JOINTS

Intramedullary geometry is highly variable with volar cortex is 20% thicker. Access to metacarpal is easy through incision over intermetacarpal valleys. Metacarpals are tightly bound by strong interosseious ligament at their bases and deep transverse intermetacarpal ligaments distally. These ligaments maintain transverse arches and limits shortening in metacarpal fractures. A 2mm of shortening can cause 7 degrees of extensor lag. Metacarpal is weakest at neck where comminution is more common.

Ossification [7]:

Metacarpal shaft has one primary centre of ossification appearing at 9th week of development. Base of first metacarpal develops from secondary centre of ossification appearing at 2-3 yr and fuses with shaft at about 16-18 years. Head of second to fifth metacarpal develops from secondary centre appearing at 2-3 year and fuses with shaft at about 16-18 years.

Intrinsic muscles of hand [7]:

There are 20 intrinsic muscles in the hand that serve the function of adjusting the hand during gripping and carry out skilled movements of the hand. The origin and insertion of these muscles are within the territory of the hand.

These are

1. **Four thenar muscles:**
    a. Abductor pollicis brevis – abducts the thumb.
    b. Flexor pollicis brevis – flexes metacarpophalangeal joint of thumb
    c. Opponens pollicis – opposes the thumb towards the medial four fingers

    These three thenar muscles are innervated by median nerve.
    d. Adductor pollicis – adducts the thumb and is innervated by deep branch of ulnar nerve
2. **Four hypothenar muscles:**
    a. Abductor digiti minimi – abducts the little finger
    b. Flexor digiti minimi – flexes the little finger
    c. Opponens digiti minimi – pull forward the 5^{th} metacarpal as in cupping the palm

    These three hypothenar muscles are innervated by deep branch of ulnar nerve

d. Palmaris brevis – wrinkles skin thus improving the grip of palm and is innervated by superficial branch of ulnar nerve

3. Lumbricals:

They are four in number and arise from tendons of flexor digitorum profundus and flex the metacarpophalangeal joints and extends the interphalangeal joints of 2nd to 5th digits. 1st and 2nd lumbricals are innervated by median nerve while the 3rd and 4th lumbricals are innervated deep branch of ulnar nerve.

4. Palmar interossei:

They are four in number and adduct the fingers towards the centre of middle finger and is supplied by deep branch of ulnar nerve.

Origin and insertion:

1st palmar interossei – arises from medial side of base of 1st metacarpal and is inserted into the medial side of base of proximal phalanx of thumb.

2nd palmar interossei - arises from medial side of base of 2nd metacarpal and is inserted into the dorsum of base of distal phalanx of index finger via extensor expansion.

3rd palmar interossei – arises from lateral side of 4th metacarpal and is inserted into the dorsum of base of distal phalanx of ring finger via extensor expansion.

4^{th} palmar interossei – arises from lateral side of 5^{th} metacarpal and is inserted into dorsum of base of distal phalanx of little finger via extensor expansion.

5. <u>Dorsal interossei:</u>

They are four in number and abduct the fingers from centre of the middle finger. In addition, it flexes the metacarpophalangeal joints and extends the interphalangeal joints. These are innervated by deep branch of ulnar nerve.

<u>Origin and insertion:</u>

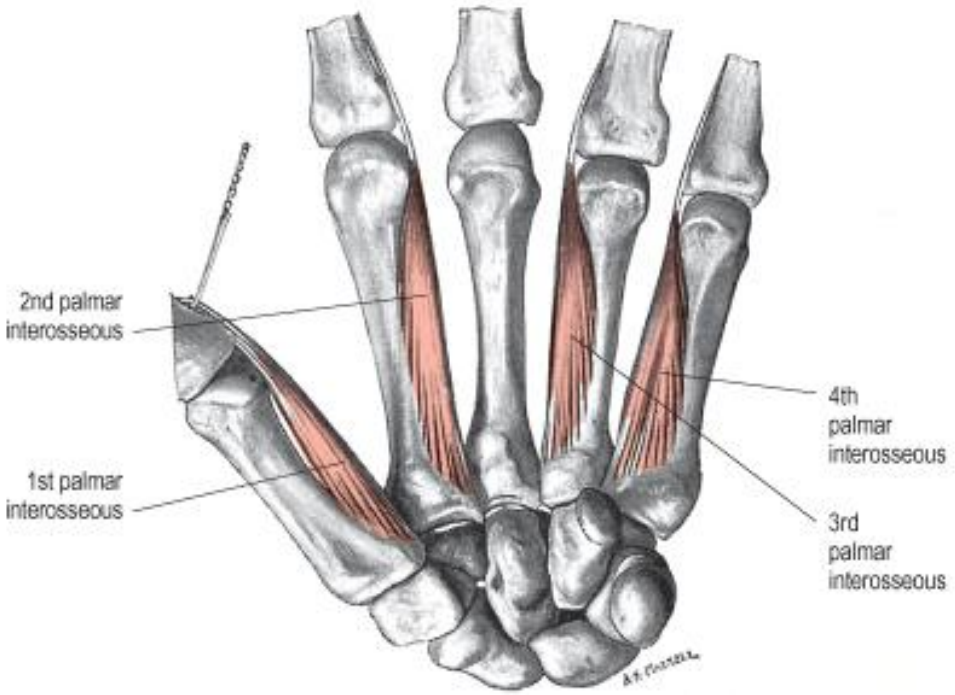
1^{st} dorsal interossei – arises from adjacent sides of 1^{st} and 2^{nd} metacarpals

2^{nd} dorsal interossei – arises from adjacent sides of 2^{nd} and 3^{rd} metacarpals

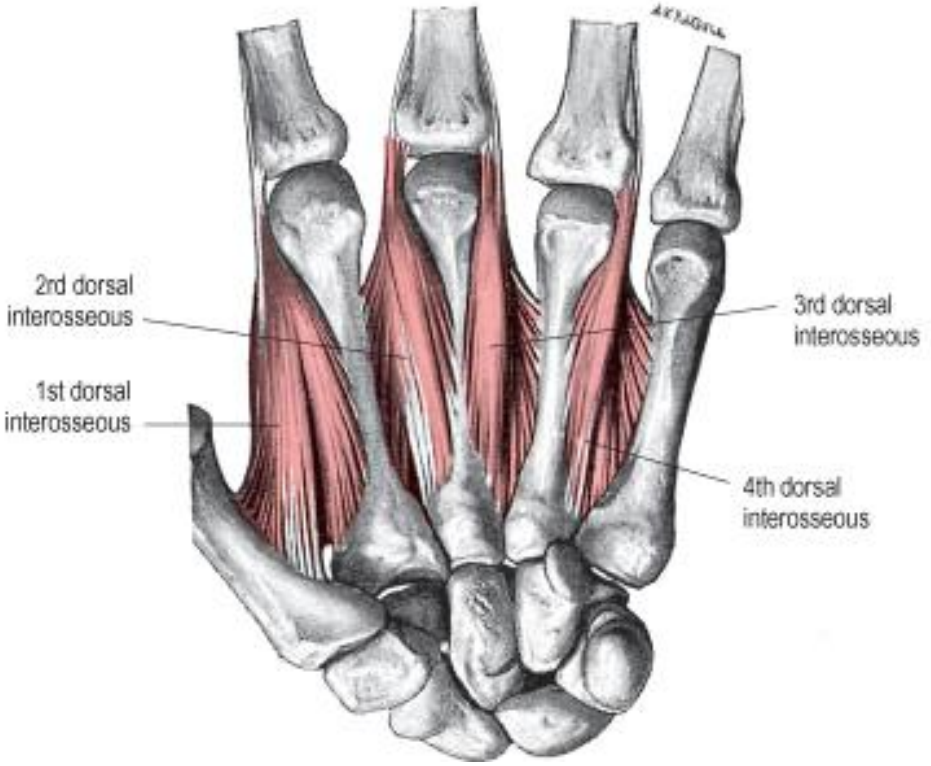
3^{rd} dorsal interossei – arises from adjacent sides of 3^{rd} and 4^{th} metacarpal

4^{th} dorsal interossei – arises from adjacent sides of 4^{th} and 5^{th} metacarpal

All these four dorsal interossei are inserted into dorsum of base of distal phalanx of 2^{nd}, 3^{rd} and 4^{th} digits via extensor expansion.



PALMAR INTEROSSIE



DORSAL INTEROSSEI

ARTERIAL SUPPLY OF HAND:

Vascular supply of hand is by terminal branches of ulnar and radial arteries. Volar aspect of hand is supplied by superficial and deep palmar arch.

Superficial palmar arch:

It is formed by direct continuation of ulnar artery (superficial palmar branch) and joined on lateral side by superficial branch of radial artery. It gives four digital branches for medial three and half fingers and lateral three digital branches joined by palmar metacarpal arteries arising from deep palmar arch.

Deep palmar arch:

It forms the 2nd channel connecting the radial and ulnar arteries in the palm and is situated deep to long flexor tendons. It is formed by terminal part of radial artery and completed medially by deep palmar branch of ulnar artery. It gives off

a. Three palmar metacarpal arteries that supply medial four metacarpals
b. Three perforating arteries that passes through medial three interosseous spaces with dorsal metacarpal arteries.
c. Recurrent branch which arises from concavity of the arch and passes proximally and supplies carpal bones and joints.

Dorsum of hand – is supplied by branches of radial artery and includes

a. 1st dorsal metacarpal artery
b. Princeps pollicis artery
c. Radialis indicis artery

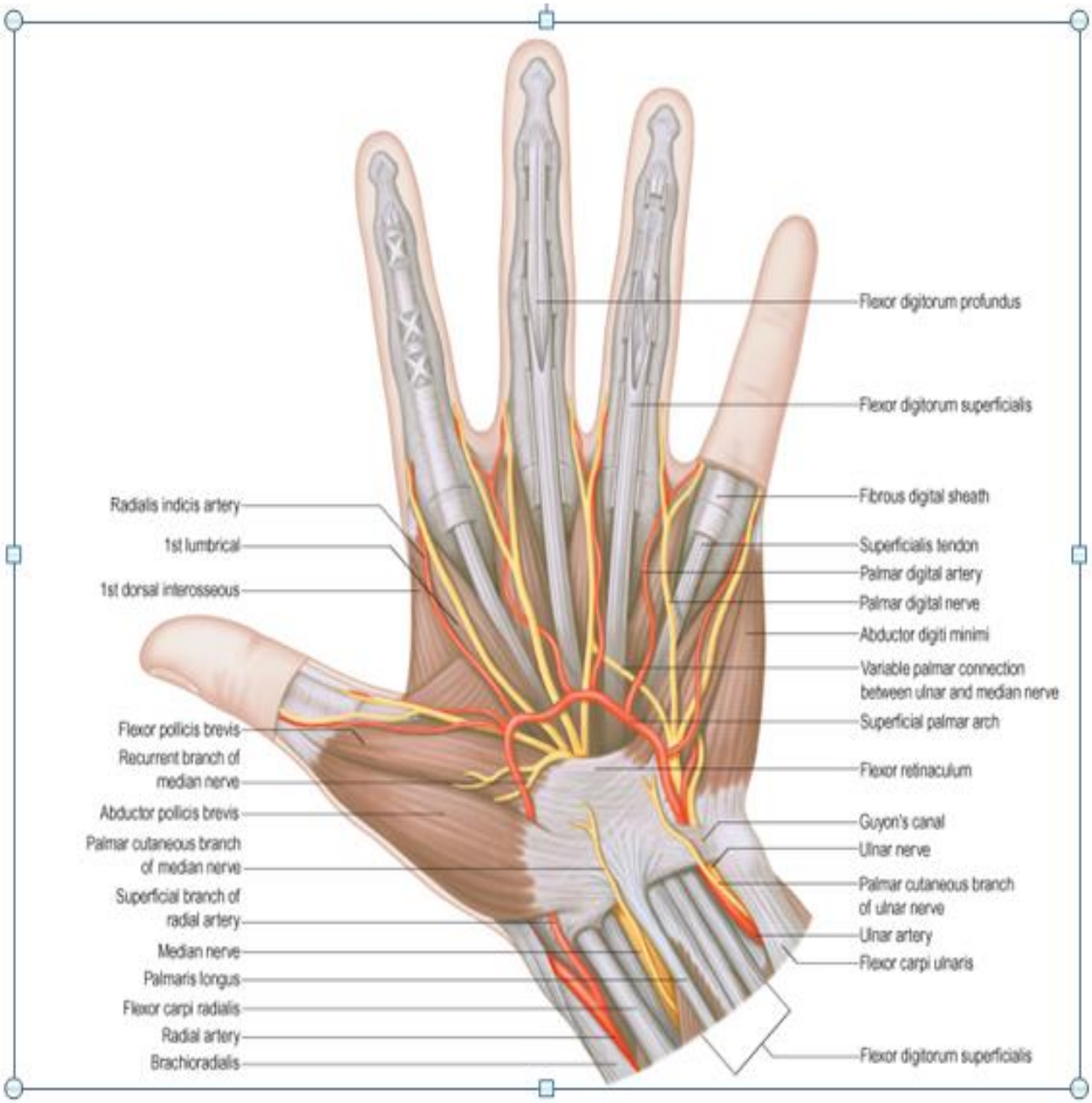
Nerve supply of hand:

1. Ulnar nerve – It is also known as musician's nerve. It gives of two primary branches – superficial and deep branch.

   Superficial branch – is cutaneous. It gives muscular branch to Palmaris brevis and cutaneous branch to medial one and half fingers.

   Deep branch – it gives muscular branch that supplies muscles of hypothenar eminence, medial two lumbricals, both palmar and dorsal interossei and adductor pollicis. It gives articular branch that supplies the wrist joint.
2. Median nerve – It is also known as labourer's nerve. It controls the movement of the thumb which is crucial in the mechanism of gripping by hand. It gives muscular branch to all thenar muscles except adductor pollicis and 1st and 2nd lumbricals. It gives sensory branch to lateral three and half digits.
3. Radial nerve – Superficial branch of radial nerve gives four digital branches that supply the skin of digits and lateral and medial side of thumb, lateral side of index finger.

BLOOD SUPPLY AND NEVE SUPPLY OF HAND



BIOMECHANICS OF METACARPAL FIXATION [9,10]:

1. Interfragmentary screw is biomechanically effective tool alone or with plates in resisting failure loads same as intact bone
2. Self-tapping screws are as strong as standard screws avoiding a separate step
3. Plate functions as tension band. Thus placed on dorsal surface in metacarpal fracture
4. Interosseous wire construct placed in orthogonal planes is not improved with addition of k wires and is the only construct which can compete with plates and screws.
5. Interosseous wires are stronger than k wires but less rigid than plates and screws
6. Modern plating tolerate loads better allowing full active motion and rehabilitation
7. Locking intramedullary nails are used in special cases like gunshot wounds
8. External fixators can be applied for open fractures

LITERATURE REVIEW

Fractures of metacarpals

Metacarpal and phalangeal fractures are most common fractures of upper extremity. 70% of these fractures commonly occur between the ages of 10-45 yrs. Early in 20th century these fractures were all managed nonoperatively. Operative fixation of hand fractures was limited for the past 4 decades. Today most fractures are managed successfully by non operative modalities as most fractures are functionally stable before and after closed reduction and are well managed with protective splint and early mobilization. Only a certain fractures required operative fixation which depends on many factors like [8]:

a) Fracture geometry – transverse, oblique, spiral or comminuted
b) Fracture location – extra articular or intra articular
c) Fracture with deformity – angular, rotational or shortening
d) Whether the fracture is open or closed
e) Associated osseous and soft tissue injury
f) Intrinsic fracture stability
g) Additional factors like patient age, occupation, socio economic status, systemic illness and patient compliance

In spite of numerous treatment modalities SWANSON states [11]

"Hand fractures can be complicated by deformity from no treatment, stiffness from overtreatment, both deformity and stiffness from poor treatment"

Increased popularity of operative treatment at present are due to the following reasons [12]

1) Improved designs of implants and materials
2) Availability of self tapping and miniature screws of 1mm diameter that can be placed percutaneously
3) Availability of low profile plates which are easy to contour and cut but can withstand sufficient loads
4) Better understanding of biomechanical principle of internal fixation
5) Demanding public expectations
6) Availability of improved radiographic imaging by cross section CT permitting multiplanar analysis of fracture
7) Availability of hand specialist and hand therapist

In general, risk of permanent stiffness should be prevented by avoiding prolonged immobilization. However, aggressive attempts of internal fixation leads to tendon adhesion, soft tissue damage, infection and need for implant removal.

Ultimate outcome depends on judicious selection of cases for operative fixation which gives better outcome than non operative management .

Indications for operative fixation of metacarpal fixation includes [8]:

1) Displaced fracture like angulated transverse fracture, malrotated oblique and spiral fracture, shortened comminuted fractures
2) Intra articular and peri articular fractures
3) Open fracture
4) Fracture with segmental bone loss
5) Multiple hand fractures
6) Fracture associated with soft tissue injury like vessel, tendon, nerve and skin

METACARPAL HEAD FRACTURES

These are rare intra articular fractures and these fractures are usually comminuted. They are more common in index metacarpal because of relatively immobile carpometacarpal joint. These are usually associated with complex dorsal metacarpophalangeal dislocation [13].

Radiological evaluation is done with AP, lateral and oblique view. Special view called Brewerton view is used to asses fracture geometry. Brewerton view is taken with metacarpophalangeal joint flexed to 65 degrees and dorsum of fingers lying flat on x ray plate and x ray tube angled to 15 degrees in ulnar to radial direction. This view gives better appreciation of articular contour.

TREATMENT

Usually these fractures are treated by open reduction and internal fixation

1) Osteochondral and avulsion fractures are treated with open reduction and internal fixation with a single lag screw placed through dorsal approach
2) Comminuted intraarticular fractures with metaphyseal impaction are managed by skeletal traction. But this treatment modality is associated with complication like stiffness from extensor tendon adhesion and avascular necrosis of head (common in index and middle fingers)

METACARPAL NECK FRACTURES

Also known as boxers fracture. But it is a misnomer since it is rarely seen in professional boxers and is more commonly seen in people who hit against solid objects.

This fracture presents with problems of

a) palpable metacarpal head in palm
b) decreased range of motion
c) loss of metacarpal head prominence

The classic deformity in metacarpal neck fractures is dorsal angulation of apex due to:

a) impaction occurs on dorsum of head
b) more comminution in volar aspect
c) action of intrinsic muscle on volar aspect causing flexion of metacarpal head

TREATMENT

Depends on following factors:

a) Rotational deformity – least tolerated by index and middle metacarpal than ring and little finger metacarpal because of relatively immobile carpometacarpal joint of index and middle finger

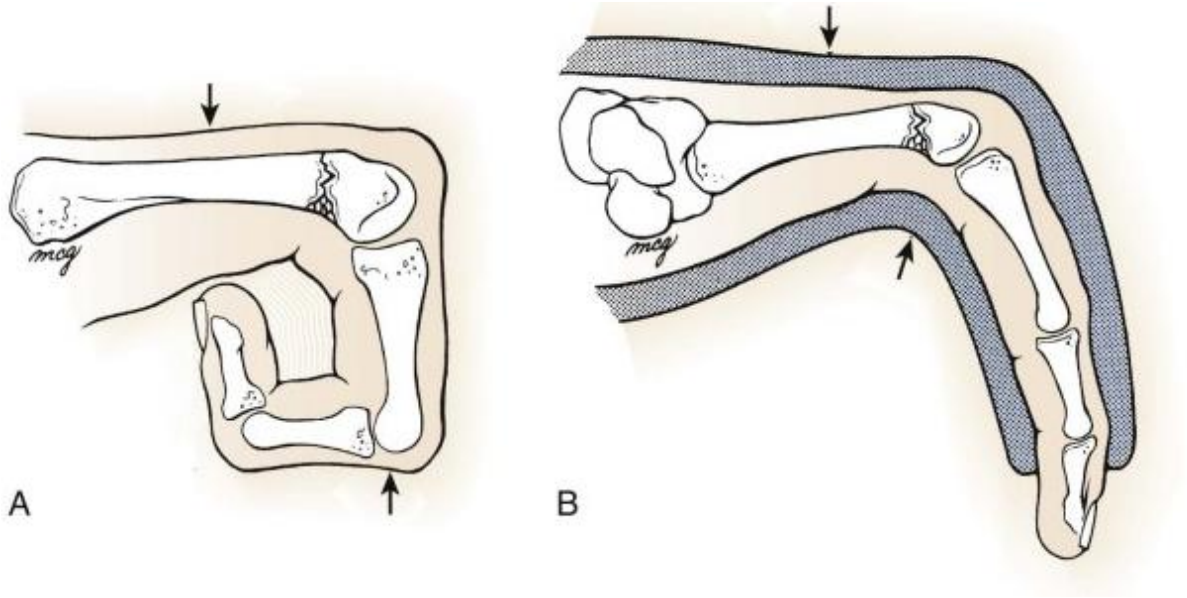
b) Angular deformity - up to 40 degrees is tolerated by little and ring finger whereas 10-15 degree of angulation is not accepted in index and middle metacarpals

Various treatment modalities:

1) Closed reduction and cast immobilization
2) Closed reduction and percutaneous pinning
3) Closed reduction and antegrade intramedullary fixation – bouquet osteosynthesis
4) Open reduction and internal fixation with mini condylar blade plate osteosynthesis

Reduction maneuver of metacarpal neck fracture – JAHSS MANEUVER [14]

Metacarpal neck fracture is reduced by closed method by flexing the metacarpophalangeal joint to 90 degrees which relaxes intrinsic muscle and tight collateral ligaments then proximal phalanx is pushed dorsally against metacarpal head thus correcting dorsal angulation [14].



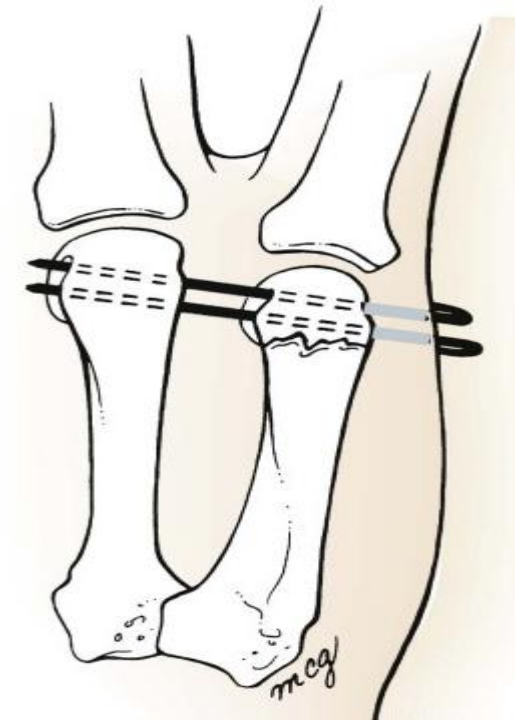
JAHSS MANOEVER

Closed reduction and cast immobilization:

Reduction is done by Jahss maneuver followed by application of ulnar gutter splint with metacarpophalangeal joint flexed in 90 degree and interphalangeal joints in extension (intrinsic plus position)

Closed reduction and K wire stabilization:

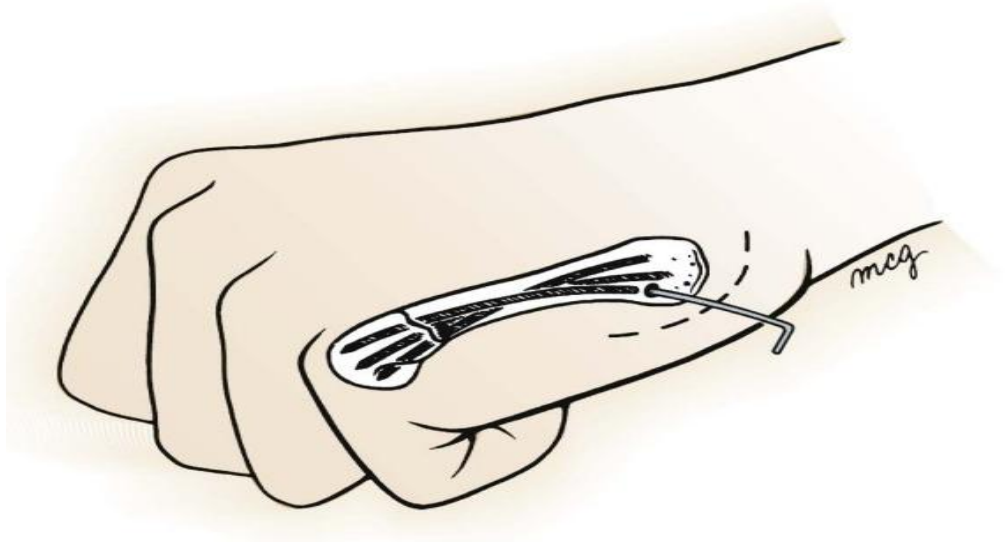
Closed reduction done by Jahss maneuver and reduction stabilized with K wire applied longitudinal or criss cross fashion or transverse fixation to adjacent metacarpals; this treatment is less rigid and requires some external immobilization for 3 weeks and complications include pin migration, pin tract infection and pin protrusion and less rigid fixation .



TRANSFIXATION K-WIRE

Closed reduction and antegrade intramedullary fixation (Bouquet osteosynthesis) [15]

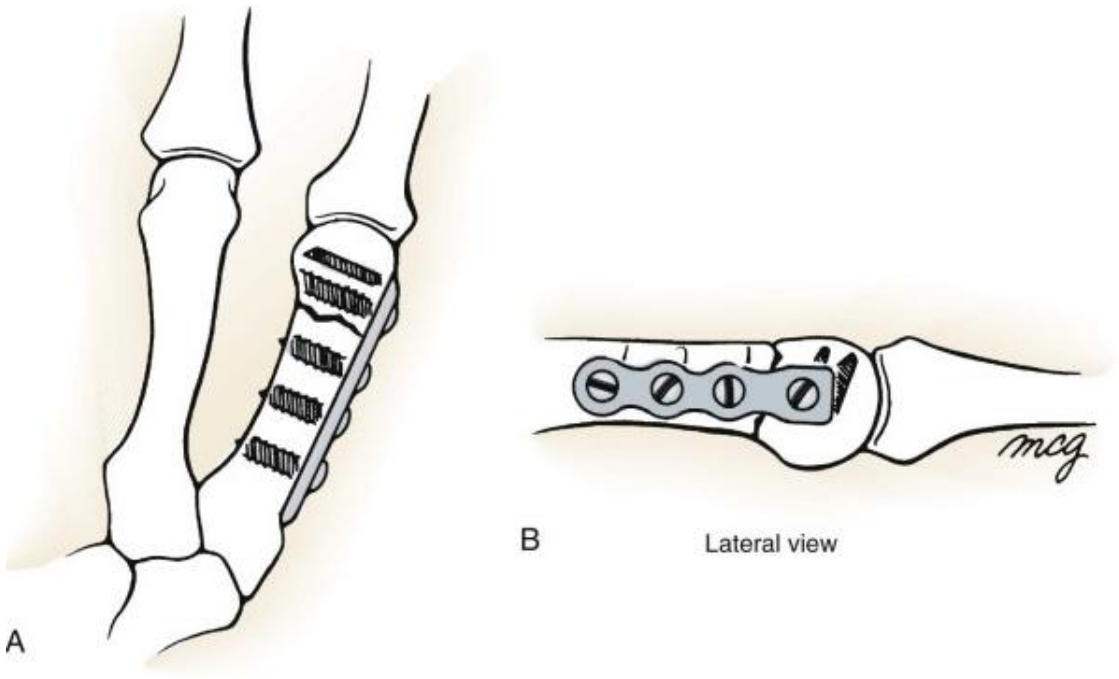
Here, 3 prebent K wires are passed in antegrade manner through proximal metaphysis of metacarpal. This technique is relatively stable than percutaneous K wire fixation but is associated with complication like articular surface damage and neuritis due to ulnar sensory nerve.



INTRAMEDULLARY FIXATION

Open reduction and internal fixation with mini condylar blade plate [16]:

This is indicated in irreducible fractures with angular and rotational malalignment.



MINI CONDYLAR BLADE PLATE

Usually metacarpal neck fractures are managed by closed reduction and cast immobilization. Operative treatment is indicated in the following situation :

1. Dorsal angulation greater than 70 degrees
2. Any rotational malalignment
3. Open fractures
4. Pseudoclawing – here there is compensatory hyperextenson of metacarpophalangeal joint with flexion of interphalangeal joints due to excessive metacarpal neck flexion.

METACARPAL SHAFT FRACTURES

Metacarpal shaft fractures are classified based on the fracture configuration

1) Transverse #
2) Oblique and spiral #
3) Comminuted #

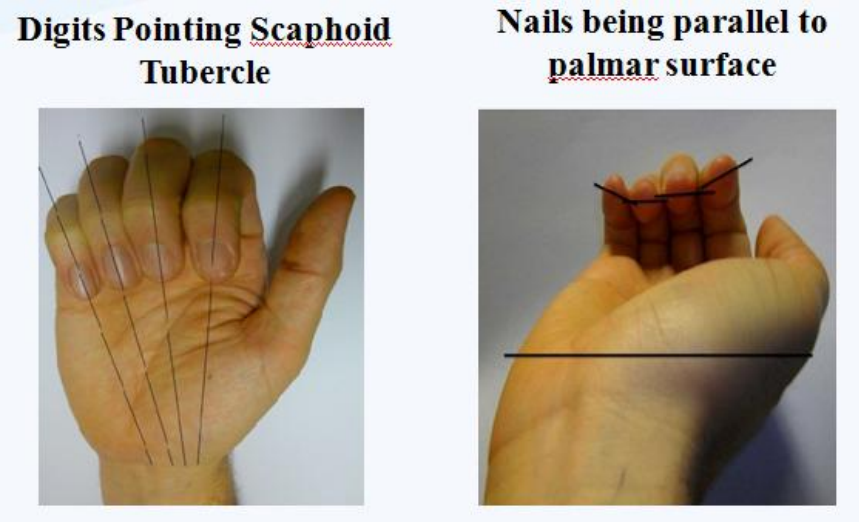
1) TRANSVERSE FRACTURES

Transverse fractures are due to the result of axial loading mechanism and presents with classic deformity of dorsal apex angulation due to deforming force by interosseous muscle. Reduction is needed when the angulation is more than 30 degree for little finger and more than 20 degree for ring finger and any amount of angulation for middle and ring finger

2) OBLIQUE AND SPIRAL FRACTURES

These are due to torsional force mechanism and presents with classical deformity of rotational malalignment. This rotational malalignment is poorly tolerated and are hardly assessed by plain radiograph. This rotational malalignment is evident only by clinical examination by clenching the fist. In

normal patients the clenched fist shows all fingers pointing towards the scaphoid tubercle [17] or assessed by scissoring of fingers. In case of oblique and spiral fractures the rotational malalignment is assessed by scissoring of fingers



3) COMMINUTED FRACTURES

These are due to end result of direct impact and usually associated with soft tissue injury and presents as shortening of the finger.

MANAGEMENT:

Treatment options include:

1) Closed reduction and plaster immobilization
2) Closed reduction and percutaneous pinning
3) Open reduction and K wire stabilization

4) Open reduction with tension band or composite wiring
5) Open reduction with cerclage and interosseous wiring
6) Open reduction with intramedullary fixation
7) Open reduction with interfragmentary screw fixation
8) Open reduction with plate osteosynthesis
9) Open reduction with bio absorbable fixation
10) External fixation

1) CLOSED REDUCTION AND PLASTER IMMOBILIZATION

Most of the metacarpal fractures are inherently stable and can be treated with cast immobilization when there is no rotational malalignment on clinical examination. Usually a short arm cast is applied where the wrist is held in 30-40 degree of extension and metacarpophalangeal joint flexed to 80-90 degrees and interphalangeal joints extended with additional buddy strapping helping in controlling rotation. This position of immobilization is called INTRINSIC PLUS POSITION OR CLAM DIGGER POSITION [(18)]. This position of immobilization relaxes the intrinsic muscles and has limited incidence of joint contractures .

CLAM DIGGER CAST

2) CLOSED REDUCTION AND PERCUTANEOUS PINNING

This treatment modality is applied in unstable metacarpal fracture. Here an awl is used to make a cortical window at the base of the metacarpal distal to the carpometacarpal joint. 3-4 prebent K wires (30 degree) are inserted and buried into the medullary canal. Alternatively transverse K wires are inserted after reduction by transfixing to the adjacent uninvolved metacarpals. These transverse transfixation K wires are equal in stiffness to the plates and screws. The advantages of percutaneous K wiring are, they are easy to insert, requires minimal dissection but lacks rigidity. The pin may get loosened and distract the fracture and may be associated with pin tract infection and may require additional external support in the form of splinting for initial 3 weeks.

OPEN REDUCTION

Open reduction is indicated in less than 5% percent of metacarpal and phalangeal fractures where closed manipulation fails [19]. Various definitive indications for open reduction are:

1) An unstable fracture: Border metacarpals are more unstable due to lack of adjacent soft tissue support on both sides. Rigid fixation is not necessary but stable fixation is necessary for early rehabilitation
2) Malaligned fractures: The rotational malalignment in spiral and oblique fractures is unacceptable which cannot be corrected by closed technique where an open reduction is needed
3) Multiple metacarpal fractures: Here the stabilization effect of adjacent metacarpal is lost thus requiring open reduction
4) Open fractures where there is bone loss, contamination and soft tissue injury

Regarding the displacement, dorsal angulation results in the following:

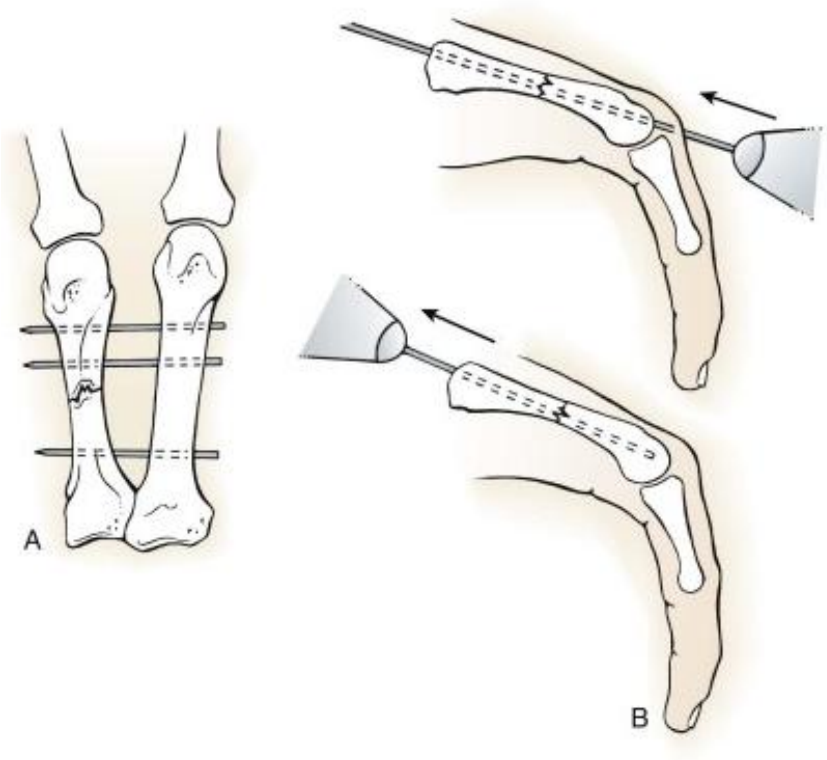
1) Prominent metacarpal head in palm causing loss of grip strength
2) Pseudoclaw deformity due to hyperextension of metacarpophalangeal joint
3) Cosmetically disfiguring dorsal prominence
4) Shortened metacarpal resulting in weakness of intrinsic muscle

Regarding the angular deformity, sagital plane angulation is well tolerated in ring and small finger upto 30-40 degrees and in index and middle fingers upto 10-20 degrees. Angulation more than these often requires open reduction and internal fixation.

Regarding shortening, up to 2-5mm is well tolerated more than which intrinsic muscle weakness occurs and often requires open reduction and internal fixation.

3)OPEN REDUCTION AND INTERNAL FIXATION WITH KIRSCHNER WIRES

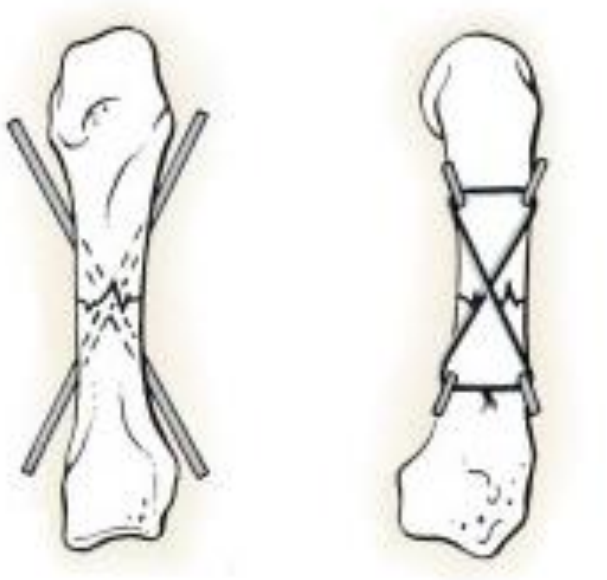
This is technically easy and can be applied single or multiple, longitudinal or crossed, or transmetacarpal fixation. These may be applied in a antegrade or retrograde fashion and are not rigid and can cause pin irritation, pin protrusion, pin loosening, pin tract infection and pin migration.



TRANS METACARPALFIXATION OF K-WIRE

4)OPEN REDUCTION AND INTERNAL FIXATION WITH COMPOSITE WIRING

This is a combination of Kirschner wire and monofilament stainless steel wire applied in a tenion band fashion through transverse drill hole in proximal and distal fragment around crossed k wires. Gives superior strength and stiffness compared to crossed k wires. Fixation is rigid to allow early motion. It is indicated in transverse fracture with angulation. Contraindicated in fracture communition or bone loss .



INTEROSSEOUS WIRING

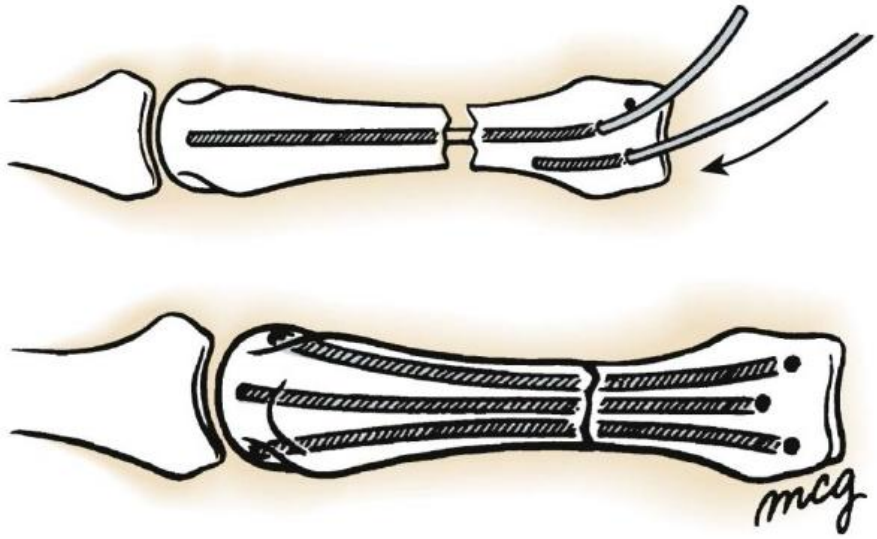
5)CERCLAGE AND INTEROSSEOUS WIRING [20]

Here, 24G Stainless Steel wire is used. This technique is indicated for spiral and oblique fractures. It can be done as a sole procedure or can be combined with k wiring if the fracture is found to be comminuted or if the fracture is found associated with bone loss. This procedure is rigid enough to allow early post operative mobilization.

6)INTRAMEDULLARY FIXATION

Intramedullary fixation is indicated for a transverse fracture and contraindicated in spiral and oblique fracture. The disadvantage of

intramedullary fixation is that it lacks rotational stability and increased incidence of pin migration and there is chance of fracture distraction. Recently three prebent k wires are used as intramedullary device which provides some degree of rotational stability by three point fixation. In case of segmental bone loss these intramedullary devices can act as an internal spacer and the bone defect can then be covered with a cortico-cancellous bone graft .



INTRAMEDULLARY FIXATION WITH PREBENT K-WIRES

7)INTERFRAGMENTARY COMPRESSION SCREWS

The only indication of interfragmentary compression screw is a long oblique and long spiral fracture. In these fractures the interfragmentary screws are sufficiently rigid to allow early range of motion. In long oblique

and long spiral fractures two interfragmentary screws are applied. One is applied at 90 degrees to the long axis of the bone which resists axial compression forces. The second interfragmentary screw is applied at 90 degrees to the fracture plane which resists torsional displacement forces.

The technique of interfragmentary screw fixation: usually a 2.7mm screw is used [8]

Step 1: Both cortices are drilled with a 2mm drillbit.

Step 2: Countersink made at near cortex.

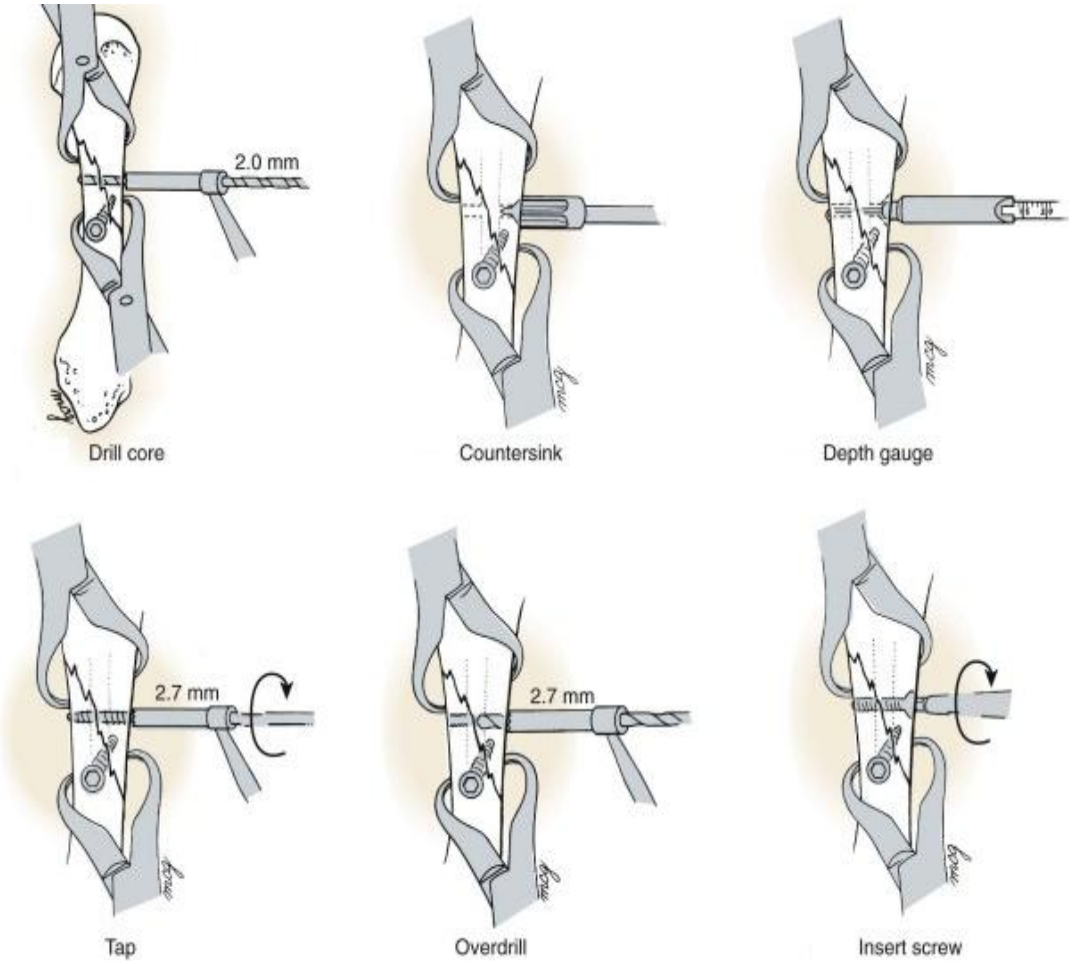
Step 3: Length measured using depth gauge

Step 4: Threads cut with a 2.7mm tap

Step5: Near cortex is overdrilled to create glidehole for interfragmentary compression

Step6: Placement of screw.

These screws should be placed at least twice the screw diameter away from the fracture site [21].



LAG SCREW APPLICATION

8)OPEN REDUCTION AND INTERNAL FIXATION WITH PLATE OSTEOSYNTHESIS

Plate osteosynthesis provide excellent results in all irreducible multiple fractures, displaced fractures (unstable fractures) [48]. Usually, a low profile micro plate is used and these have the advantage where the periosteum can be closed over the plate preventing adhesions. Plates are usually applied on the dorsal surface (tension surface) which provides more stable fixation than all

other modalities of fixation allowing early mobilization of fingers. These low profile plates have advantage of ease of contouring .

The complications of plate fixation include:

a) malunion
b) Non-union
c) Stiffness due to tendon adhesion when the periosteum could not be approximated
d) Plate loosening
e) Plate breakage
f) Complex regional pain syndrome

These complications are avoided by meticulous soft tissue handling and adequate periosteal coverage over the plate.

9)BIOABSORBABLE FIXATION

Bioabsorbable fixation provides equivalent stability as compared with stainless steel plate and has the advantage of avoiding implant removal.

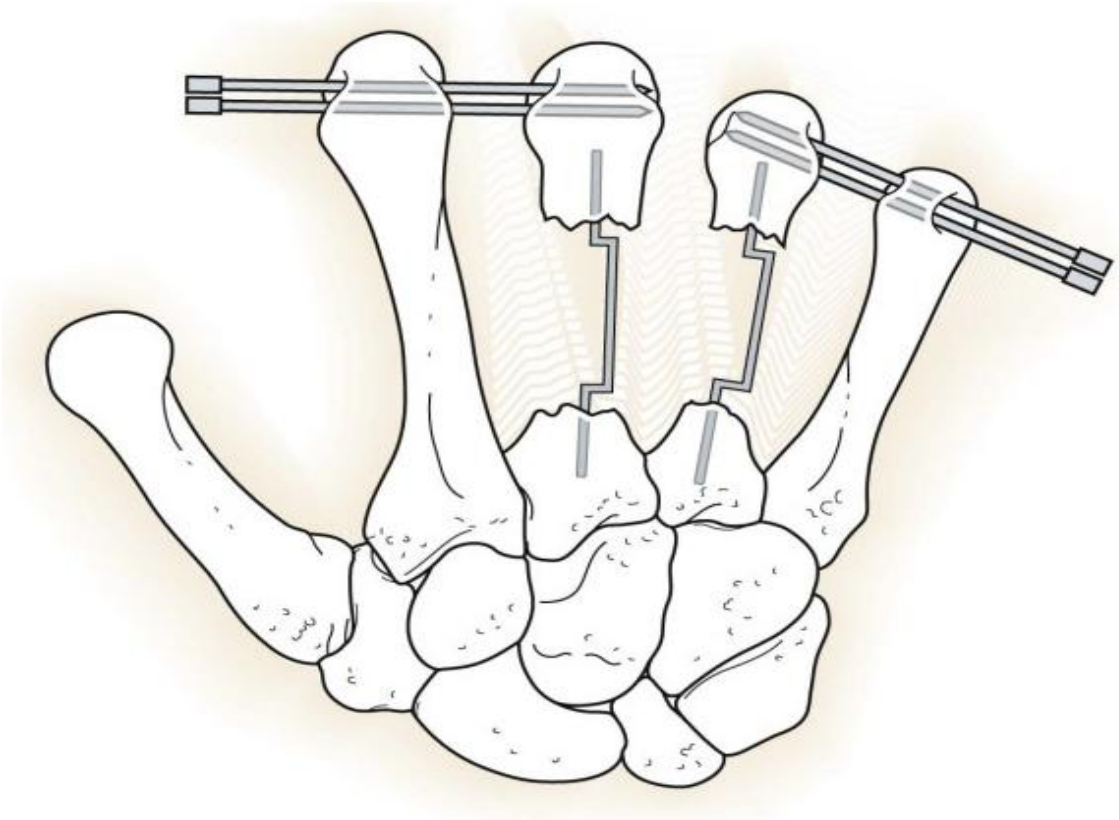
Initially bioabsorbable plates were made of polyglycolic acid which induce non infectious inflammatory response which are reduced by the newer

bioabsorbable implants made of poly–l-lactide implant [22]. Even these are associated with complications like keloid formation and soft tissue swelling which usually resolves by 6 months [8].

METACARPAL FRACTURES WITH SEGMENTAL BONE LOSS

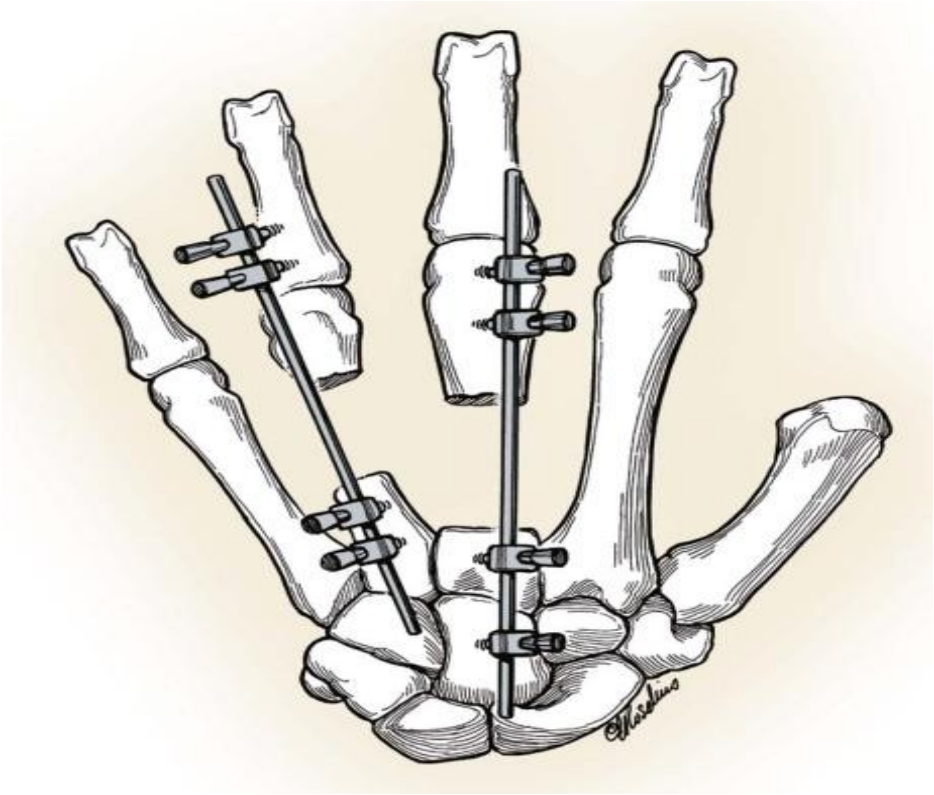
This is really a challenging situation and is associated with open injury with variable amount of soft tissue injury. These are managed by following techniques:

1) Maintain the length of metacarpal with intermetacarpal K wires – spacer wires.

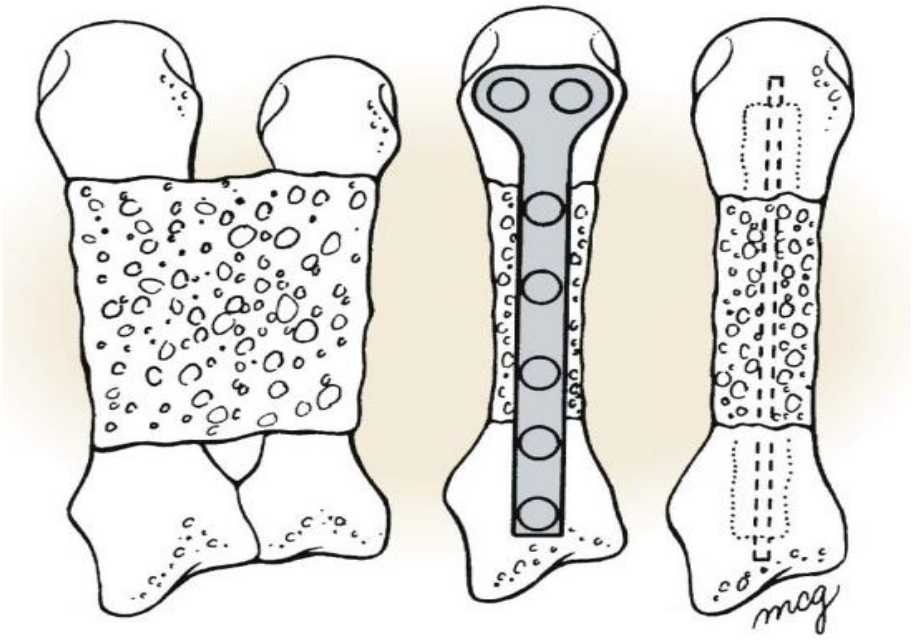


K WIRE SPACER

2) Length is maintained by application of distraction external fixators [23]



3) Even plates are used to maintain the length of metacarpals.



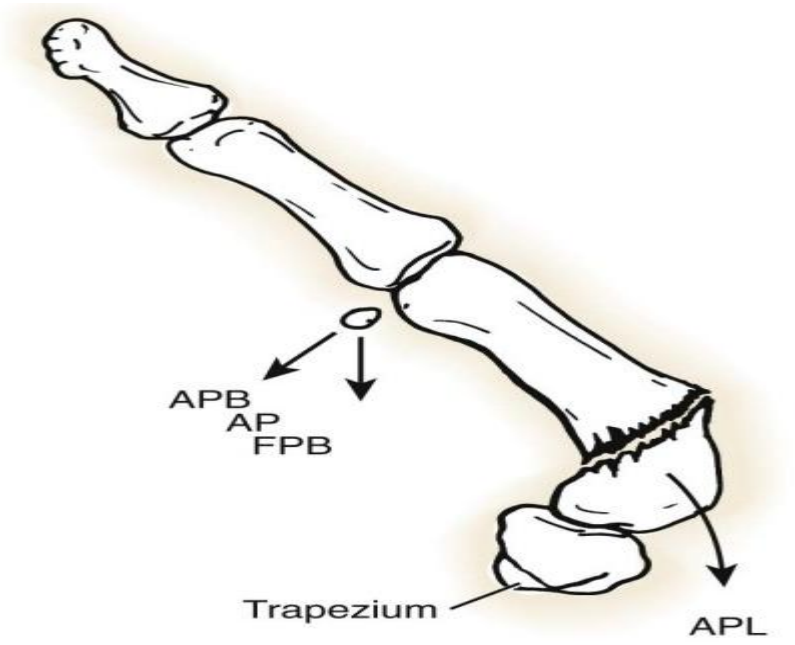
After maintaining the length by these devices, the defect is covered with cortico cancellous bone graft harvested from iliac crest [8].

THUMB METACARPAL FRACTURES

These are classified as :

1) Metacarpal head fractures
2) Metacarpal shaft fractures
3) Metacarpal base fractures
    a. Extra articular or epibasal which is more common
    b. Intra articular fractures

Usual displacement of thumb metacarpal fractures is dorsal angulation. Abductor pollicis brevis and flexor pollicis brevis flexes the distal fragment while the abductor pollicis longus extends the proximal fragment .



EPIBASAL FRACTURE OF THUMB METACARPAL

These metacarpal head and shaft fractures are usually managed by

1) Thumb spica cast
2) Closed reduction and percutaneous pinning – when the angulation is greater than 30 degrees which results in hyper extension of metacarpophalangeal joint.
3) External fixators are applied in open comminuted fractures

BENNETT'S FRACTURE

It is an intra articular fracture dislocation of the base of the thumb metacarpal. Bennett fragment is a volar ulnar fragment which is held in its anatomical position by anterior oblique ligament attaching the fragment to trapezium. The remaining metacarpal base with shaft is displaced laterally proximally and dorsally by the pull of abductor pollicis longus.

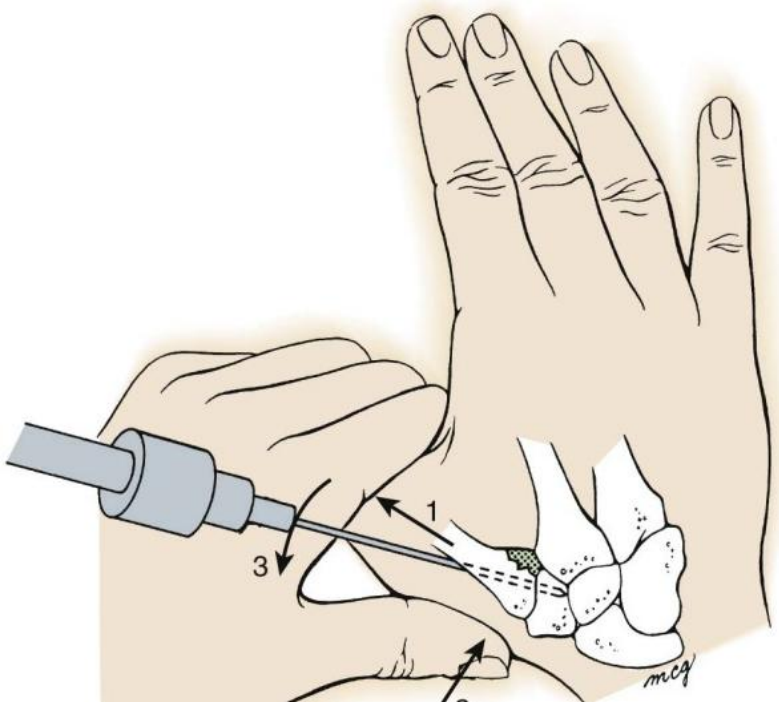
This fracture is inherently unstable and always requires operative treatment. Treatment modalities are :

1) Closed reduction and percutaneous pinning [24]:

   Reduction manoeuvre: – longitudinal traction is applied first. Then pressure is applied at thumb metacarpal base with pronation of thumb which reduces the fracture. Then the fracture is stabilized by

percutaneous pinning of metacarpal base to trapezium. Pinning the bennett fragment is usually not indicated.

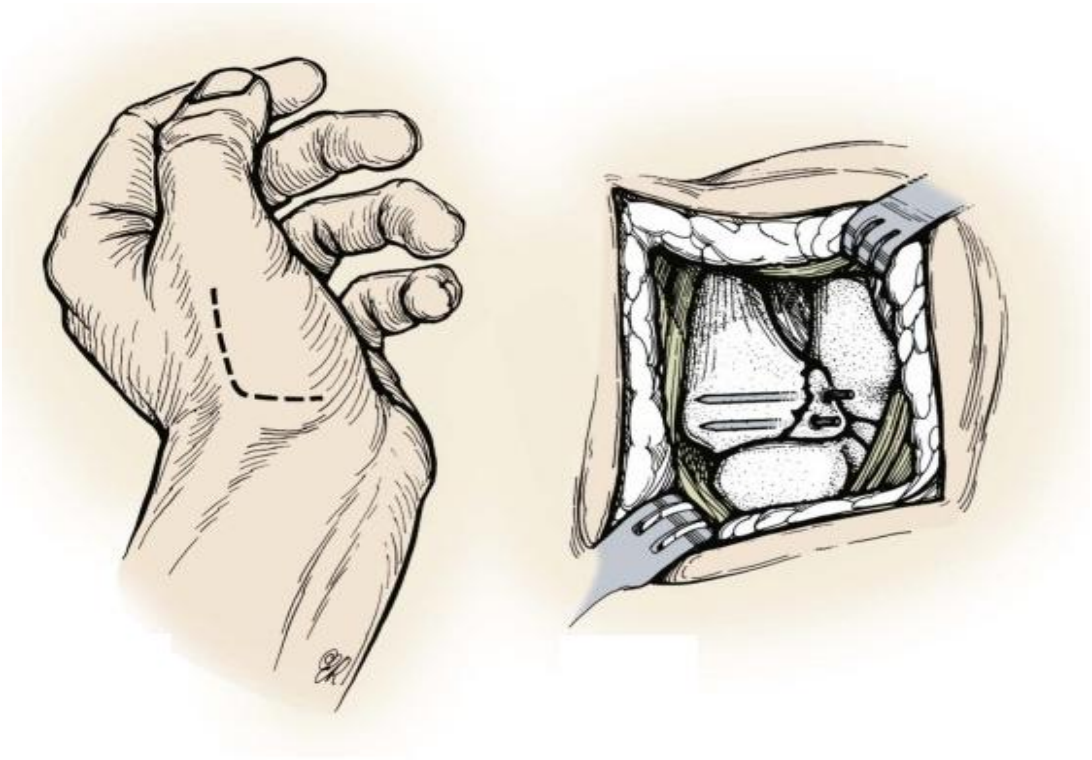
2) Closed reduction and interfragmentary screw fixation - when the bennett's fragment is of sufficient size, internal fixation with interfragmentary screw can be done. Screw is applied by percutaneous technique.
3) Open reduction and internal fixation with K wire/lag screw. This is indicated for irreducible fractures.



CLOSED PINNING OF BENNET FRACTURE

Wagner's approach [25]: Incision is made on the subcutaneous border of thumb metacarpal between abductor pollicis longus and thenar muscle. The joint capsule is incised and the bennett fragment is reduced with

metacarpal base using reduction clamp. Fracture fragment when sufficiently large can be fixed with lag screw. Smaller fragments are stabilized with K wires .



WAGNER'S APPROACH

Complications of bennett's fracture:

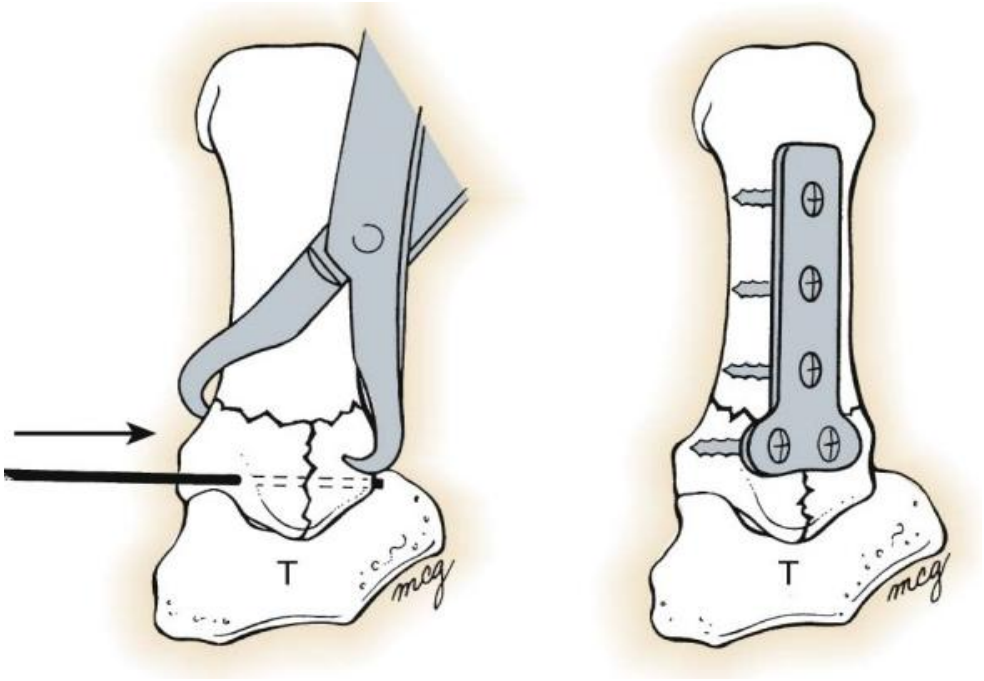
1) Painful arthritis – managed by trapezio metacarpal arthrodesis
2) First web space contracture (due to prolonged immobilization with thumb in adduction) – prevented by early mobilization

ROLANDO'S FRACTURE

It is intra articular comminuted fracture of thumb metacarpal base. Closed reduction followed by percutaneous pinning is difficult in this fracture as all articular fragments could not be reduced. Reduced could be successful with only minimal comminution where there are only two fragments and often Rolando's fracture needs to be internally fixed.

Treatment options include:

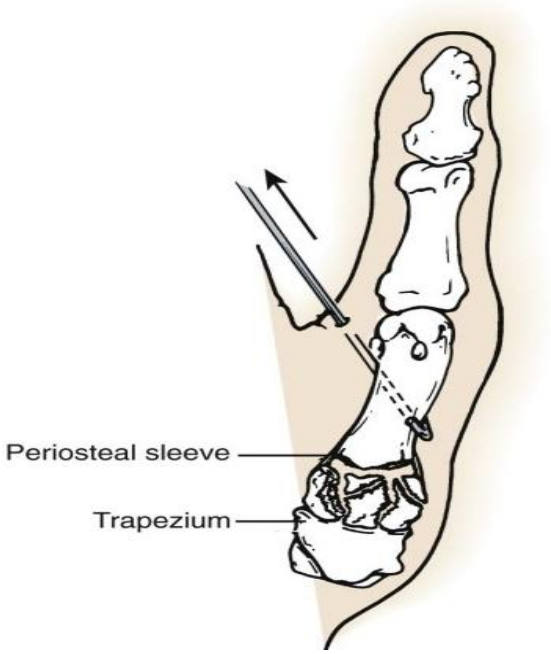
1. Closed reduction and percutaneous pinning-in least comminuted two fragment fractures.
2. Open reduction and internal fixation with multiple K wires/plate osteosynthesis-indicated in fractures with comminuted fragments sufficiently large enough to hold the screws. Here fragments are reduced by longitudinal traction and provisional fixation done with K wires, articular congruency verified under fluoroscopy guidance and fracture stabilised with T or L configured plates and screws of 2.7 or 2mm diameter.



ROLANDO'S FRACTURE FIXED WITH PLATE

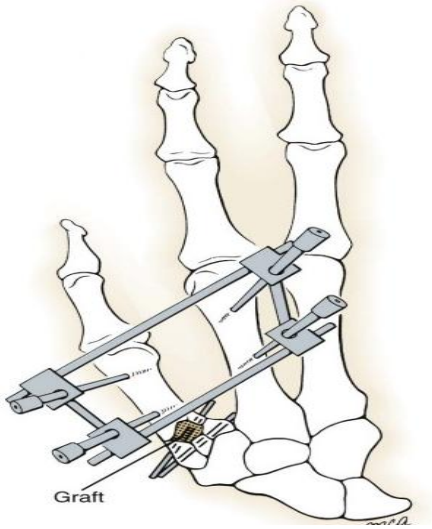
3. Skeletal traction-THOREN'S TRACTION [26]. This is an oblique skeletal traction applied in case of severely comminuted intraarticular fractures which cannot be fixed with plates and screws.

   Procedure – 1cm longitudinal incision made on radial aspect of thumb metacarpal distal to the insertion of abductor pollicis longus and 1mm K wire is drilled obliquely in thumb metacarpal in distal to proximal direction then proximal end of pin is bent to 90 degrees. Wound is then closed. Then a forearm cast with bango outrigger applied excluding thumb web with rubber band traction applied for 4 to 6 weeks. This procedure is simple and associated with low complication rate.



THOREN'S TRACTION

4. Mini external fixator (Quadrilateral frame) [27] -This procedure is primarily indicated for severely comminuted fractures of thumb base. Here the distraction is applied by a device which connects the thumb and the index metacarpal shaft .

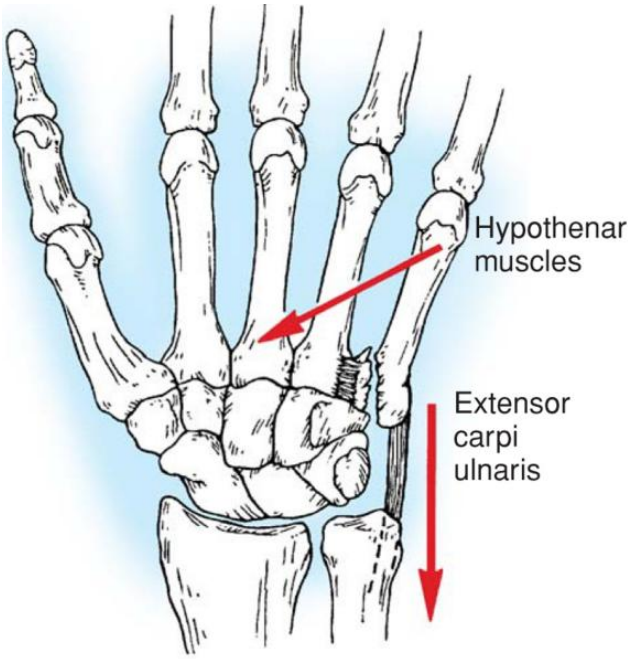


QUADRILATERAL FRAME

REVERSE BENNETT FRACTURE:

It is otherwise known as BABY BENNETT FRACTURE. It is a intraarticular fracture of fifth metacarpal base. It is an unstable fracture like Bennett fracture. Extensor carpi ulnaris tendon is inserted in the 5^{th} metacarpal base on the dorsal aspect which pulls the distal fragment proximally and ulnarly, whereas the small fragment on radial volar aspect is held in position by the ligament attaching the fragment to the hamate and the base of 4^{th} metacarpal.

As this fracture is inherently unstable, treatment of this fracture is closed reduction followed by percutaneous pinning. And then a protective forearm cast is applied for 4 to 6 weeks .



REVERSE BENNET FRACTURE

COMPLICATIONS OF METACARPAL FRACTURES:

1. Malunion – Intraarticular or Extraarticular

   Extraarticular malunion includes

   a. Malunion with dorsal angulation

   b. Malunion in malrotation

2. Osteomyelitis
3. Non union
4. Stiffness

MALUNION:

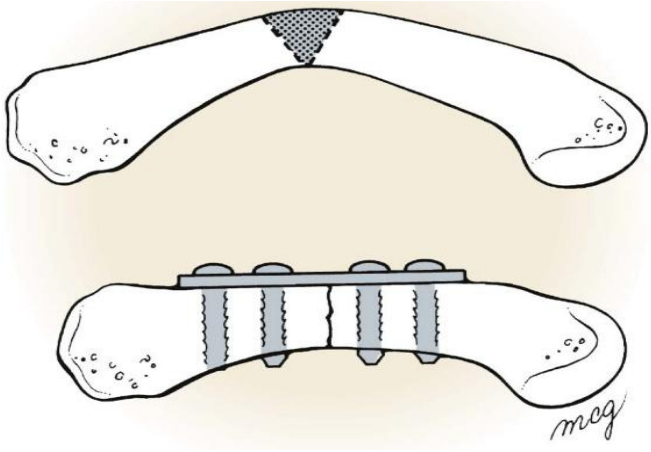
It is of two types – Extraarticular and Intraarticular.

Extraarticular malunions – with dorsal angulation:

This usually results from a malunited transverse fracture of the shaft where the malunion occurs in the sagittal plane with the dorsal angulation as the distal fragment is flexed by the intraosseous muscle which axis lies volar to the long axis of metacarpal shaft. This angulation is poorly tolerated both functionally (as the metacarpal head is prominent in the palm causing pain and weakness of grip strength) and cosmetically (due to pseudoclawing where the metacarpophalangeal joint is hyperextended and the interphalengeal joints are flexed)

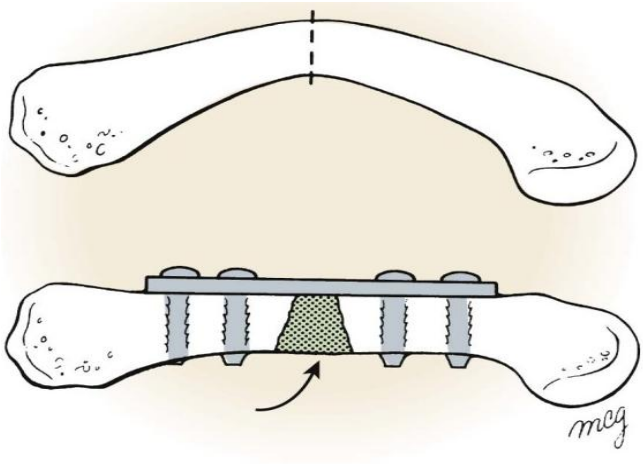
Treatment:

This deformity is corrected by closed wedge or open wedge osteotomy.Closed wedge osteotomy is a simple technique [28]. And the length gained by the dorsal angulation is corrected by shortening. After taking dorsal wedge of bone on the dorsal aspect osteotomy is closed correcting the angular deformity and stabilised with a dorsal miniplate and screws .



CLOSED WEDGE OSTEOTOMY

Open wedge osteotomy is indicated when the dorsal angulation is associated with shortening of the metacarpal. Here after osteotomy of metacarpal shaft, proximal and distal fragments are wedge opened on volar aspect and the bone graft harvested from the iliac crest is placed in the open wedge then proximal and distal fragments are stabilised with plate and screws [8].



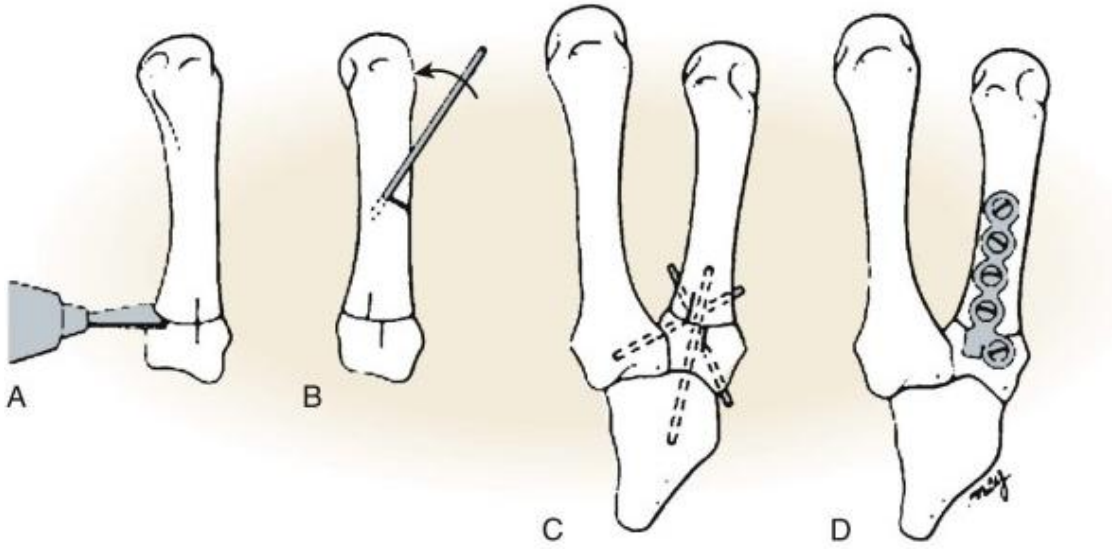
OPEN WEDGE OSTEOTOMY

MALUNION IN MALROTATION:

This deformity is a result of malunited oblique and spiral fractures. This deformity is not radiologically evident. But can be better appreciated clinically by noting scissoring of the fingers where involved finger overlaps the adjacent finger. This deformity is functionally disabling as the grip strength is markedly impaired.

Treatment:

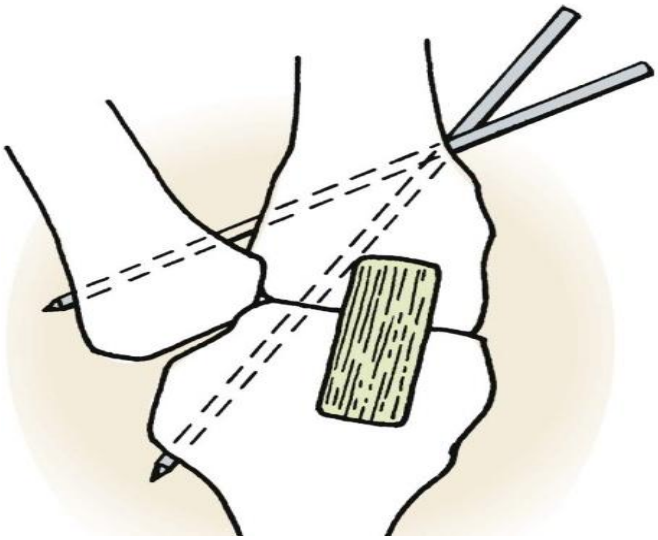
The corrective osteotomy is done through the base of the metacarpal where the malrotation upto 25 degrees can be corrected [(29)]. After rotational correction provisional K wire is used to transfix the osteotomy and intraoperatively rotational correction is checked by passive flexion and extension of fingers, in case of successful rotational correction all finger tips point towards scaphoid tuberosity .



CORRECTIVE OSTEOTOMY FOR MALROTATION

INTRAARTICULAR MALUNIONS:

This usually results in painful arthritis which is most common at the mobile carpometacarpal joints of 1st,4th and 5th digits. This malunion is difficult to treat by corrective osteotomies and often requires arthrodesis.



ARTHRODESIS OF CARPOMETACARPAL JOINT

OSTEOMYELITIS:

Osteomyelitis of metacarpal fractures are rare because of abundant blood supply of hand. This usually occurs in compound fractures with extensive soft tissue injury. This is treated by thorough wound debridement until the wound is surgically clean and appropriate systemic antibiotics given for a period of 4 to 6 weeks.

NONUNION:

Nonunion of closed metacarpal fractures are uncommon. Nonunion is mostly of atropic and hypovascular. This usually occurs in compound fractures, fractures with bone loss, in case of osteomyelitis when immobilisation is inadequate and in case of poor fracture fixation (where the fractures are fixed in distraction) [30]

Treatment:

Resection of pseudoarthrosis followed by stable internal fixation with bone grafting .

STIFFNESS:

This can result from fracture itself or in the setting of fracture treatment. Stiffness is due to tendon adhesions occurring in compound fractures where the extensor tendons is adherent to the underlying bone. This can be treated by

dynamic metacarpophalangeal flexion splinting or tenolysis and metacarpophalangeal capsulotomy.

In case of closed metacarpal fractures – Stiffness occurs due to intrinsic muscle dysfunction occurring secondary to contracture. This is prevented by early mobilisation of metacarpophalangeal and interphalangeal joints when the fracture is clinically sticky as evident by painless movement of the fingers which usually takes 3 weeks. Intrinsic muscle release is rarely needed in improving the function .

IMPLANT PROFILE

1 mm AO mini plate:

Composition: stainless steel. AO stainless steel implants are produced from implant quality 316L stainless steel which typically contains iron (62.5%), chromium (14.5%), nickel 2.8%), molybdenum and minor alloy elements

Length: range from 28mm to 50mm

Breadth: 5mm

Thickness: 1mm

Holes: 4-8 holed

Configuration: straight plate (for shaft fractures), L – plate& T – plate (for periarticular fractures)

Type: noncompression

Screws composition – stainless steel

Screw type: non self tapping type, round headed with single slot

Screw pitch: 0.5mm

Screw length: 8-16mm

INSTRUMENTS USED:

Drill bit

- composition: stainless steel
- diameter: 1mm

Drill used: power drill with RPM : 20,000-30,000

Coolant: external saline irrigation

Tap: stainless steel, 2mm diameter

Plating kit:

- Reduction clamps
- Plate holding forceps
- Screw holder
- Screw driver
- Bone spike
- Periosteal elevator
- Mini retractors

INSTRUMENTS

IMPLANTS - PLATES AND SCREWS

EVALUATION OF OUTCOME

For evaluating functional outcome of unstable metacarpal fractures treated with plate osteosynthesis, we use used the American Society For Surgery Of The Hand (ASSH) Total Active Flexion (TAF) scoring system [31,32].

This system takes into account the degree of flexion at metacarpophalangeal joint, proximal and distal interphalangeal joints for digits (2-5), for thumb the degree flexion at metacarpophalangeal and interphalangeal joint.

Extensor deficit is measured in degrees and the total active flexion score is the sum of flexion at metacarpophalangeal joints and interphalangeal joints minus the extensor deficit.

TAF from MCPJ to DIPJ: digit 2-5

Degree of flexion	Rating
220-260	Excellent
180-220	Good
130-180	Fair
<130	Poor

TAF from MCPJ and IPJ: thumb

Degree of flexion	Results
120-140	Excellent
100-120	Good
70-100	Fair
<70	Poor

PART B

PREAMBLE

Nowhere in the body are form and function more closely related than in the hand. Often these metacarpal fractures are treated as minor injuries causing major functional disability. In order to maintain hand function man's most important tool, the treatment of choice in recent years has shifted from predominantly conservative measures to more surgical procedures. Unstable metacarpal fractures require internal fixation. Long term follow up depends upon fracture angulation & rotation .Rotation of the digit impairs- functional grip and can be a source of chronic pain. Metacarpal shortening affects interosseous function with a 10mm loss of length corresponding up to 55% muscle power loss.

Hand function – affected by 1) Angulation of the fracture greater than 30 degrees , 2) Rotational deformity greater than 10 degrees , 3) Gross shortening of the metacarpal >5mm

Many factors such as delicate handling of tissues, preservation of gliding planes for tendons, prevention of infection, early and appropriate physiotherapy other than accurate reduction and fixation affect recovery of good mobility.

This study includes 20 cases all of whom were adults. Closed unstable metacarpal fractures were selected. The outcome was analysed with special

emphasis on active movement of fingers at metacarpophalangeal and interphalangeal joints.

Based on our findings we hereby submit **“Functional Outcome Of Closed Metacarpal Fractures Treated With Minifragment Plate And Screws”.**

AIM OF THE STUDY

Metacarpal fractures are common in adolescents and young active individuals. Functional outcome of these fractures depend upon severity of injury and the achievement of treatment. Mostly these are treated by conservative methods. Unstable fractures where closed reduction and final outcome are unsatisfactory are treated by operative measures. There are multiple surgical options for treating metacarpal fractures like K-wire fixation, interosseous wiring, plateosteosynthesis, etc.

In this study we assess Functional outcome of closed metacarpal fractures treated with plates and screws using the American Society for Surgery of the Hand (ASSH) Total Active Flexion (TAF) score - a prospective study

OBJECTIVES OF THE STUDY

1. To study the various mechanism and pattern of metacarpal fractures and their surgical management with plates & screws
2. To study the functional outcome of metacarpal fractures treated surgically.
3. To study the technical difficulties and complications of metacarpal fractures treated surgically

INCLUSION CRITERIA:

1. Age more than 18 years.
2. Physical fitness for surgery
3. Sex : Both male and female

EXCLUSION CRITERIA:

1. Age less than 18 years.
2. Patient not willing or medically unfit for surgery
3. Compound injury

INDICATIONS:

Indications for plate fixation of the metacarpals are

1. Multiple fractures with gross displacement
2. Displaced diaphyseal transverse, short oblique, or short spiral fractures
3. Comminuted intraarticular and periarticular fractures -displaced
4. Comminuted fractures with shortening or malrotation or both

MATERIAL AND METHODS

SOURCE OF DATA :

Adult patients with metacarpal fractures admitted to GOVT RAJAJI HOSPITAL, MADURAI will be taken up for study after obtaining the consent.

Period of study: From SEP 2012 to SEP 2014.

DESIGN OF THE STUDY: Prospective

METHOD OF COLLECTION OF DATA:

Patients with metacarpal fractures are selected after clinical and radiological analysis during the period of study from Sep 2012 to Sep 2014

All the patients selected for study will be examined according to protocol, associated injuries noted and clinical and lab investigations carried out in order to get fitness for surgery.

Consent of the patient will be taken for surgery. Patient will be followed till Union is achieved clinically as well as radiologically.

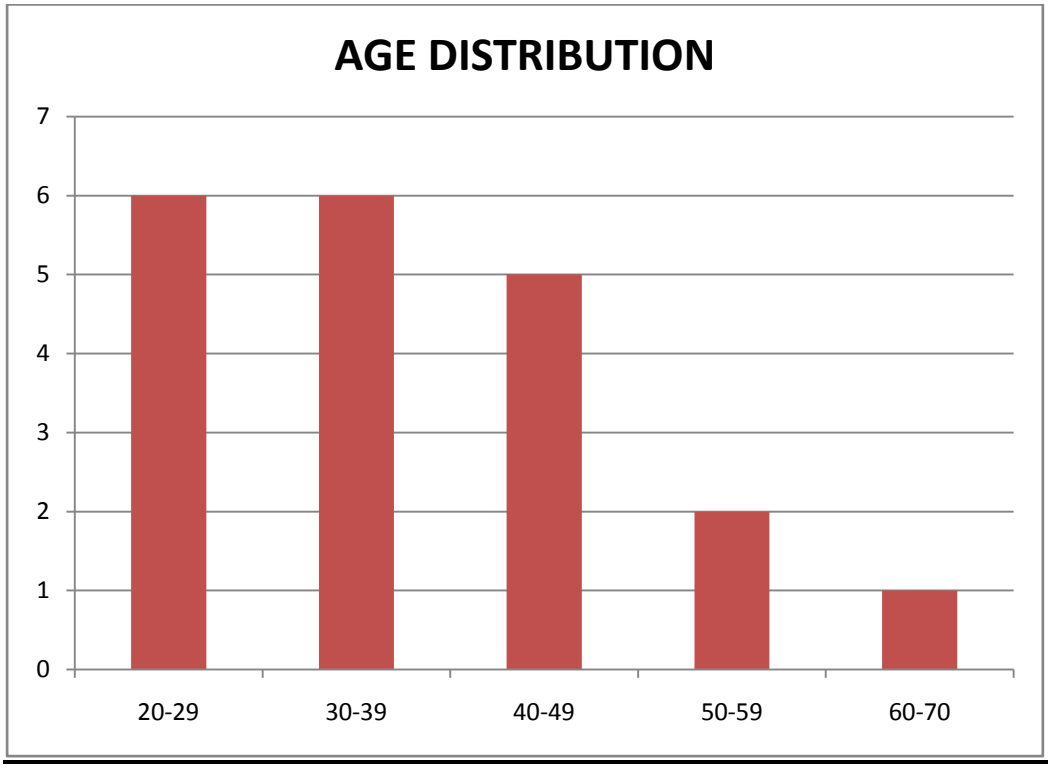
Time required for union, range of motion of surrounding joints and complications occurred before / during / after surgery will be studied in detail.

Minimum of 20 cases will be studied without any sampling procedure

I. AGE DISTRIBUTION

Age group varied from 20 years to 70 years with mean age of 45 years. Incidence of fracture was observed maximum between 20-50 years.

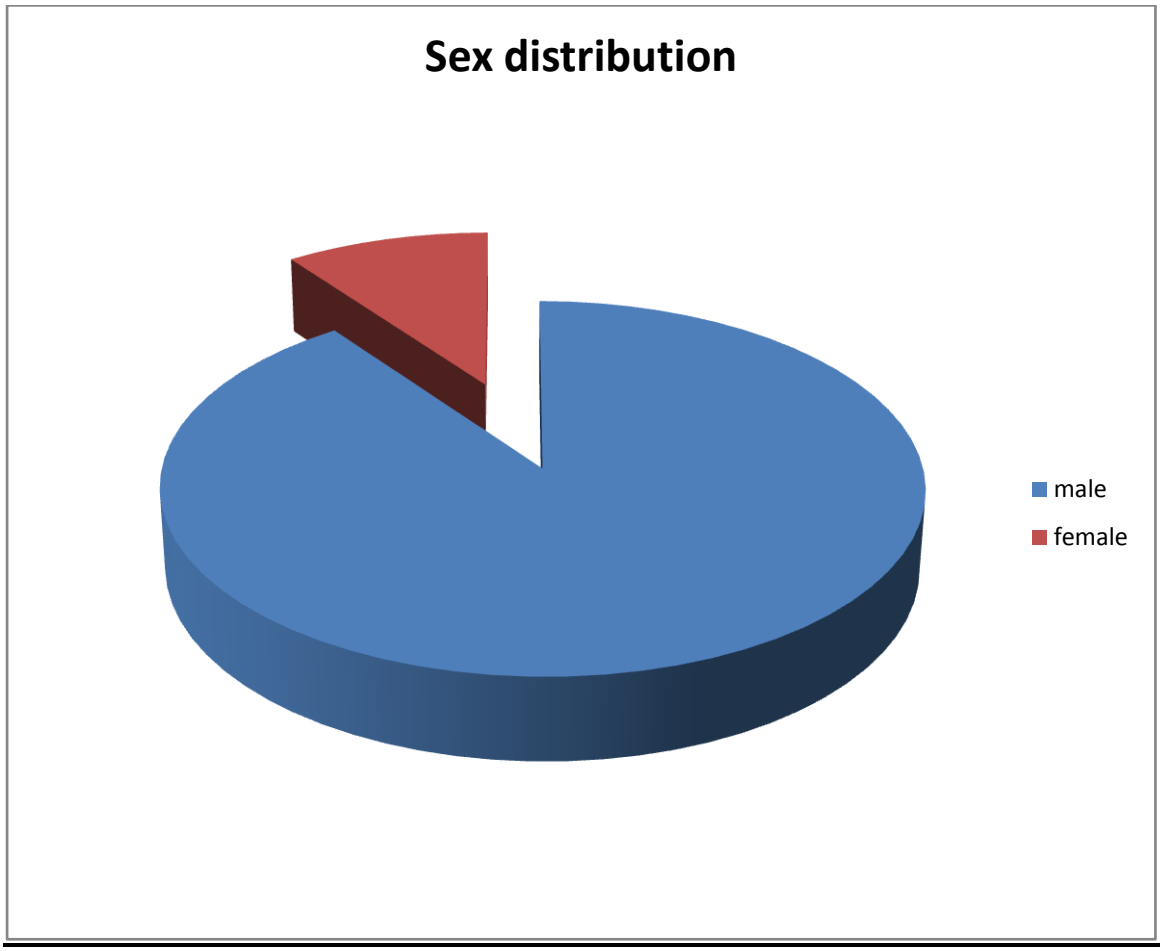
Age group	Number of cases	Percentage
20-29	6	30
30-39	6	30
40-49	5	25
50-59	2	10
60-70	1	5



II. SEX DISTRIBUTION

Among the 20 cases, males were predominant

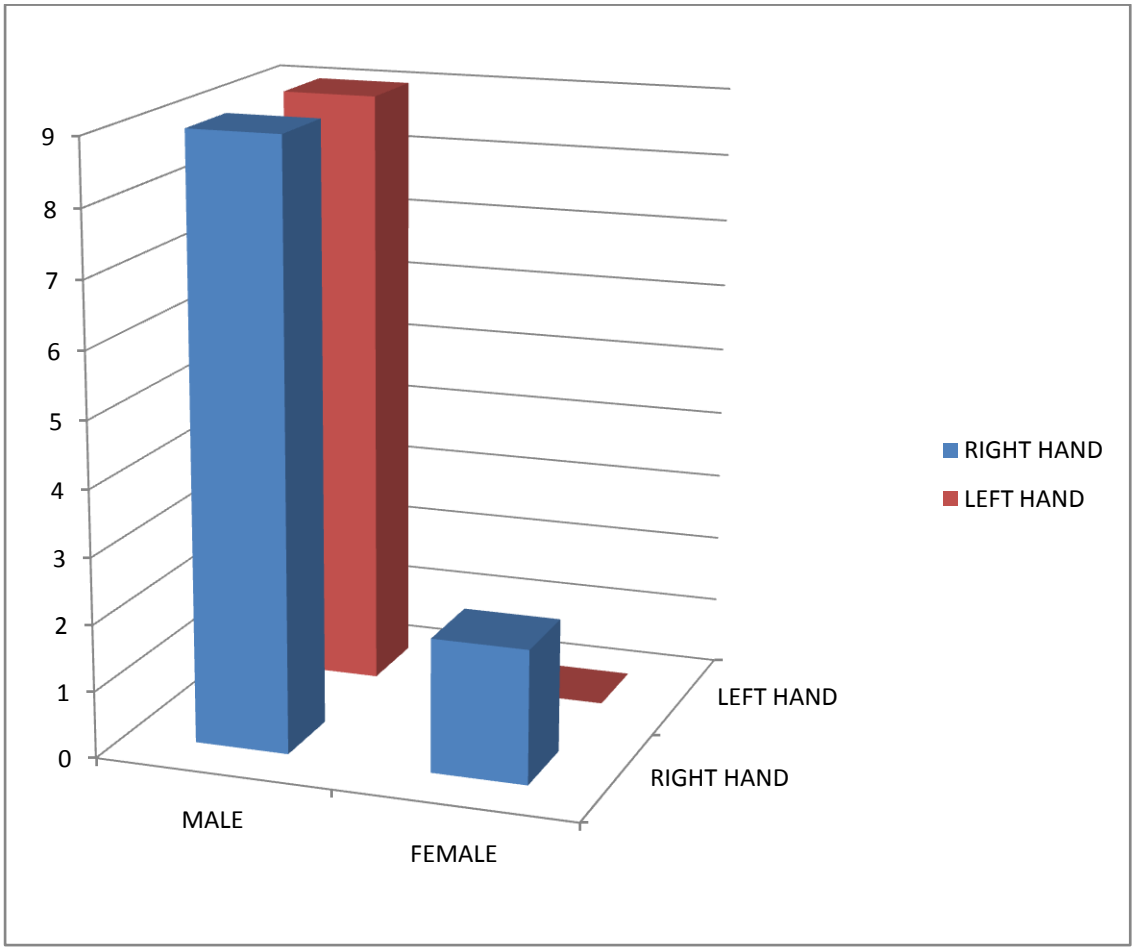
Sex	Number of cases	Percentage
Male	18	90
Female	2	10



III. SIDE OF INJURY

SEX	RIGHT	LEFT	BILATERAL	TOTAL
Male	9	9	0	18
Female	2	0	0	2
Percentage	55	45	-	-

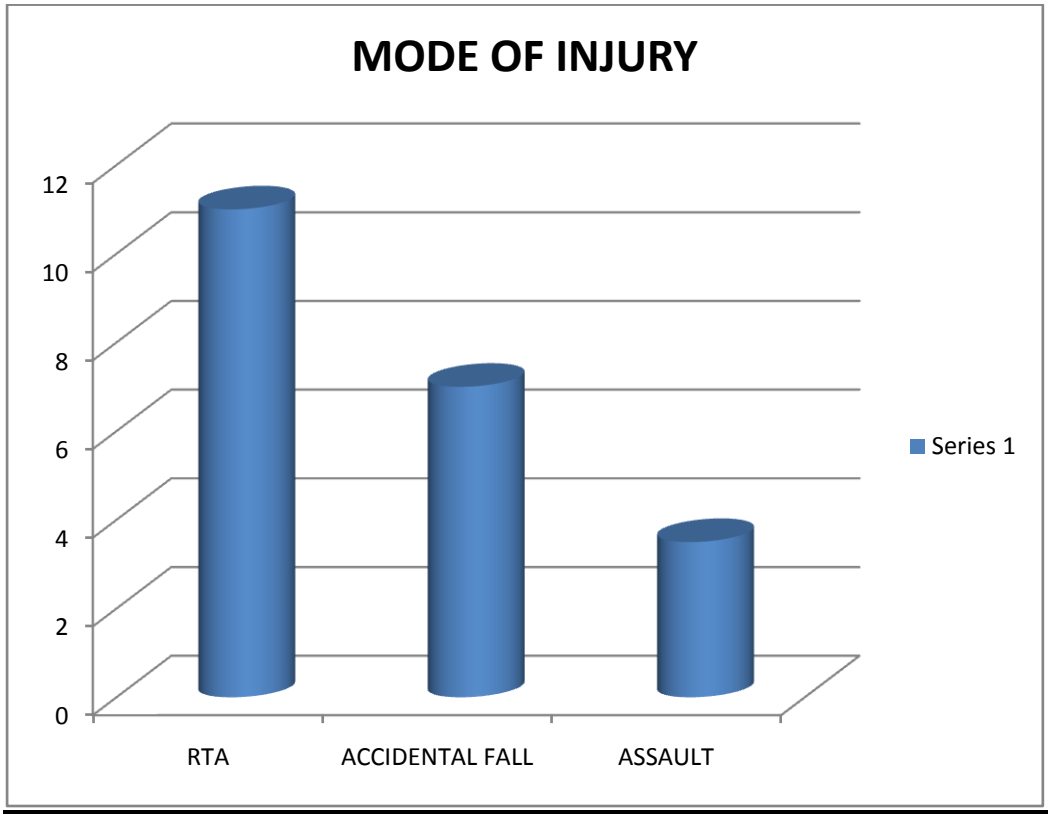
SIDE OF INJURY



IV. MODE OF INJURY

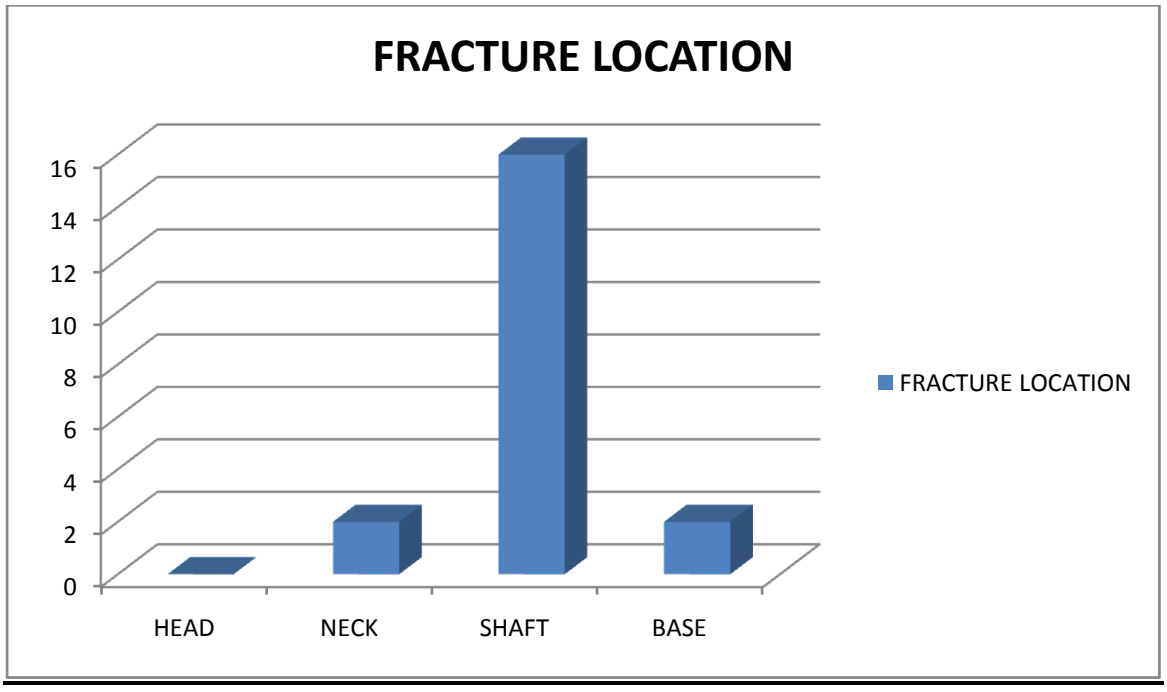
Commonest mode of injury being Road Traffic Accident (RTA)

MODE OF INJURY	NO OF CASES	PERCENTAGE
RTA	11	55
ACCIDENTAL FALL	7	35
ASSAULT	2	10



V. CLASSIFICATION OF FRACTURES

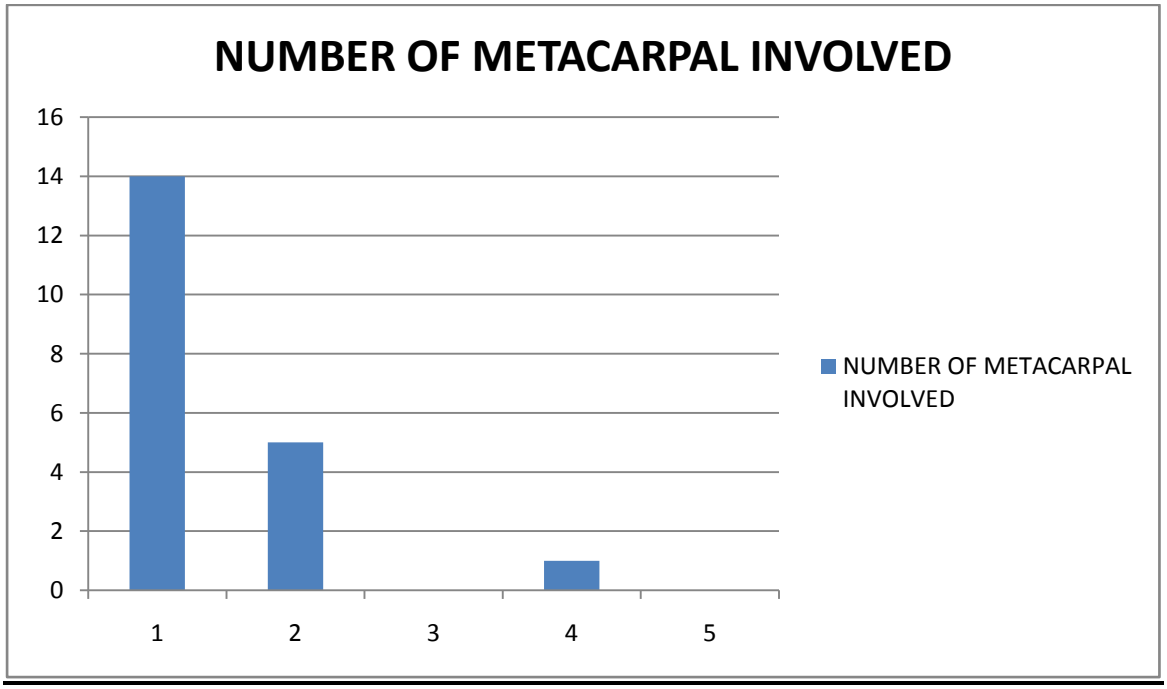
FRACTURE LOCATION	NO OF CASES	PERCENTAGE
HEAD	-	-
NECK	2	10
SHAFT	16	80
BASE	2	10



VI. NUMBER OF METACARPAL INVOLVED

Single metacarpal involvement being the most common accounting for 70% of the cases.

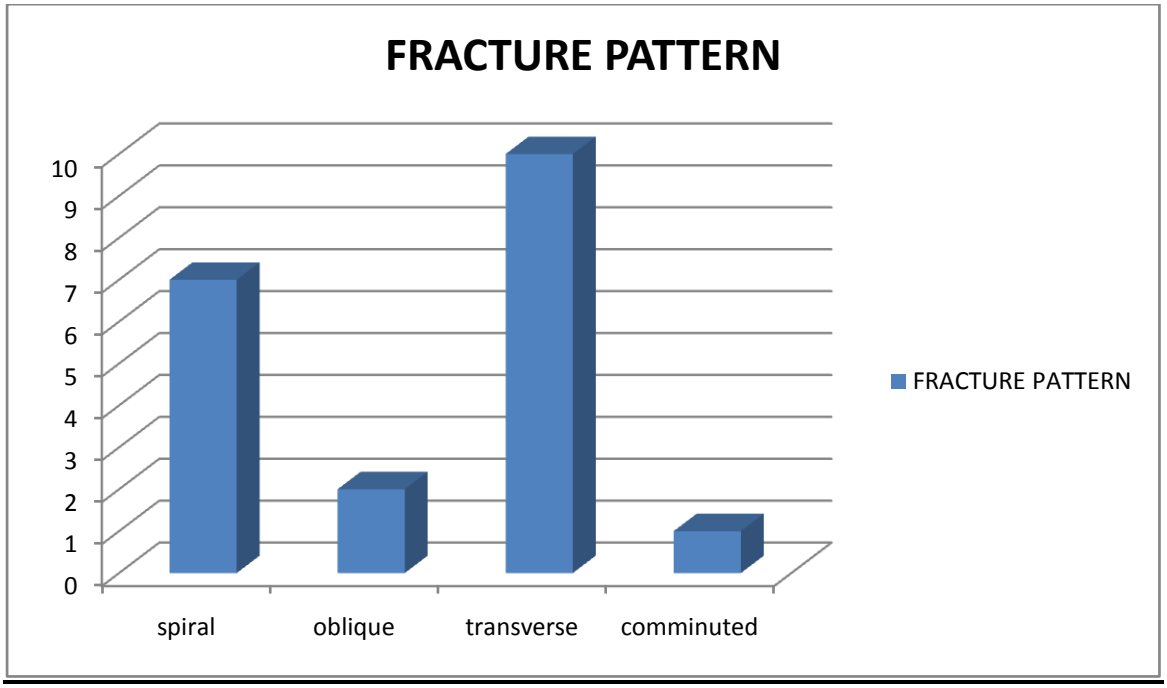
NO OF METACARPALS INVOLVED	NO OF CASES	PERCENTAGE
1	14	70
2	5	25
3	0	-
4	1	5
5	0	-



VII. FRACTURE PATTERN

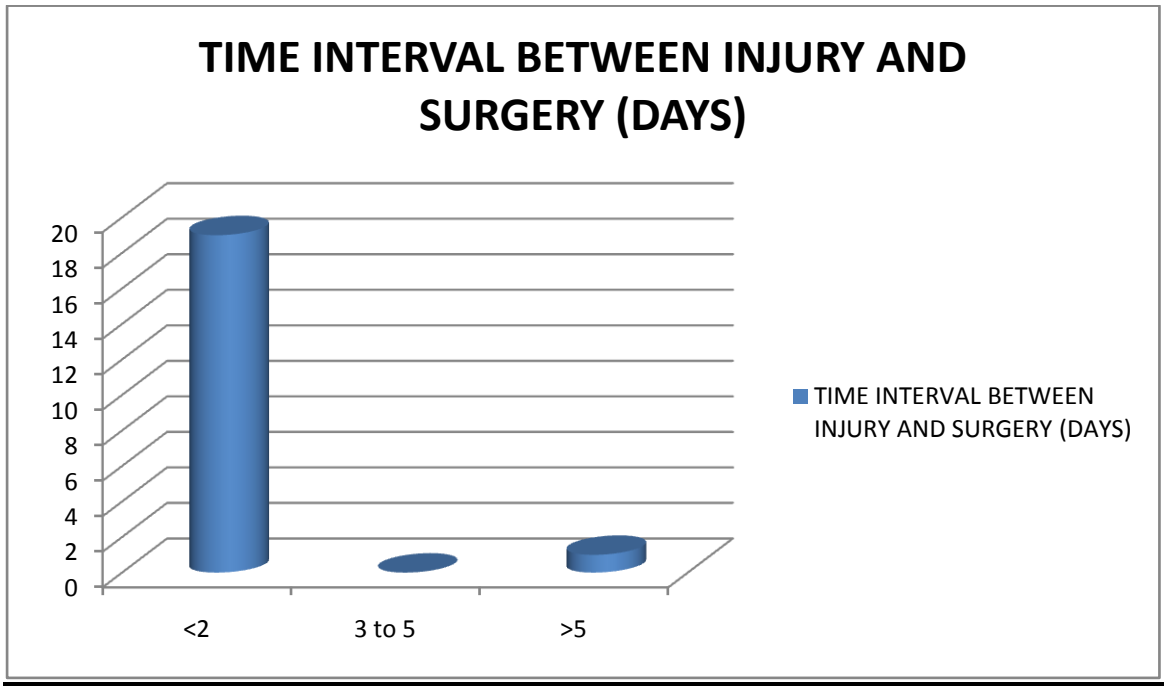
Transverse fracture pattern being most common accounting for 50%

FRACTURE CONFIGURATION	NUMBER OF CASES	PERCENTAGE
SPIRAL	7	35
OBLIQUE	2	10
TRANSVERSE	10	50
COMMINUTED	1	5



VIII. TIME INTERVAL BETWEEN INJURY AND SURGERY

TIME INTERVAL (DAYS)	NO OF CASES	PERCENTAGE
< 2	19	95
3-5	0	-
>5	1	5



IX. ASSOCIATED INJURIES

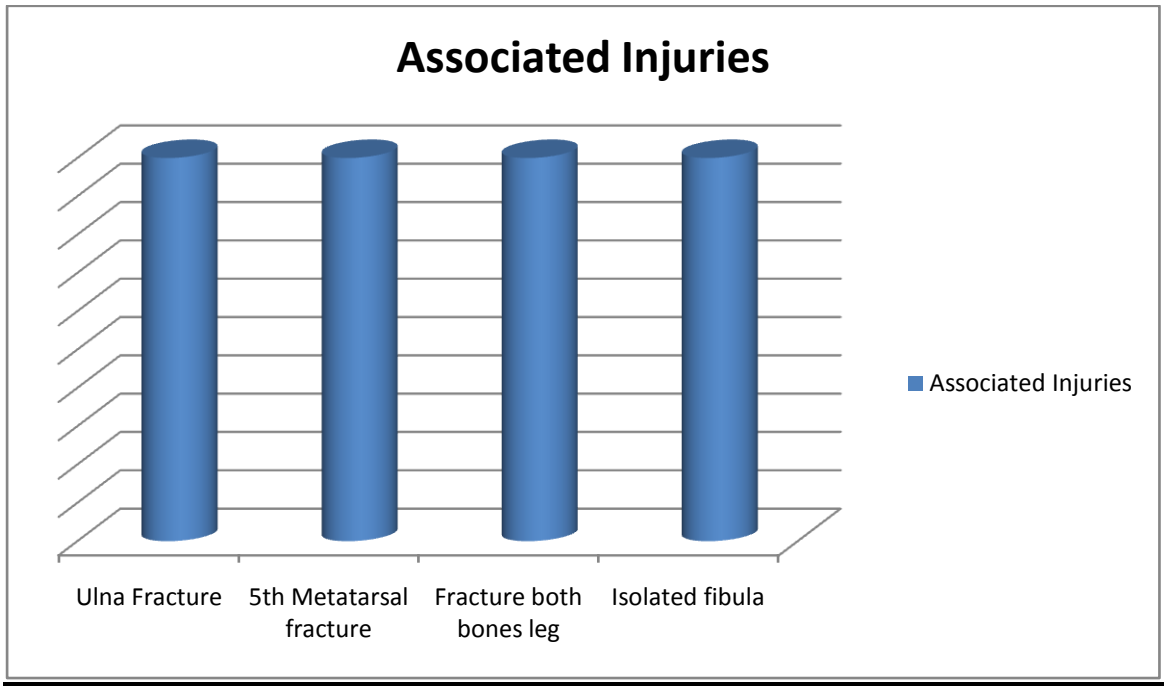
4 Cases had associated other bony injuries.

Fracture of shaft of ulna - 1

Fracture shaft of 5th metatarsal - 1

Fracture both bones leg - 1

Fracture isolated fibula- 1



X. COMPLICATIONS

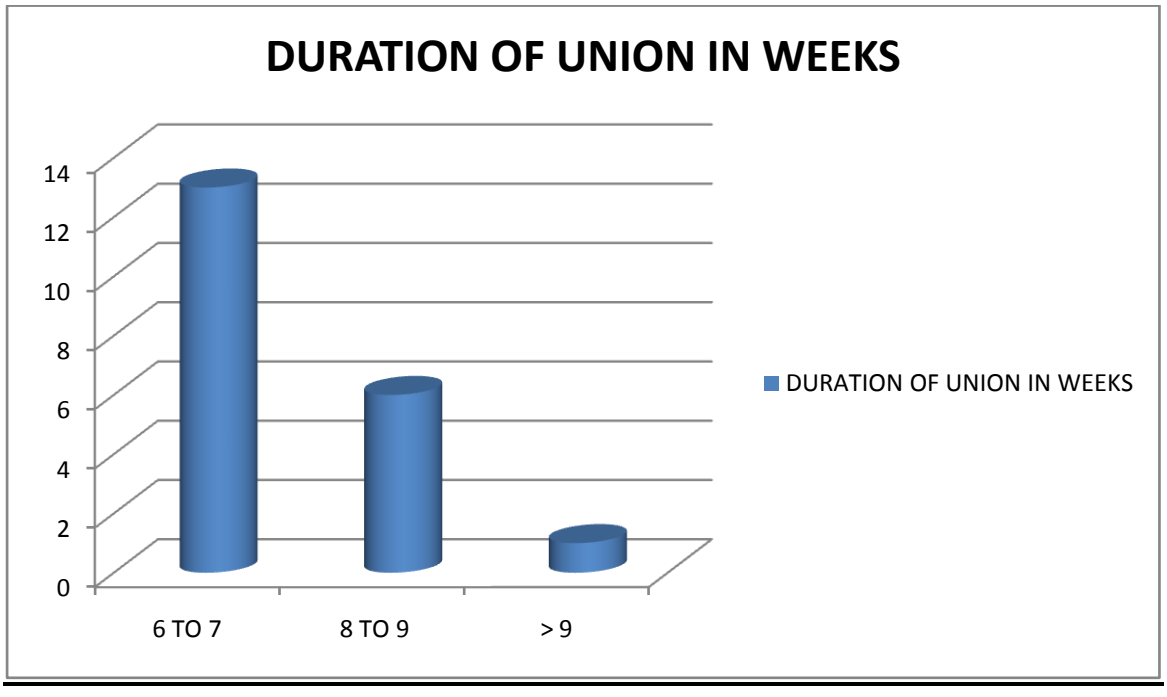
4 Cases developed complications. Infection seen in 10% (2 out of 20 cases). Stiffness seen in 10% (2 out of 20 cases)

	NO OF CASES	PERCENTAGE
INFECTION	2	10
STIFFNESS	2	10
TENDON IRRITATION	-	
NON UNION	-	
MALUNION	-	
IMPLANT BREAKAGE	-	

XI. UNION TIME

In most of the cases bony union was achieved in 6-7 weeks accounting for 65%.

DURATION IN WEEKS	NO OF CASES	PERCENTAGE
6-7	13	65
8-9	6	30
>9	1	5



PRE OPERATIVE PREPARATION:

Base line blood investigations, x-rays –pre op,post op

A minimum of two views – anteroposterior and oblique – are mandatory for assessing:

1. Degree of angulation
2. Amount of shortening
3. Presence of comminution

PROCEDURE AND POSTOPERATIVE PROTOCOL

All patients were admitted in casualty department and were resuscitated. If there were any major associated injuries they were treated accordingly at first. After the general condition of the patient improved, radiographs – anteroposterior and oblique views were taken. Fracture reduced in closed manner at first under sedation and volar below elbow slab was applied. Unstable fractures were taken up for surgery – open reduction and internal fixation with plate osteosynthesis.

Most of the cases were taken up for surgery on the 1st or 2nd day of admission. Patient who were associated with major injuries were taken up for surgery between 5 to 7 days after admission.

SURGICAL PROCEDURE – OPEN REDUCTION INTERNAL FIXATION WITH PLATE OSTEOSYNTHESIS

Tourniquet was used in all the cases before surgery

Metacarpal fractures are approached by dorsal incision made on radial border for the first and second metacarpal, ulnar border for the fifth metacarpal. For the 3rd and 4th metacarpals the approach is made using a dorsal longitudinal incision made between these bones. Then extensor tendons were retracted and anatomical reduction of the fracture fragments are carried out. Reduction is held using point reduction forceps or a stabilizing K wire. Interfragmentary lag screws were used in long spiral and oblique fractures. Plate configuration were chosen according to the fracture pattern (straight plate for shaft fractures, T or L configured plates were used for periarticular fractures) and fixed with screws. Meticulous attention was carried out in soft tissue dissection and adequate soft tissue coverage (periosteum) was made over the plate to avoid irritation to overlying extensor tendon. Thorough wound wash was given and wound closed without drain. Splinting of the hand was done with a volar below elbow slab.

POST OPERATIVE PROTOCOL

Hand was kept in elevation for 24-48 hours for controlling pain and swelling. Wound was inspected at second post operative day. Thereafter, active mobilization of fingers started and increased progressively within the limits of pain tolerance. Patients were discharged on 5^{th} post operative day and physiotherapy carried out on outpatient basis. Sutures were removed on 10^{th} postoperative day.

Follow up was done at 4^{th}, 6^{th} and 8^{th} weeks and assessed for clinical progress in terms of range of movements and radiological evaluation done to note fracture union or any loss of reduction.

CLINICALPICTURES: CASE1

PRE OP X RAY

AFTER FIXATION

Extension of MCP and IP joints

Flexion of MCP &IP Joints

Pinch strength

Grip strength

CASE 2

PRE OP

FIXATION WITH # UNION

Extension of MCP,IP joints

Flexion of MCP,IP Joints

Grip strength

Pinch strength

CASE 3

PRE OP

FIXATION WITH BONE UNION

EXTENSION OF MCP,IP JOINTS

FLEXION AT MCP,IP JOINTS

CASE 4

PRE OP

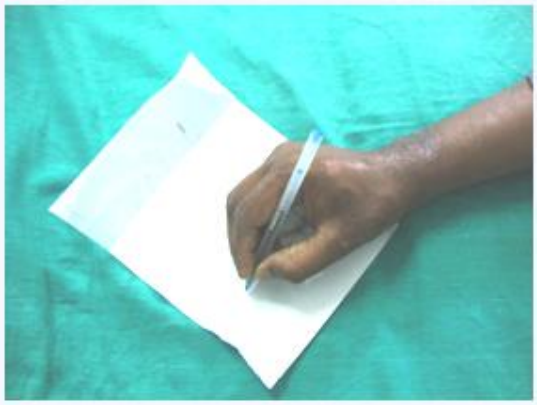
AFTER FIXATION

ADDUCTION OF THUMB

FLEXION OF THUMB

EXTENSION OF THUMB

PINCH STRENGTH



CASE 5

PRE OP

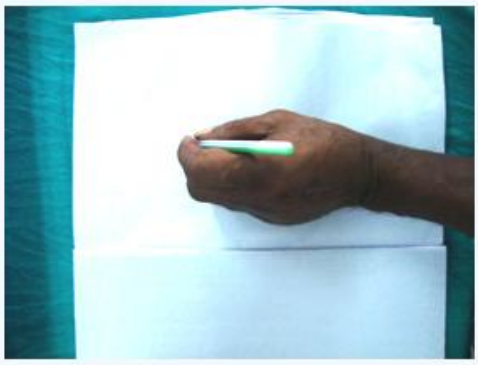
AFTER FIXATION

EXTENSION OF MCP,IP JOINTS

FLEXION AT MCP,IP JOINTS

GRIP STRENGTH

PINCH STRENGTH



CASE 6

PRE OP

AFTER FIXATION

EXTENSION OF MCP,IP JOINTS

FLEXION AT MCP,IP JOINTS

GRIP STRENGTH

PINCH STRENGTH

CASE 7:

PRE OP

AFTER FIXATION

EXTENSION OF MCP,IP JOINTS

FLEXION AT MCP,IP JOINTS

CASE 8:

PRE OP

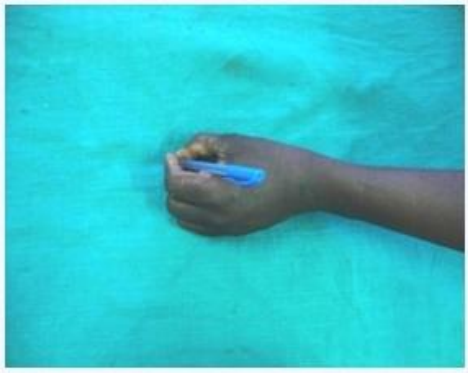
AFTER FIXATON

EXTENSION OF MCP,IP JOINTS

FLEXION AT MCP,IP JOINTS

GRIP STRENGTH

PINCH STRENGTH



CASE 9

PRE OP

AFTER FIXATION

EXTENSION OFMCP,IP JOINTS

FLEXION AT MCP,IP JOINTS

GPIP STRENGTH

PINCH STRENGTH

CASE 10

NECK OF 5TH METACARPAL

AFTER FIXATION

EXTENSION OF MCP&IP JOINTS

ACTIVE FLEXION OF MCP&IP JOINTS

PITFALLS AND THEIR MANAGEMENT

1. Infection:

Two cases developed wound infection, both were superficial infection. Pus culture for sensitivity was sent in the two cases and treated with appropriate antibiotics and regular dressings. The superficial infections subsided with treatment for 3 weeks and none of the cases required implant exit.

2. Finger stiffness:

2 Patients with multiple metacarpal fractures developed finger stiffness and one case had fractures in all the four metacarpals and the other had fracture involving two metacarpals. The patients were put on strict regimen involving active mobilization exercises. Eventually all patients had improved range of movements following physiotherapy.

COMPLICATIONS

STIFFNESS

RESULTS

20 patients were included in this study. 6 patients had multiple metacarpal fractures (30% cases). Right hand was involved in 11 of the patients (55%). 2 out of 20 were female patients (20%). All the 20 patients who underwent open reduction and internal fixation with plate osteosynthesis for unstable metacarpal fractures achieved bone union (100%). In most of the cases bony union was seen between 6-8 weeks, average period being 7.2 weeks (range 6-12 weeks). Spiral and oblique fractures united at 6 weeks, transverse and comminuted fractures united at around 8 weeks.

Functional outcome assessed by ASSH (American Society for Surgery of the Hand) TAF (Total Active Flexion) score was excellent in 16 patients (80%), good in 2 patients (10%), fair in one patient (5%), poor in one patient (5%). The overall results are satisfactory.

2 patients developed superficial wound infection, both were the case of multiple metacarpal fractures (both of these case had involvement of two metacarpal). Both these cases with superficial infection settled with daily dressing and antibiotics. 2 patients had stiffness of metacarpophalangeal and interphalangeal joints and both were cases of multiple metacarpal fractures for whom physiotherapy was continued and patients showed improved range of motion,and the results in these patients are fair & poor.

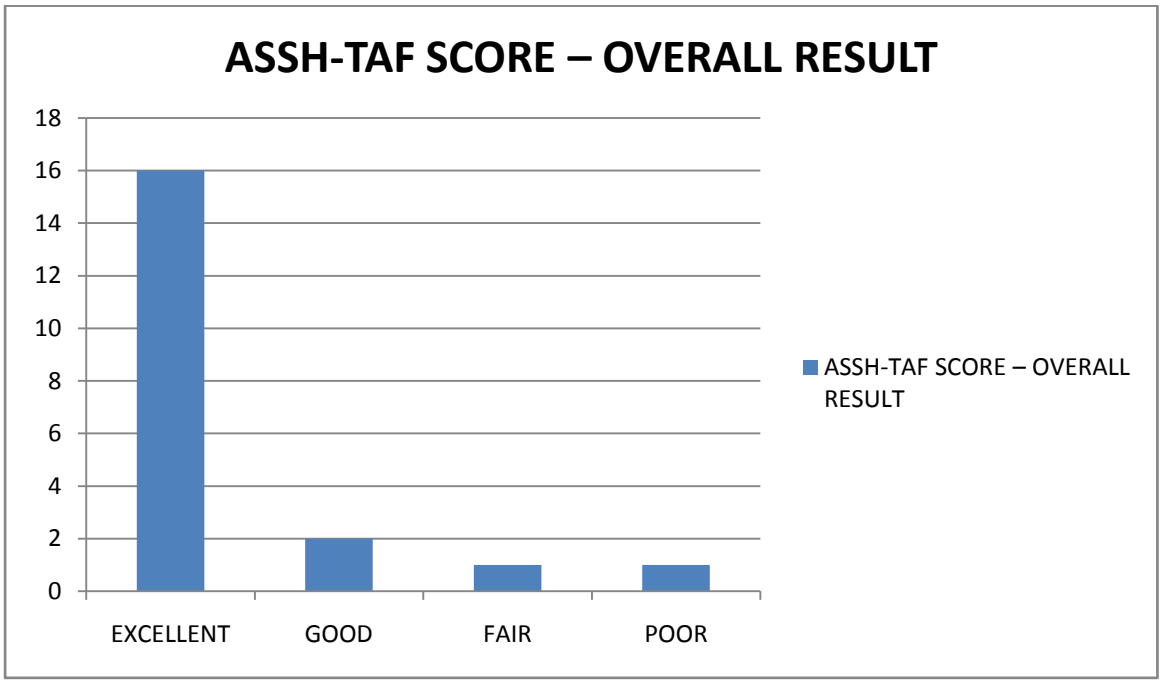
None of the patients in our study developed tendon irritation, this is due to extra cautious effort taken to cover the plate (low profile plate) with soft tissue (periosteum)for free gliding of overlying extensor tendon. No cases had angular or rotational displacement of fractures. No cases had implant breakage. None of the patients required implant removal.

ANALYSIS OF FUNCTIONAL OUTCOME

The functional outcome was assessed using AMERICAN SOCIETY FOR SURGERY OF THE HAND (ASSH) TOTAL ACTIVE FLEXION SCORE (TAF) and the following results were obtained.

ASSH-TAF SCORE – OVERALL RESULT:

GRADING	NO OF CASES	PERCENTAGE
EXCELLENT	16	80
GOOD	2	10
FAIR	1	5
POOR	1	5



DISCUSSION

Most of the metacarpal fractures are stable before or after closed reduction and are managed successfully by conservative method of protective splinting followed by early mobilization [33,34]. Only a small percentage of metacarpal fractures are unstable and in these patients the functional results following closed treatment are unsatisfactory. These are the cases indicated for open reduction and internal fixation which are usually less than 5 % of hand fractures [8, 35]. James et al [36] reported that closed method used in treatment of unstable fractures had loss of function in 77 % of fingers.

Open reduction and internal fixation with K wire [1] is one of the treatment modalities in these unstable fractures but they provide less rigid fixation and are rotationally unstable, there is increased association of pin tract infection and problems due to protruding ends of K-wire are significant. Interosseous wiring with K- wire although provides rigid fixation equivalent to plating are useful only in transverse diaphyseal fractures.

Metacarpal fractures can be fixed with external fixator [37-41]. Report by Shehadi et al [38] showed full return of total range of motions in up to 100% of metacarpal fractures treated with external fixator. This mode of fixation is useful in compound metacarpal fractures with bone loss. But the routine use of external fixator is discouraged as there is loosening of construct following pin

tract infection leading to loss of fixation and there is difficulty in constructing and applying the fixator .

Intramedullary fixation with prebent K- wires were used for transverse and short oblique fractures [42,43,44,45]. They provide comparable functional outcome with plate and screw fixation. But there is incidence of loss of reduction, penetration of metacarpophalangeal joint by hardware, thus necessitating a second surgery for hardware removal.

There are many literature studies showing satisfactory results of unstable metacarpal and phalangeal fractures treated with AO miniplate and screws [46-57]. A study by Souer et al [58] showed good functional outcome by total active motion more than 230 degree in 18 of 19 patients for whom plate fixation was done in closed unstable metacarpal fractures. Another study by Gupta et al [1] showed excellent functional outcome with total active movements more than 230 degree in all of his patients of unstable metacarpal fractures treated with plate fixation. Another study by Dabezies Schutte [50] showed no complication in 27 unstable metacarpal fractures treated with plate fixation. Low complication rate seen in our study was similar to these results.

In our study on 20 patients, 2 patients developed superficial wound infection. In both of these cases of superficial infection, there was wound discharge on second post operative day which settled with daily dressing and antibiotics and this does not affect the final outcome. 2 Patients with multiple

metacarpal fractures developed finger stiffness and one case had fractures in all the four metacarpals and the other had fracture involving two metacarpals. Eventually all patients had improved ROM following physiotherapy.

In unstable metacarpal fractures, plate fixation is a better option for several reasons [32]:

1) They provide stable fixation in all unstable metacarpal fractures thus allowing early mobilization of fingers
2) Shortening seen in multiple metacarpal fractures which are corrected by plating restores the power of interossei muscle thereby retaining the grip strength of hand.
3) Multiple metacarpal fractures are usually associated with severe soft tissue injury. In these unstable metacarpal fractures, treatment with plate osteosynthesis provides anatomical reduction of fracture with rigid stabilization allowing early mobilization of joints without loss of reduction thus preventing stiffness and yields good functional results.

In our study of unstable metacarpal fractures treated with plate osteosynthesis all the cases showed bone union (100%). The functional result assessed by American Society For Surgery Of The Hand (ASSH) Total Active Flexion score showed excellent result in 80% of the patients (16 of 20 cases), good in 10% of cases (2 of 20 cases). Stable and rigid fixation provided by mini plates and

screws allowed early mobilization of fingers thereby preventing stiffness and achieved overall good functional results. Although there were 10% (2 cases) of superficial infection, all settled with regular dressing and antibiotics without affecting final functional outcome.

CONCLUSION

Plate and screw fixation is a good option for treating closed unstable metacarpal fractures, where other modalities of fixation are less effective, the rigid stable fixation provided by plating which withstands load without failure allowed early mobilization and achieved good functional results .

Detailed clinical and radiological assessment of fracture, careful preoperative planning, meticulous dissection, precision in surgical technique (coverage of plate with soft tissue) and choosing the correct implant (low profile plate) are critical in achieving good results and minimising the complication .

MASTER CHART

S. NO	AGE IN YEARS	SEX M/F	MODE OF INJURY	DIAGNOSIS	SIDER/L	NO OF METACARPALS INVOLVED	FRACTURE PATTERN	TIMING OF SURGERY (Days)	ASSOCIATED INJURIES	UNION TIME (Weeks)	RANGE OF MOVEMENTS (Degrees)	RETURN TO WORK (Weeks)	POSTOP COMPLICATIONS	FUNCTIONAL OUTCOME BY TOTAL ACTIVE FUNCTION SCORE
1	30	F	Fall	# Shaft of 2nd metacarpal	R	1	Spiral	2	-	6	250	7	-	Excellent
2	23	M	RTA	# Shaft of 3rd metacarpal	L	1	Spiral	1	-	6	250	7	-	Excellent
3	62	M	Fall	# Neck of 5th metacarpal	R	1	Transverse, Comminuted	2	-	7	200	10	-	Good
4	47	F	Assault	# Shaft of 5th metacarpal	R	1	Comminuted	2	# Shaft of ulna	8	190	14	-	Good
5	36	M	Fall	# Shaft of 4th metacarpal	R	1	Long oblique	1	-	6	250	7	-	Excellent
6	51	M	RTA	# Shaft of 3rd, 4th metacarpal	L	2	Transverse	2	# Shaft of 5th metatarsal Rt foot	9	200	14	Stiffness	Poor
7	24	M	RTA	Extra Articular # base of thumb	R	1	Transverse	1	-	7	130	9	-	Excellent
8	21	M	RTA	Extra Articular # Base of thumb	R	1	Transverse	1	-	8	130	10	-	Excellent
9	45	M	RTA	# Shaft of 2nd,3rd, 4th,5th metacarpal	L	4	Transverse	7	#shaft of both bone leg left	12	640	16	Stiffness	fair
10	28	M	RTA	#head of 2nd metacarp	L	2	Oblique	1	-	7	230	8	-	Excellent

				al,#shaft of 3rd metacarpal										
11	35	M	FALL	#shaft of 2nd metacarpal	R	1	Spiral	1	-	6	250	7	-	Excellent
12	40	M	RTA	#shaft of 3rd metacarpal	R	1	Spiral	1	-	6	240	7	-	Excellent
13	39	M	RTA	# shaft of 4th,5th metacarpal	L	2	Transverse	2	-	8	460	10	-	Excellent
14	45	M	RTA	# shaft of 2nd,3rd metacarpal	L	2	Transverse	2	Isolated fibula #	8	460	12	Superficial infection	Excellent
15	55	M	FALL	#neck of 5th metacarpal	L	1	Transverse ,communited	1	-	8	230	10	-	Excellent
16	23	M	RTA	#shaft of 5th metacarpal	R	1	Transverse	1	-	7	230	9	-	Excellent
17	32	M	RTA	# shaft of 4th metacarpal	R	1	Spiral	1	-	6	250	7	-	Excellent
18	45	M	FALL	#shaft 2nd metacarpal	L	1	Spiral	1	-	6	240	7	-	Excellent
19	29	M	ASSAULT	# shaft of 5th metacarpal	L	1	Transverse	2	-	7	240	8	-	Excellent
20	35	M	FALL	#shaft of 4th,5th metacarpal	R	2	Spiral	1	-	6	450	7	superficial infection	Excellent

ANNEXURE - I

P R O F O R M A

Case No :

NAME : I.P. No :

AGE/SEX

D. O. A :

EDUCATION: D.O.S :

OCCUPATION: D. O. D :

ADDRESS :

CONSULTANT:

1. PRESENTING COMPLAINTS

2. HISTORY OF PRESENT ILLNESS

Mode of injury-Direct / Indirect – RTA

- Assault

- Fall on outstretched hand

- Others

Duration / side affected

3. First Aid Measures immediate

4. Past History

5. Family history

6. Personal History

Occupation: Nature of work

Diet : vegetarian / non vegetarian / mixed

Habits : Smoker / Alcoholic / none

EXAMINATION:

1. General physical examination:

Built:

Vitals - Pulse_____ Beats/min Temp_____ °C

B. P;_____ mm of Hg R.R--Cycles/min

2. Systemic examination

CVS

RS

PA

CNS

3. Local Examination:

Inspection:

Side

Attitude

Swelling

Deformity

Wounds

Others

Palpation:

Tendernes

Crepitus

Distal pulses Radial artery Ulnar artery

Neurological examination of Peripheral Nerves-Basic

Motor

Sensory

Radial Nerve

Ulnar Nerve

Median Nerve

4. Associated injuries:

5. Complications:

INVESTIGATIONS:

Blood routine- Hemoglobin, Total WBC count

Differential count, ESR

BT, CT, prothrombin time

RBS, B. urea, S.creatinine

HIV 1 and 2, HbsAg

Urine routine

X-ray Hand – AP,Oblique

Level of fracture

Displacement

Type of fracture

X-ray chest PA View and ECG – if patient is more than 40 years

TREATMENT:

1. Pre-operative treatment:

Volar Below Elbow POP slab

Antibiotics, tetanus toxoid

Analgesics

Preoperative evaluation

2. Surgical procedure:

Type of anaesthesia - GA/brachial block

Duration of surgery

Approach - Dorsal

Operative findings

Operative Complications

Difficult reduction Stable/Unstable

Placement of Plate and Screws

3. Post operative:

Post operative Immobilisation Type and Duration

Antibiotics

Suture removal

Complications

4. Advice on Discharge

5. Duration of Hospital stay

6. Follow up

Parameters	**6th week**	**3 months**	**6 months**
Pain			
Radiograph (union)			
Flexion at MCP,IP jts			
Finger grip			
Pinch strength			

ANNEXURE – II

CONSENT FORM

FOR OPERATION/ANAESTHESIA

I_____ Hosp. No._____ in my full senses hereby give my full

consent for _____ or any other procedure deemed fit which is a diagnostic

procedure / biopsy / transfusion / operation to be performed on me / my son / my daughter / my ward_____age under any anaesthesia deemed fit. The nature, risks and complications involved in the procedure have been explained to me in my own language and to my satisfaction. For academic and scientific purpose the operation/procedure may be photographed or televised.

Date:

Signature/Thumb Impression

of Patient/Guardian

Name:

Designation Guardian Relation ship

Full address

Ref.No.6506/E1/5/2014

Madurai Medical College,
Maduai -20 Dated: 11.08.2014.

Institutional Review Board/Independent Ethics Committee
Capt.Dr.B.Santhakumar,MD (FM). deanmdu@gmail.com
Dean, Madurai Medical College &
Government Rajaji Hospital, Madurai 625 020 . Convenor

Sub: Establishment – Madurai Medical College, Madurai-20 –
Ethics Committee Meeting – Meeting Minutes - for August 2014 –
Approved list – reg.

The Ethics Committee meeting of the Madurai Medical College, Madurai was held on 05th August 2014 at 10.00 Am to 12.00 Noon at Anaesthesia Seminar Hall at Govt. Rajaji Hospital, Madurai . The following members of the Ethics Committee have attended the meeting.

1.Dr.V.Nagarajan,M.D.,D.M(Neuro) Ph: 0452-2629629 Cell No.9843052029 nag9999@gmail.com.	Professor of Neurology (Retired) D.No.72, Vakkil New Street, Simmakkal, Madurai -1	Chairman
2.Dr.Mohan Prasad, MS.M.Ch. Cell.No.9843050822 (Oncology) drbkcmp@gmail.com	Professor & H.O.D of Surgical Oncology (Retired) D.No.32, West Avani Moola Street, Madurai.-1	Member ecretary
3. Dr.L.Santhanalakshmi, MD (Physiology) Cell No.9842593412 dr.l.santhanalakshmi@gmail.com.	Vice Principal, Prof. & H.O.D. Institute of Physiology Madurai Medical College	Member
4.Dr.K.Parameswari, MD(Pharmacology) Cell No.9994026056 drparameswari@yahoo.com.	Director of Pharmacology Madurai Medical College.	Member
5.Dr.S.Vadivel Murugan, MD., (Gen.Medicine) Cell No.9566543048 svadivelmurugan_2007@rediffmail.com.	Professor & H.O.D of Medicine Madurai Medical College	Member
6.Dr.A.Sankaramahalingam, MS., (Gen. Surgery) Cell.No.9443367312 chandrahospitalmdu@gmail.com	Professor & H.O.D. Surgery Madurai Medical College.	Member
7.Mrs.Mercy Immaculate Rubalatha, M.A., Med., Cell.No.9367792650 lathadevadoss86@gmail.com	50/5, Corporation Officer's Quarters, Gandhi Museum Road, Thamukam, Madurai-20.	Member
8.Thiru.Pala.Ramasamy, B.A.,B.L., Cell.No.9842165127 palaramasamy2011@gmail.com	Advocate, D.No.72,Palam Station Road, Sellur, Madurai-20.	Member
9.Thiru.P.K.M.Chelliah, B.A., Cell No.9894349599 pkmandco@gmail.com	Businessman, 21 Jawahar Street, Gandhi Nagar, Madurai-20.	Member

The following Project was approved by the Ethical Committee

Name of P.G.	Course	Name of the Project	Remarks
Dr.V.Mohankrishnan mohankrishnaortho@gmail.com	PG in MS (Orthopaedic) Madurai Medical College, and Govt. Rajaji Hospital, Madurai	Functional outcome of closed metacarpal Fractures Treated Mini Fragment plates and screws – A prospective study.	Approved

Please note that the investigator should adhere the following: She/He should get a detailed informed consent from the patients/participants and maintain it Confidentially.

1. She/He should carry out the work without detrimental to regular activities as well as without extra expenditure to the institution or to Government.
2. She/He should inform the institution Ethical Committee, in case of any change of study procedure, site and investigation or guide.
3. She/He should not deviate the area of the work for which applied for Ethical clearance. She/He should inform the IEC immediately, in case of any adverse events or Serious adverse reactions.
4. She/He should abide to the rules and regulations of the institution.
5. She/He should complete the work within the specific period and if any Extension of time is required He/She should apply for permission again and do the work.
6. She/He should submit the summary of the work to the Ethical Committee on Completion of the work.
7. She/He should not claim any funds from the institution while doing the work or on completion.
8. She/He should understand that the members of IEC have the right to monitor the work with prior intimation.

Member Secretary
Ethical Committee

Chairman
Ethical Committee

19.8.14
DEAN/Convenor
Madurai Medical College & Govt.
Rajaji Hospital, Madurai- 20.

To
The above Applicant
-thro. Head of the Department concerned

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