PROSPECTIVE STUDY OF FUNCTIONAL OUTCOME ANALYSIS OF MINI EXTERNAL FIXATOR IN SHORT LONG BONES

Dissertation Submitted to

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for the award of

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BRANCH II

DEPARTMENT OF ORTHOPAEDICS

TIRUNELVELI MEDICAL COLLEGE

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY

CHENNAI, INDIA

APRIL 2016

CERTIFICATE

This is to certify that this dissertation titled "**PROSPECTIVE STUDY OF FUNCTIONAL OUTCOME ANALYSIS OF MINI EXTERNAL FIXATOR IN SHORT LONG BONES** is a bonafide work done by **DR S.A.KARTHI CUMARAN** Post graduate student in the department of Orthopaedics, Tirunelveli Medical College Hospital.

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This is to certify that the work entitled "**PROSPECTIVE STUDY OF FUNCTIONAL OUTCOME ANALYSIS OF MINI EXTERNAL FIXATOR IN SHORT LONG BONES"** which is being submitted for M.S.ORTHOPAEDICS is a bonafide work done by **Dr. S.A.KARTHI CUMARAN,** Postgraduate student in the department of Orthopaedics, Tirunelveli Medical College Hospital, Tirunelveli.

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

Recommended and Forwarded

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This is to certify that the work entitled "**PROSPECTIVE STUDY OF FUNCTIONAL OUTCOME ANALYSIS OF MINI EXTERNAL FIXATOR IN SHORT LONG BONES"** which is being submitted for M.S.ORTHOPAEDICS is a work done by **Dr. S.A.KARTHI CUMARAN,** Postgraduate student in the department of Orthopaedics, Tirunelveli Medical College Hospital, Tirunelveli under my guidance.

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I **Dr. S.A.KARTHI CUMARAN,** solemnly declare that this dissertation titled "**PROSPECTIVE STUDY OF FUNCTIONAL OUTCOME ANALYSIS OF MINI EXTERNAL FIXATOR IN SHORT LONG BONES ''** was prepared by me at Tirunelveli Medical College Hospital under the guidance of Prof & HOD **DR.ELANGOVAN CHELLAPPA,** Tirunelveli medical College Hospital, Tirunelveli in partial fulfillment of Dr.M.G.R.Tamilnadu Medical University regulations for the award of M.S.Degree in Orthopaedics.

I have not submitted this dissertation to any other university for the award of any degree or diploma previously.

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ETHICAL COMMITTEE CERTIFICATE

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PROTOCOL TITLE: PROSPECTIVE STUDY OF FUNCTIONAL OUTCOME ANALYSIS OF MINI EXTERNAL FIXATOR IN SHORT LONG BONES.

NAME OF PRINCIPAL INVESTIGATOR: Dr. Karthi Cumaran S.A, MBBS.,
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Dear Dr. Karthi Cumaran, *The Tirunelveli Medical College Institutional Ethics Committee (TIREC) reviewed and discussed your application during the IEC meeting held on 14.05.14.*

THE FOLLOWING DOCUMENTS WERE REVIEWED AND APPROVED

1. TIREC Application Form ☐
2. Study Protocol ☐
3. Department Research Committee Approval ☐
4. Patient Information Document and Consent Form in English and Vernacular Language ☐
5. Investigator's Brochure ☐
6. Proposed Methods for Patient Accrual Proposed ☐
7. Curriculum Vitae of the Principal Investigator ☐
8. Insurance /Compensation Policy ☐
9. Investigator's Agreement with Sponsor ☐
10. Investigator's Undertaking ☐
11. DCGI/DGFT approval ☐
12. Clinical Trial Agreement (CTA) ☐
13. Memorandum of Understanding (MOU)/Material Transfer Agreement (MTA) ☐
14. Clinical Trials Registry-India (CTRI) Registration ☐

THE PROTOCOL IS APPROVED IN ITS PRESENTED FORM ON THE FOLLOWING CONDITIONS

1. The approval is valid for a period of 2 year/s or duration of project whichever is later
2. The date of commencement of study should be informed
3. A written request should be submitted 3weeks before for renewal / extension of the validity
4. An annual status report should be submitted.
5. The TIREC will monitor the study
6. At the time of PI's retirement/leaving the institute, the study responsibility should be transferred to a person cleared by HOD
7. The PI should report to TIREC within 7 days of the occurrence of the SAE. If the SAE is Death, the Bioethics Cell should receive the SAE reporting form within 24 hours of the occurrence.
8. In the events of any protocol amendments, TIREC must be informed and the amendments should be highlighted in clear terms as follows:
    a. The exact alteration/amendment should be specified and indicated where the amendment occurred in the original project. (Page no. Clause no. etc.)
    b. The PI must comment how proposed amendment will affect the ongoing trial. Alteration in the budgetary status, staff requirement should be clearly indicated and the revised budget form should be submitted.
    c. If the amendments require a change in the consent form, the copy of revised Consent Form should be submitted to Ethics Committee for approval. If the amendment demands a re-look at the toxicity or side effects to patients, the same should be documented.
    d. If there are any amendments in the trial design, these must be incorporated in the protocol, and other study documents. These revised documents should be submitted for approval of the IEC, only then can they be implemented.
    e. Approval for amendment changes must be obtained prior to implementation of changes.
    f. The amendment is unlikely to be approved by the IEC unless all the above information is provided.
    g. Any deviation/violation/waiver in the protocol must be informed

STANDS APPROVED UNDER SEAL

14/10/2014

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PLAGIARISM CERTIFICATE

CONTENTS

INTRODUCTION

Fractures of the miniature long bones are the most common fractures of the extremities. It includes metacarpal and phalanges fractures in hand , metatarsals and phalanges fractures in foot.

Optimum treatment depends on location of fracture site (intra articular versus extra articular), fracture pattern (transverse, spiral ,oblique ,comminuted),deformity (angular,rotational,shortening), open or closed, associated soft tissue injuries, and stability of fracture. Outcome is also influenced by other factors such as patient's age, occupation, socio economic status, the presence of systemic illness, surgeon's skill and the patient's compliance.

In general, fractures of miniature long bones are classified into stable or unstable fractures. Stable fractures requires minimal immobilization, whereas unstable fractures may require closed or open reduction with internal fixation, external stabilization. Fractures with articular step-off, open fractures (especially in those with bone loss and significant soft-tissue injury), fractures with significant shortening or bone loss, and fractures that fail closed reduction are indications for surgical treatment. Internal fixation should be achieved with minimal soft-tissue disruption in order to limit scarring and disruption of the blood supply of the fractured bone .If this is not possible, protected motion should begin as soon as possible based upon the nature of the fracture and the surgeon's experience.

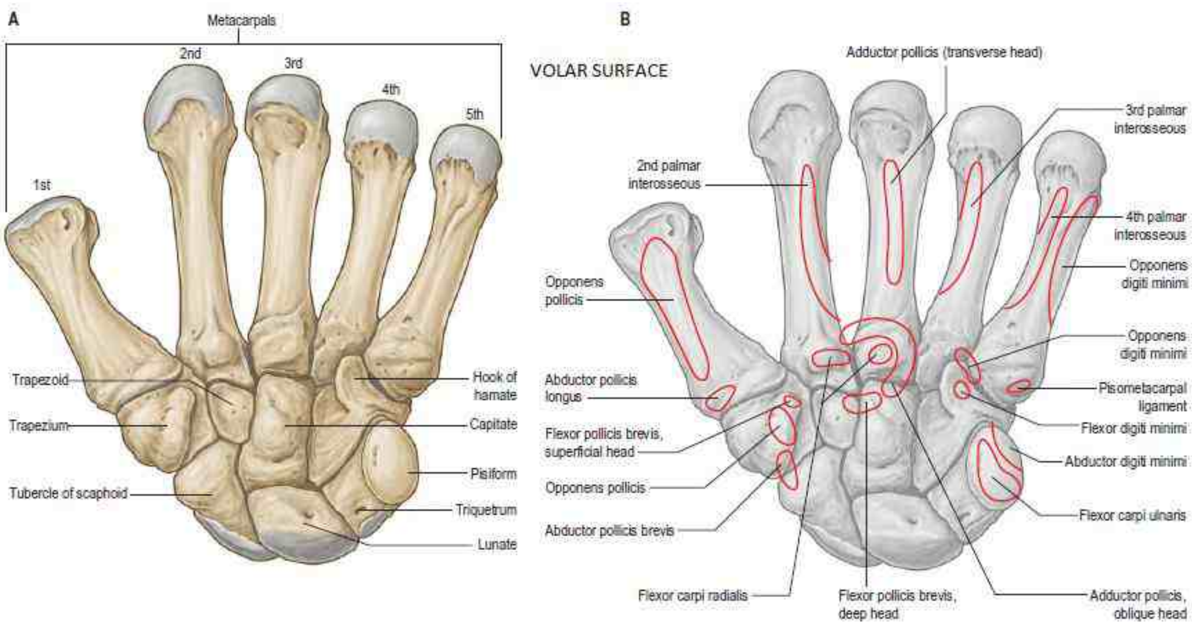
Comminuted fractures are inherently unstable and are more frequently associated with injuries to tendons, nerves, and vascular structures than are simple fractures. Ultimate stiffness correlates with severity of initial injury to bone and soft tissues. Comminuted fractures tend to lead to a higher risk for stiffness than simple fractures.This is especially true of articular fractures as compared with extra articular fractures.

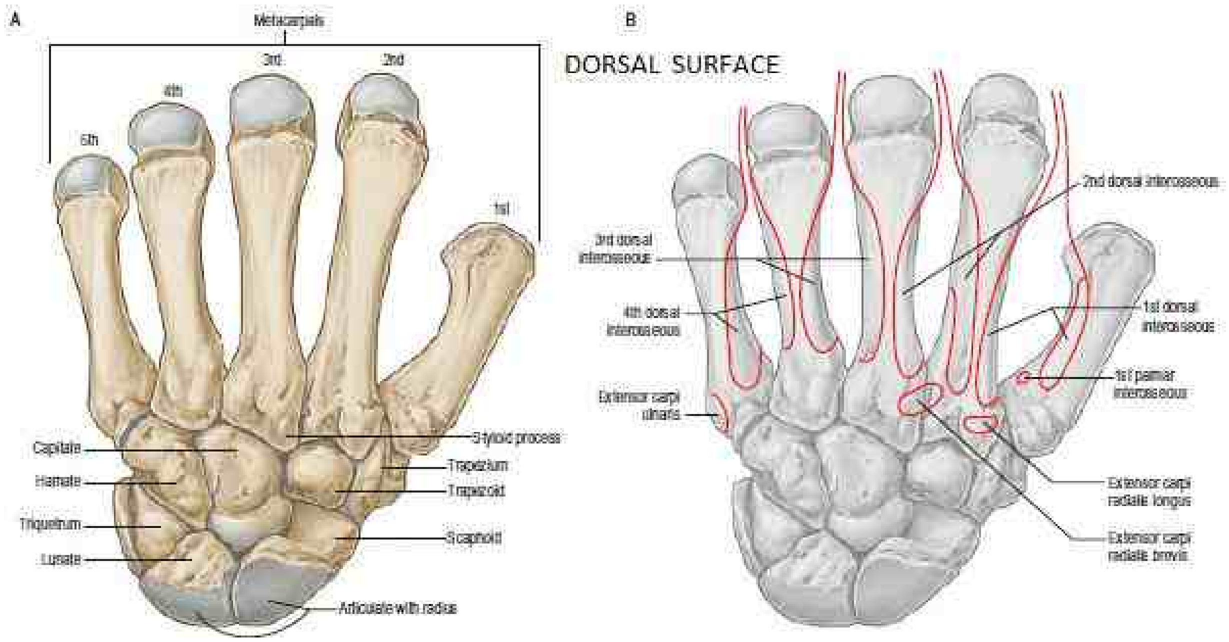
External fixation devices are positioned to avoid compromise to the tendons, so that early motion is not compromised. The fracture was exposed through a longitudinal incision in the extensor tendon, which gave excellent exposure; this stable construct allowed protected motion early. The aftercare and supervised rehabilitation program is very important to achieve maximum recovery and function.Dynamic external fixation methods have been developed for treatment of difficult articular fractures, especially about the PIP joint. These methods are technically challenging . Operating room fluoroscopy units are useful aids in reduction and placement of fixation devices.

ANATOMY OF HAND

METACARPALS

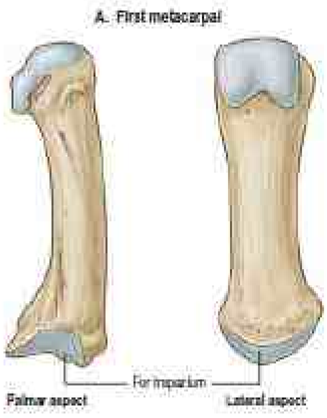
There are five metacarpal bones . These are miniature long bones, consists of head, shaft and base. Metacarpal head are rounded and forms convex articular surface. The metacarpal bases articulates with carpal bones and with other metacarpals , except the first and second. Metacarpal shaft have concave palmar surfaces, which form hollows for the attachment of palmar muscles.The dorsal surface of metacarpal shaft possess a distal triangular area. The medial four metacarpals are divergent. First metacarpal is rotated medially around its axis about 90°, so that its dorsal surface becomes lateral, its radial border comes palmar, its palmar surface comes medial, and its ulnar border becomes dorsal.





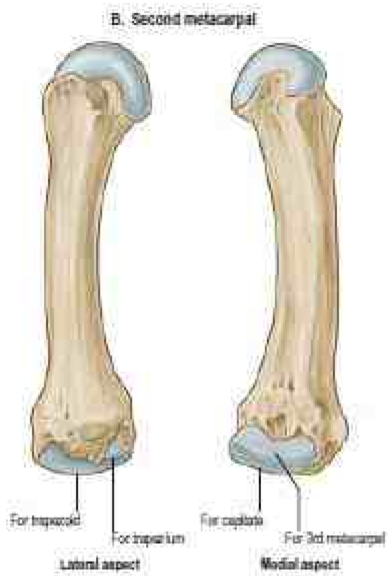
FIRST METACARPAL

The first metacarpal is short and thick. The long axis of the bone is divergent distally . Metacarpal head is less convex.The shaft is flat and broad on the dorsal surface. The palmar (medial) surface is longitudinally concave.Opponens pollicis is attached to the radial border . First dorsal interosseous muscle is attached to the ulnar border . The base of first metacarpal articulates with the trapezium. Abductor pollicis longus is attached to the lateral (palmar) side, the first palmar interosseous muscle is attached to the ulnar side. The head is less convex than in other metacarpals and is transversely broad.



SECOND METACARPAL

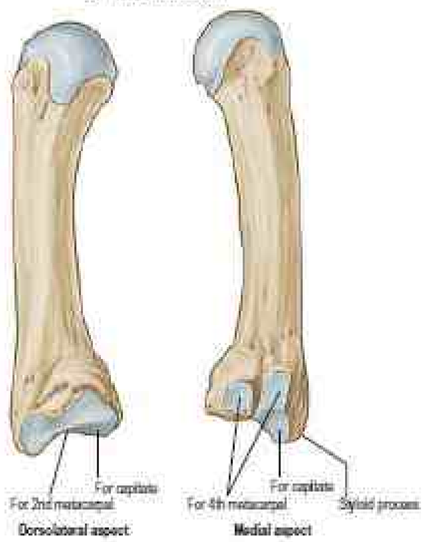
The second metacarpal has the longest shaft and largest base. Base articulates with the trapezoid and is grooved .Deep ridge medial to the groove articulates with the capitate . Quadrilateral facet on the dorsal surface of base articulates with the trapezium.Extensor carpi radialis longus is attached dorsal to this facet. Flexor carpi radialis is attached to the small tubercle on the palmar surface. The medial side of the base articulates with the third metacarpal by a long facet. The medial surface is divided by a faint ridge into two strips. Second palmar interosseous is attached to the palmar strip, the radial head of the second dorsal interosseous is attached to the dorsal strip.



THIRD METACARPAL

Short styloid process is present over the dorsal surface . Base of the third metacarpal articulates with the capitate . Centrally constricted bases articulates with the bases of the second metacarpal and the fourth metacarpal.The palmar surface of the base receives a flexor carpi radialis sends a slip to its palmar surface; extensor carpi radialis brevis sends a slip to the dorsal surface, near the styloid process . Second dorsal interosseous is attached to the lateral surface , third dorsal interosseous is attached to the medial surface, and the transverse head of adductor pollicis is attached to the ridge

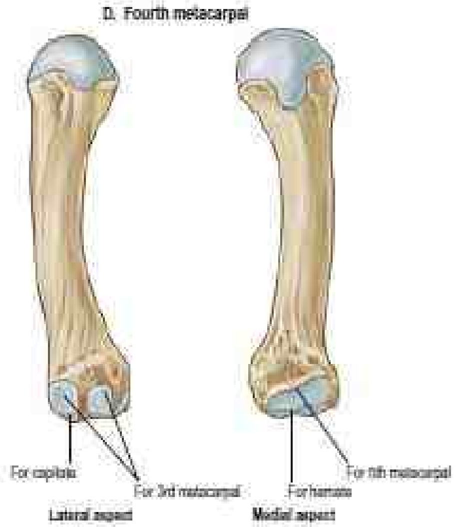
C. Third metacarpal



FOURTH METACARPAL

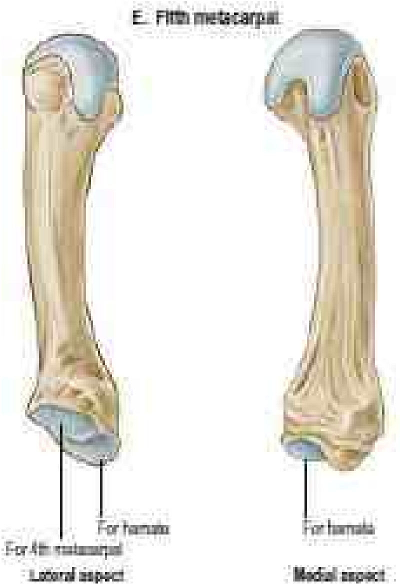
Shorter and thinner . Base articulates with the base of the third metacarpal through lateral facets. Medial facet articulates with the fifth metacarpal base. Third palmar interosseous and the third dorsal interosseous are attached to the lateral surface. Fourth dorsal interosseous is attached to the medial surface.

D. Fourth metacarpal



FIFTH METACARPAL

The medial basal surface is non-articular . The lateral basal surface is articulates with the hamate. Opponens digiti minimi is attached to the medial surface. The fourth palmar interosseous and a the ulnar part of the fourth dorsal interosseous are attached to the lateral surface.



PHALANGES

Each phalanx consists of

1) Head
2) Shaft and
3) Proximal base

The palmar surface is flat. The bases of the proximal phalanges consists of oval facets for articulation with metacarpal heads. The bases of the middle phalanges articulates with the heads of the proximal phalanges by concave facet. The bases of the distal phalanges articulates with the heads of the middle phalanges. Articular ligaments and numerous muscles are attached to the phalanges.A corresponding tendon of flexor digitorum profundus and,on its dorsal surface, extensor digitorum, are attached to the base of each distal phalanx on its palmar surface. A tendon of flexor digitorum superficialis and its fibrous sheath are attached to the sides of a middle phalanx, and a part of extensor digitorum is attached to the base dorsally. A fibrous flexor sheath is attached to the sides of a proximal phalanx, part of the corresponding dorsal interosseous is attached to its base laterally, and another dorsal interosseous is attached medially. The phalanges of the little finger and the thumb differ. Abductor and flexor digiti minimi are attached to the medial side of the base of the proximal phalanx of the little finger. The tendon of extensor pollicis brevis and the oblique head of adductor pollicis (dorsally), and the oblique and transverse heads of adductor pollicis, sometimes conjoined with the first palmar interosseous (medially), are attached to the proximal phalanx of the thumb on its base.The margins of the proximal phalanx are not sharp, because the fibrous sheath is less strongly developed than it is in the other digits.

INTRINSIC MUSCLES OF THE HAND

It consists of three groups and a superficial muscle.

THENAR MUSCLES

Flexor pollicis brevis

Abductor pollicis brevis

Opponens pollicis and

Adductor pollicis

HYPOTHENAR MUSCLES

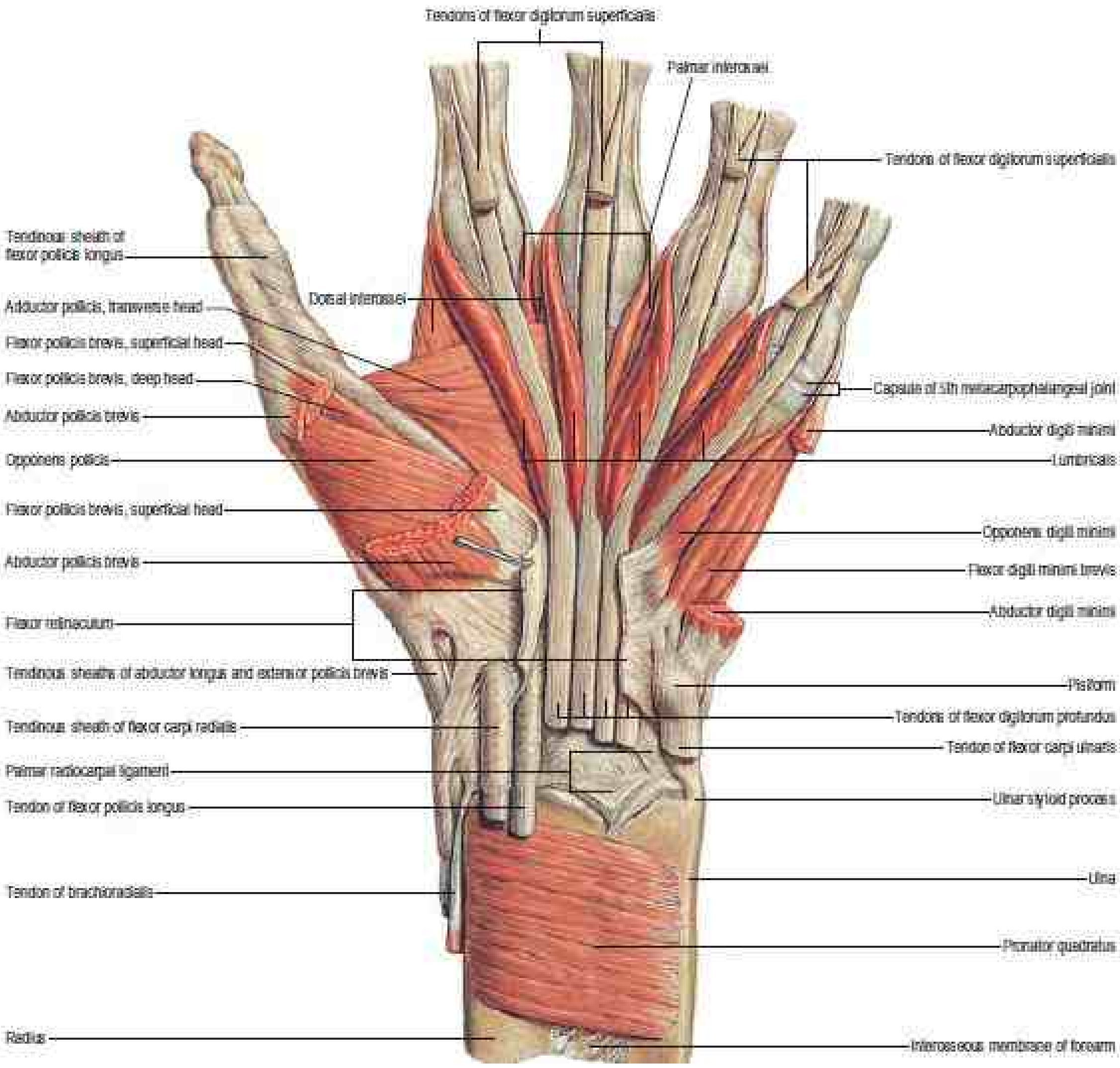
Abductor digiti minimi

Flexor digiti minimi brevis and

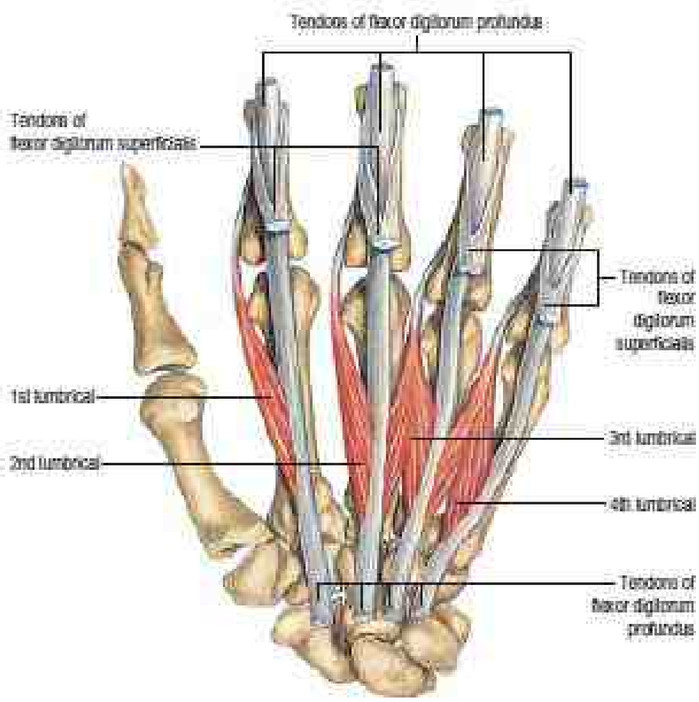
Opponens digiti minimi

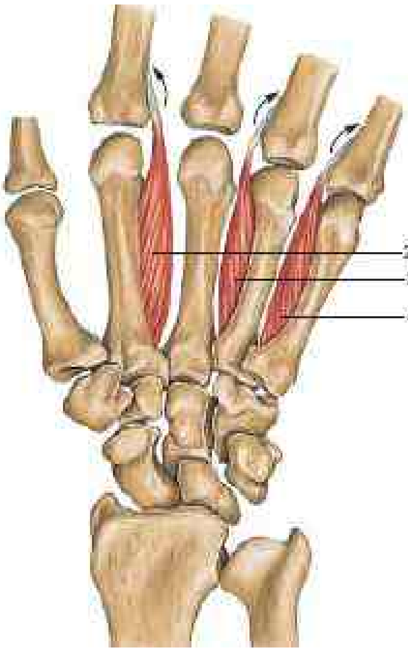
Interossei and lumbricals act on the fingers. Palmaris brevis is a superficial muscle that lies under the palmar skin.

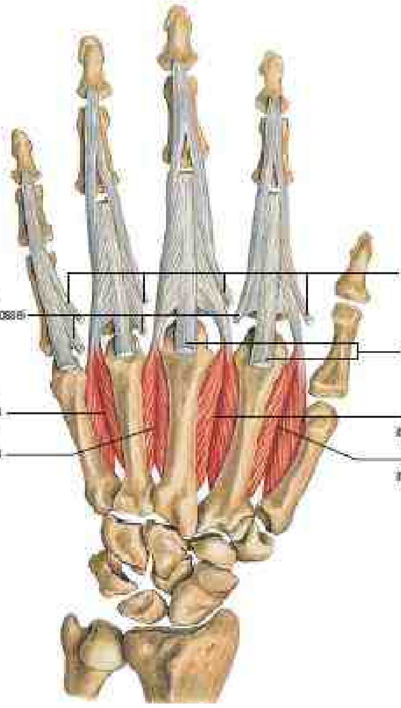
INTRINSIC MUSCLES OF THE HAND



MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
		THENAR COMPARTMENT			
Abductor pollicis brevis [APB]	Scaphoid, trapezium	Lateral proximal phalanx of thumb	Median	Thumb abduction	Palpable in lateral thenar eminence
Flexor pollicis brevis [FPB]	Trapezium	Base of proximal phalanx of thumb	Median	Thumb MCP flexion	Palpable in medial thenar eminence
Opponens pollicis	Trapezium	Lateral thumb MC	Median	Oppose thumb, rotate medially	Opposition is most important action
		ADDUCTOR COMPARTMENT			
Adductor pollicis	1. Capitate, 2nd & 3rd MC	Base of proximal phalanx of thumb	Ulnar	Thumb adduction	Radial artery between its two heads
	2. 3rd Metacarpal				
		HYPOTHENAR COMPARTMENT			
Palmaris brevis [PB]	Transverse carpal ligament [TCL]	Skin on medial palm	Ulnar	Wrinkles skin	Protects ulnar nerve
Abductor digiti minimi [ADM]	Pisiform	Base of proximal phalanx of SF	Ulnar	SF abduction	Palpable laterally
Flexor digiti minimi brevis [FDMB]	Hamate, TCL	Base of proximal phalanx of SF	Ulnar	SF MCP flexion	Palpable medially
Opponens digiti minimi [ODM]	Hamate, TCL	Medial side 5th MC	Ulnar	Oppose SF, rotate laterally	Deep to other muscles in the group







MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
		INTRINSICS			
Lumbricals 1 & 2	FDP tendons (lateral 2)	Lateral bands	Median	Extend PIP, flex MCP	Only muscles in body to insert on their own antagonist.
Lumbricals 3 & 4	FDP tendons (medial 3)	Lateral bands	Ulnar	Extend PIP, flex MCP	
Interosseous: Dorsal [DIO]	Adjacent metacarpals	Proximal phalanx & extensor expansion	Ulnar	Digit abduction	DAB: Dorsal ABduct
Interosseous: Volar [VIO]	Adjacent metacarpals	Proximal phalanx & extensor expansion	Ulnar	Digit adduction	PAD: Palmar Adduct (volar 5 palmar)

ANATOMY OF FOOT

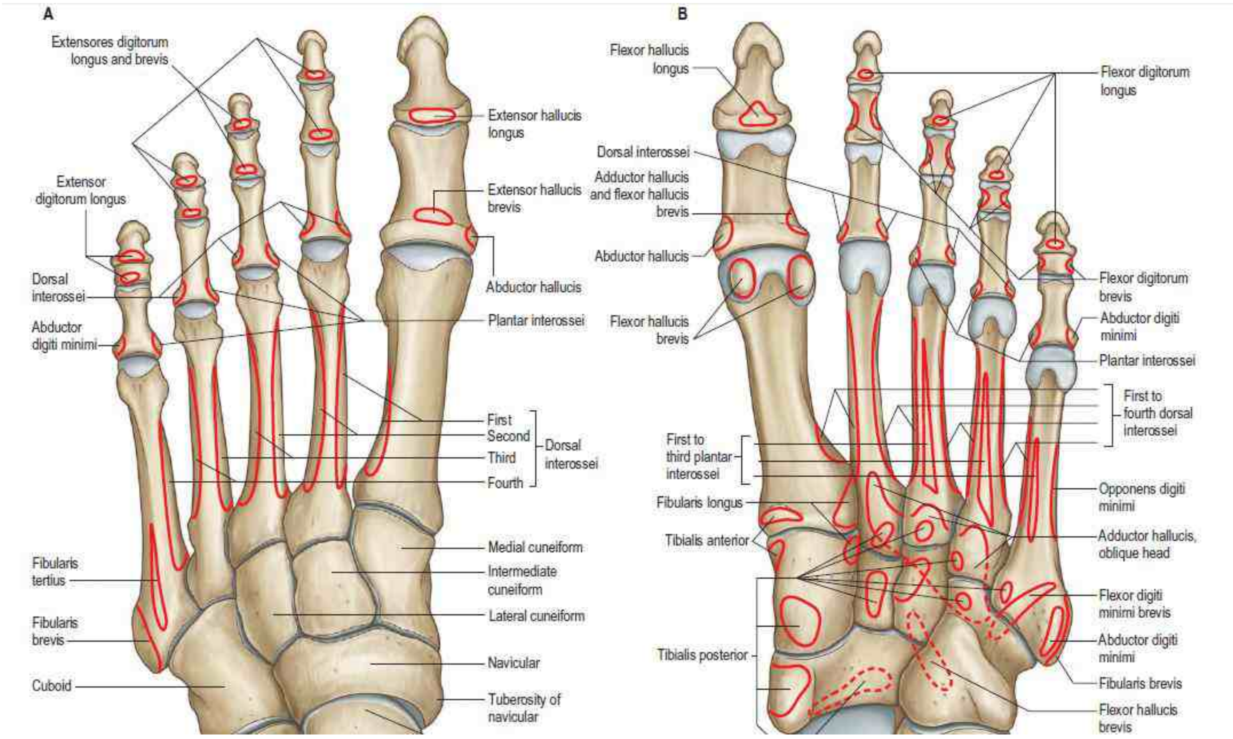
METATARSALS

There are five metatarsal bones connecting the tarsal bones and phalanges. Each metatarsal have a shaft, proximal base and distal head.All metatarsals are long and slender except the first and fifth metatarsals.They have convex dorsal surface and concave plantar surface longitudinally . Prismatic in cross section and they taper distally. Their bases articulate with tarsal bones and adjacent metatarsal bases. Tarsometatarsal joint, inclines proximally and laterally, except the first.Metatarsal bases lie oblique relative to their shafts. The head of the metatarsal articulate with the proximal phalanges. The collateral ligament of the metatarsophalangeal joint is attached to the flat depression on the sides of the head. Os intermetatarseum ,a rare accessory bone is sometimes seen between the medial cuneiform and the bases of the first and second metatarsal bones .

BONE	ANATOMICAL FEATURES	BLOOD SUPPLY	INNERVATION
First metatarsal	Shortest and thickest, large head has a plantar elevation The base sometimes has a lateral facet that articulates with second metatarsal	Via first dorsal & plantar metatarsal arteries & medial plantar artery	Deep fibular and medial plantar nerves
Second metatarsal	Longest .Its base bears four articular facets. The proximal facet is concave and triangular articulates with the intermediate cuneiform, dorsomedial facet with the medial cuneiform,two lateral facets,dorsal and plantar	Via second dorsal & plantar metatarsal arteries & medial plantar artery	Deep fibular and medial plantar nerves
Third metatarsal	Flat triangular base,articulating proximally with the lateral cuneiform, medially with the second metatarsal, , and laterally, with the fourth metatarsal	Via third dorsal & plantar metatarsal arteries & medial plantar artery	Deep fibular and lateral plantar nerves
Fourth metatarsal	The fourth metatarsal is smaller than the third .Its base has quadrilateral facet that articulates with the cuboid; lateral facet articulates with the fifth metatarsal,medial oval facet articulates with the third metatarsal.	Via fourth dorsal & plantar metatarsal arteries & medial plantar artery	Deep fibular and lateral plantar nerves
Fifth metatarsal	It has a tuberosity (styloid process) on the lateral side of its base .The base articulates with the cuboid proximally , and with the fourth metatarsal medially	Via dorsal & plantar metatarsal arteries & medial plantar artery	Sural,superficial fibular & lateral plantar nerves
Phalanges	Two in the hallux, and three in other toes .Sometimes there are only two phalanges in the little toe . The base is concave which articulates with the metatarsal head . Middle phalanges are small and short, but broader .Distal phalanx has a broad base that articulates with the middle phalanx .	Plantar & dorsal digital arteries	Plantar & dorsal digital nerves

MUSCLE ATTACHMENTS TO METATARSALS AND PHALANGES

BONE	MUSCLE ATTACHMENT
First metatarsal	Medially-tendon of tibialis anterior To plantar aspect - tendon of fibular longus To proximal aspect of lateral surface -medial head of first dorsal interosseous
Second metatarsal	To medial surface -lateral head of first dorsal interosseous To lateral surface -medial head of first dorsal interosseous
Third metatarsal	To medial surface -Lateral head of second dorsal interosseous & first plantar To lateral surface -medial head of third dorsal interosseous
Fourth metatarsal	To medial surface -lateral head of third dorsal & second plantar interossei To lateral surface -medial head of fourth dorsal interosseous
Fifth metatarsal	To medial part of dorsal surface & medial border of shaft -tendon of fibularis tertius To dorsal surface of tuberosity -fibularis brevis To plantar surface of base -abductor digiti minimi & flexor digiti minimi brevis To medial side of shaft -Lateral head of fourth dorsal and third plantar interossei
Phalanges	To plantar & dortsal aspects of bases of distal phalanges of lateral four toes -tendon of long digital flexors & extensors To hallux -flexor hallucis longus & extensor hallucis longus To bases of middle phalanges -tendon of flexor digitorum brevis & extensor digitorum brevis Medial side of proximal phalanges of second,third,fourth & fifth toes receive a lumbrical Those of second,third,fourth toes receive an interosseous muscles on both sides



MUSCLES ACTING ON FOOT

EXTRINSIC MUSCLES	ORIGIN	INSERTION	VASCULAR SUPPLY	INNERVATION	ACTION
Anterior group-Tibialis anterior	From lateral condyle & proximal half of two thirds of lateral surface of tibial shaft,anterior surface of interosseous membrane,deep surface of deep fascia	Medial & inferior surfaces of medial cuneiform & part of base of first metatarsal bone	Body by medial & anterior branches of anterior tibial artery,tendon by anterior medial malleolar artery,dorsalis pedis,medial tarsal,medial malleolar & calcaneal branches of posterior tibial artery	Deep fibular nerve,L4 & L5	Dorsiflexor of ankle joint & invertors of foot
Extensor hallucis longus	Middle two-fourths of medial surface of fibula & anterior surface of interosseous membrane	Dorsal aspect of base of distal phalanx of hallux	Anterior tibial artery,anterior medial malleolar,dorsalis pedis,plantar arteries	Deep fibular nerve,L5	Extends phalanges of hallux & dorsiflexes foot
Extensor digitorum longus	Inferior surface of lateral condyle of tibia,prox three quarters of medial	Central slip to base of middle phalanx,2 collateral slips to	Anterior tibial artery,anterior malleolar,lateral tarsal,metatarsal,plantar & digital areries	Deep fibular nerve,L5,S1	Extends lateral four toes,dorsiflexor of ankle,tighten the plantar aponeurosis

	surface of fibulaanterior surface of interosseous membrane,deep surface of deep fascia	base of distal phalanx			
Fibularis tertius	Distal third of medial surface of fibula,anterior surface of interosseous membrane	Medial part of dorsal surface of base of fifth metatarsal bone	Anterior tibial artery,anterior malleolar,lateral tarsal,metatarsal,plantar & digital arteries	Deep fibular nerve,L5,S1	Dorsiflexion of foot & eversion of foot
Lateral group-Fibularis longus	Head & prox two thirds of lateral surface of fibula,deep surface of deep fascia	1 slip to lateral side of base of 1st metatarsal & 1 slip to lateral aspect of medial cuneiform	Superior & inferior branches,circumflex branches of anterior tibial artery,fibular perforating,ant lateral malleolar,lateral calcaneal,lateral tarsal,arcuate,lateral & medial plantar	Superficial fibular nerve,L5,S1	Evert & plantar flex the ankle
Fibularis brevis	Distal two-thirds of lateral surface of fibula	Tubercle on lateral side of base of fifth metatarsal bone	Superior & inferior branches,circumflex branches of anterior tibial artery,fibular perforating,ant lateral malleolar,lateral calcaneal,lateral tarsal,arcuate,lateral & medial plantar	Superficial fibular nerve,L5,S1	Limit inversion of foot,evert & help to steady leg on foot
Posterior group-Gastrocnemius	Medial head from medial condyle & lateral head from lateral surface of lateral condyle	Into a broad aponeurosis that develops on its anterior surface	Branches of popliteal artery	Tibial nerve,S1 & 2	Chief plantar flexor of foot & also a flexor of knee
Plantaris	Lower part of lateral supracondylar line & oblique popliteal ligament	Onto calcaneus	Lateral sural,popliteal arteries,lateral superior genicular artery	Tibial nerve,S1 & 2	Act with gastrocnemius
Soleus	Posterior surface of head & prox quarter of shaft of fibula,soleal line,middle third of medial border of tibia,soleal arch	Joins with gastrocnemius	Superior from popliteal artery & inferior from proximal part of fibular artery	Tibial nerve,S1 & 2	Chief plantar flexor of foot & also a flexor of knee
Deep group-Flexor digitorum longus	Posterior surface of tibia,fascia covering tibialis posterior	Plantar surfaces of bases of their distal phalanges	Branches of posterior tibial artery	Tibial nerve,L5,S1 & 2	Plantar flexors
Flexor hallucis longus	Distal two-thirds of posterior surface of fibula,interosseous membrane,fascia covering tibialis posterior	Plantar aspect of base of distal phalanx	Fibular artery	Tibial nerve,S 1 & 2	Plantar flexors
Tibialis posterior	Medial process from posterior surface of interosseous membrane & lateral area on posterior surface of	On the intermediate cuneiform & bases of second,third &	Branches from posterior tibial & fibular arteries	Tibial nerve,L4,5	Invertor of foot & initiates elevation of heel

	tibia,lateral part from upper two thirds of posterior fibular surface	fourth metatarsal			
Intrinsic muscles-Plantar-First layer					
Abductor hallucis	Flexor retinaculum	Medial side of base of proximal phalanx of hallux	Medial calcaneal branches of lateral plantar artery,medial plantar artery,first plantar metatarsal artery	Medial plantar nerve,S1 & 2	Abduction of hallux
Flexor digitorum brevis	Medial process of calcaneal tuberosity,from central part of plantar aponeurosis	Enter digital tendon sheath accompanied by flexor digitorum longus	Medial & lateral plantar arteries,plantar metatarsal & plantar digital arteries	Medial plantar nerve,S1 & 2	Flexes the four lateral toes at proximal interphalangeal joint
Abductor digiti minimii	Both processes of calcaneal tuberosity,plantar surface of bone between them,from plantar aponeurosis	Lateral side of base of proximal phalanx of fifth toe	Medial & lateral plantar arteries,fourth plantar metatarsal & plantar digital arteries	Lateral plantar nerve,S1,2,3	Flexor of metatarsophalangeal joint of little toe
Second layer-Flexor digitorum accessorius	Medial head to concave surface of calcaneus,lateral head to calcaneus distal to lateral process of tuberosity	Inserts into flexor digitorum longus	Medial & lateral plantar artery & plantar arch	Lateral plantar nerve,S1,2,3	Flexes the lateral four toes
Lumbricals	Arise from the tendons of flexor digitorum longus exxept for first-from medial border of first tendon	End on medial sides of four lesser toes & attached to dorsal digital expansions	Lateral plantar artery,4 plantar metatarsal,dorsal digital arteries	First by medial plantar nerve & others by deep branch of lateral plantar nerve,S2,3	Maintain extension of interphalangeal joints of toes
Third layer-Flexor hallucis brevis	Lateral limb from plantar surface of cuboid,from part of lateral cuneiform & medial limb continuous with lateral division of tendon of tibialis posterior	Medial part blends with tendon of abductor hallucis,lateral with adductor hallucis	Medial & lateral plantar artery,first plantar metatarsal & plantar arch	Medial plantar nerve,S1 & 2	Flexes proximal phalanx of hallux
Adductor hallucis	Oblique head from bases of second,third & fourth metatarsal,from sheath of fibularis longus & transverse head from plantar metatarsophalangeal ligaments of third,fourth & fifth toes & deep transverse metatarsal ligaments	Oblique head medial & lateral parts.Medial part blends with lateral part of flexor hallucis brevis & attached to sesamoid bone of hallux,lateral part joins transverse head & attached to lateral sesamoid bone & to base of first phalanx of hallux	Branches of medial plantar artery,lateral plantar,plantar arch & first to fourth plantar metatarsal arteries	Deep branch of lateral plantar nerve,S2,3	Flexes proximal phalanx of hallux,also stabilizes the metatarsal heads

Flexor digiti minimii brevis	From medial part of plantar surface of base of first metatarsal & from sheath of fibularis longus	Into the lateral side of base of proximal phalanx of minimus,blends laterally with abductor digiti minimii	Arcuate & lateral tarsal arteries,lateral plantar & its digital branch	Superficial branch of lateral plantar nerve,S2,3	Flexes metatarsophalangeal joint of little toe
Fourth layer-Dorsal interossei	By two heads from sides of adjacent metatarsal bones	First into medial side of second toe,other three to lateral sides of 2^{nd},3^{rd},4^{th} toes	Arcuate artery,lateral,medial tarsal,first to fourth plantar,first to fourth dorsal metatarsal,dorsal digital arteries	Deep branch of lateral plantar nerve except fourth which is by superficial branch of lateral plantar nerve	Abduct the toes & also flex metatarsophalangeal joints,extends interphalangeal joints of lesser toes
Plantar interossei	From bases & medial sides of third,fourth & fifth metatarsal bones	Medial sides of bases of proximal phalanges of corresponding toes & into dorsal digital expansions	Lateral plantar,plantar arch,second to fourth plantar metatarsal,dorsal digital arteries of lateral three toes	Deep branch of lateral plantar nerve,except fourth which is by superficial branch of lateral plantar nerve	Adduct third,fourth,fifth toes,flex metatarsophalangeal joints & extend the interphalangeal joints
Extensor muscles-Extensor digitorum & hallucis brevis	From distal part of superolateral surface of calcaneus,from inferior extensor retinaculum	Into dorsal aspect of base of proximal phalanx of hallux,other three to lateral sides of second,third & fourth toes	Fibular artery,anterior lateral malleolar,lateral tarsal,dorsalis pedis,arcuate artery,first,second,third dorsal metatarsal,proximal & distal perforating & dorsal digital arteries	Lateral terminal branch of deep fibular nerve,L5,S1	Assist in extending phalanges of middle three toes,in hallux,assist in extension of metatarsophalangeal joint

PHALANGES OF THE FOOT

There are two phalanges in great toe and three in other toes. Sometimes there are only two phalanges in the little toe . The phalanges of the toes are much shorter and their shafts are compressed from side to side. Middle phalanges are small and short, but broader .Distal phalanges are smaller and flatter. Distal phalanx has a broad base that articulates with the middle phalanx .

FRACTURES OF METACARPALS AND PHALANGES

The incidence of metacarpal and phalanges fractures is more common in males and peaks between 10 to 40 years . In Hand,Thumb and little finger were the most frequently injured.

MECHANISM OF INJURY

The Mechanism of injury includes

1) Magnitude

2) Direction

3) Point of contact

4) Type of force

The high degree of variation with respect to mechanism of injury accounts for the broad spectrum of patterns seen in hand trauma. Axial load leads to shearing articular fractures or metaphyseal compression fractures. Axial loading along the upper extremity also leads to injuries to the carpal bones,forearm, elbow, and shoulder girdle. Bending leads to diaphyseal fractures, which can occur when the hand is trapped by an object and unable to move with the rest of the arm. Torsional force leads to spiral fractures or more complex dislocation patterns.

ASSOCIATED INJURIES

OPEN FRACTURES

Open fractures are common. Clindamycin,vancomycin, and the quinolones are useful agents against MRSA. Aminoglycosides are added for contaminated wounds and penicillin for soil or farm environments. No hard evidence exists to support continuation of antibiotics beyond the initial 24 hours.The exception to this may be bite wounds whose potential for osteomyelitis is significant if the tooth directly penetrates the cortex, allowing the saliva into the cancellous structure.Aggressive and early surgical debridement is done for all bite wounds. As the distal phalanx directly supports the nail matrix,the substantial displacement of the dorsal cortex leads to nail matrix disruption and direct repair is done. Reconstruction of residual open wounds requires the use of flaps. Mostly, transposition flaps will suffice. Sometimes , pedicle or free flaps are used.

TENDON INJURIES

Tendon damage usually occurs with an associated in open combined injuries. Closed extensor tendon ruptures near insertion point are seen associated with distal interphalangeal (DIP) joint injuries and central slip ruptures seen associated with proximal interphalangeal (PIP) joint injuries

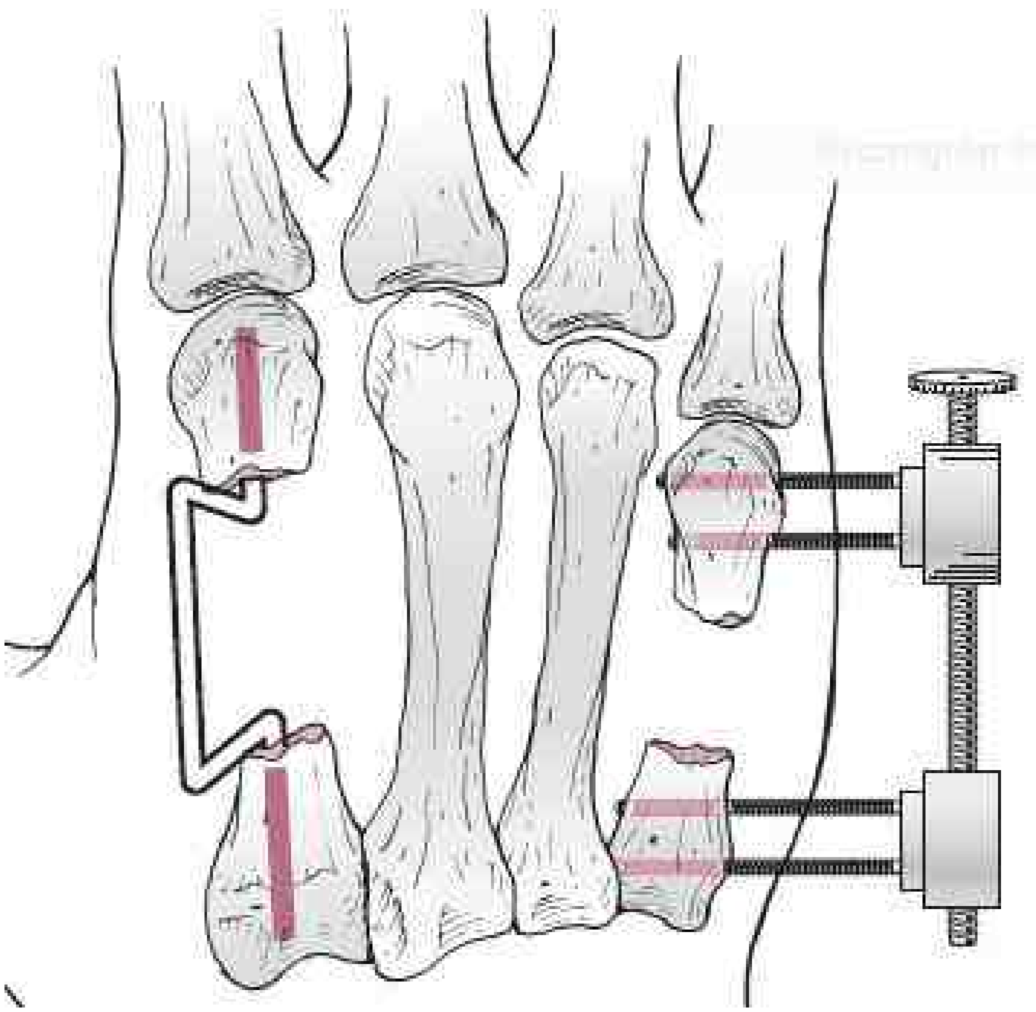
NEUROVASCULAR INJUY

Apart from open combined injuries, these tissues are rarely injured as part of simple fractures and dislocations of the hand. In major open hand trauma, there is usually a significant zone of injury. Excision of the devitalized tissues in the zone of injury including nerve and vessel tissues followed by reconstruction with autogenous grafts or adjacent transfers are done.

BONE LOSS

Segmental bone loss is common in massive hand injuries. Bone grafting is done after wound is rendered clean by single or multiple debridements using corticocancellous bone or cancellous bone. Stable fixation is achieved with either internal plate or external fixator application . With proper debridement, immediate primary bone grafting may also be used. Temporary spacer is used to preserve the volume that will later beoccupied by the graft (DELAYED BONE GRAFTING).Bone loss in the articular surface is filled with autografts of metatarsal head, immediate Silastic prosthetic replacement ,osteoarticular allografts or primary arthrodesis

SPANNING AND MAINTAINING LENGTH



FRACTURES OF METACARPALS AND PHALANGES OF HAND

FRACTURES OF PHALANGES

CLASSIFICATION

LOCATION	PATTERN	SKELETON	SOFT TISSUE	REACTION TO MOTION
Base	Tarnsverse	Simple	Closed	Stable
Shaft	Oblique	Impacted	Open	Unstable
Neck	Spiral	Comminuted		
Condyle (head)	Avulsion			
Epiphysis				

Phalangeal fractures that are stable and nondisplaced can be effectively managed by buddy taping or splint immobilisation. Stability refers to the maintenance of fracture reduction when the adjacent joints are taken through at least 30% of their normal motion However,for successful outcome of many fractures a sophisticated approach is necessary. Each fracture type has its own characteristics and can be influenced by multiple factors. Improper treatment often leads to stiffness and deformity. Fracture factors (intraarticular versus extraarticular) have a major influence on the ultimate result. The intraarticular fractures have a generally poorer prognosis than extraarticular fractures.The stability and alignment are more important than articular congruency in determining the outcome. Likewise, comminuted fractures, those associated with bone loss, and unstable fractures with significant deformity are also prone to residual disability regardless of the method of treatment. There is a direct correlation between the severity of the soft-tissue injury and the final range of motion at follow-up.

In addition, the fractures located in flexor tendon Zone II has the worst prognosis. The final range of motion after proximal phalangeal fractures depends not only on bony union but also on restoration of flexor and extensor excursion, which may be limited, especially when there is an open fracture with soft-tissue compromise. It is concluded that flexor tendon injuries have a more serious effect on recovery of digital mobility than do extensor tendon injuries. Prolonged immobilisation clearly has a detrimental influence. It is safe to immobilise the digit for 3 or fewer weeks. If the immobilisation following a phalangeal fracture is less than 4weeks, final active motion was 80 percent of normal. However, if immobilisation exceeded 4 weeks, total active motion declined to 66 percent of normal.

Finally the successful outcome depends on the selection of the appropriate treatment .The treatment is vast and ranges from buddy straping and short term splinting to the complex methods of internal fixation. Appropriate selection should be tailored to the individual patient and the fracture.

Articular Fractures of the Phalanges

Condylar Fractures:

Type I Stable fractures without displacement,

Type II Unicondylar, unstable fractures, and

Type III Bicondylar or comminuted.

Oblique x-rays are mandatory .Various treatment options include temporary splinting , screw fixation ,mini condylar plate, dynamic traction, external fixation and primary joint arthrodesis as the last resort.

Nondisplaced unicondylar fractures are potentially unstable. Immobilisation in a splint is risky and displacement should be anticipated. If this method of treatment is selected, careful x-ray follow-up is mandatory to avoid a malunion with articular incongruity. Displaced unicondylar fractures are best managed operatively. Postoperatively, early active motion is initiated and the IP joint is splinted in extension to avoid extensor lag. Although open reduction-internal fixation is the standard option for the management of condylar fractures, the results of closed reduction techniques are also satisfactory.The reduction is verified with the image intensifier.

Bicondylar fractures of the proximal phalangeal head are nearly always displaced and often comminuted. Anatomic restoration of articular congruency usually cannot be accomplished by closed manipulation.Open reduction as for unicondylar fractures is advised . First, the two condyles are reduced and fixed to each other with either a screw or Kirschner pins. Next, the head fragment is secured to the shaft in a similar fashion.In such circumstances, skeletal traction through the middle phalanx for 3 ½ to 4 weeks is preferred. The traction is secured to a forearm-based splint to immobilise the proximal phalanx but allow active flexion of the PIP joint. Fracture consolidation can be anticipated, and some articular remodeling will occur. Restoration of full motion is unlikely. Primary arthrodesis is unpredictable and may result in excessive shortening.

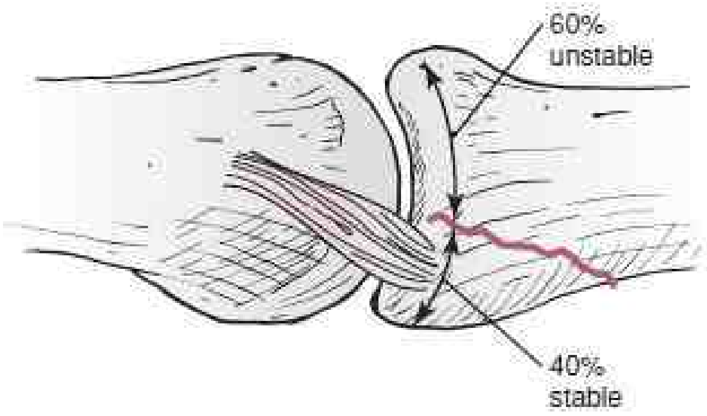
Other Fractures of the Head of the Phalanx

Extensive comminution of the phalangeal head may preclude satisfactory open reduction. These fractures are frequently associated with significant damage to the soft-tissue sleeve and are best treated nonoperatively. Treatment consists of manual molding and traction to restore general alignment, immobilization for 10 to 14 days, and early protected motion. In such fractures,External fixation plays a major role in maintainance of alignment by applying distraction.

Fractures of dorsal base,volar base or lateral base

Dorsal base avulsion fracture of the middle phalanx represent detachment of the insertion of the central tendon and usually the result of an anterior PIP joint dislocation . If the avulsed fragment is displaced more than 2mm , accurate reduction is necessary to prevent extensor lag and subsequent boutenniere deformity. Lateral volar base fracture of the proximal or middle phalanx usually represent the collateral ligament avulsion injuries.Minimally displaced lateral corner fractures that do not compromise joint stability or result in an incongruous articular surface can be treated by splinting for 10 to 14 days , followed by the protected motion. Significantly displaced corner fractures may compromise joint stability. The recommended treatment is open reduction and fixation with the K-wire or tension band wire. Epiphyseal fractures involving the proximal phalanx are opened through a dorsal tendon-splitting incision. Middle phalanx base fractures can be approached laterally by incising the interval between the transverse retinacular ligament and the dorsal apparatus.

"Pilon" fractures are unstable in every direction including axially. Fractures at the volar base of middle phalanx can be particularly unstable in relation to the percentage of articular surface involved. When the volar fragment which carries majority of collateral ligament insertion involves 40% of the articular surface, the dorsal fragment subluxates proximally and dorsally.



Treatment options are

1) Splintage

2) Traction through the middle phalanx

3) Open reduction & internal fixation

4) External fixation

Non articular Fractures of the Phalanges

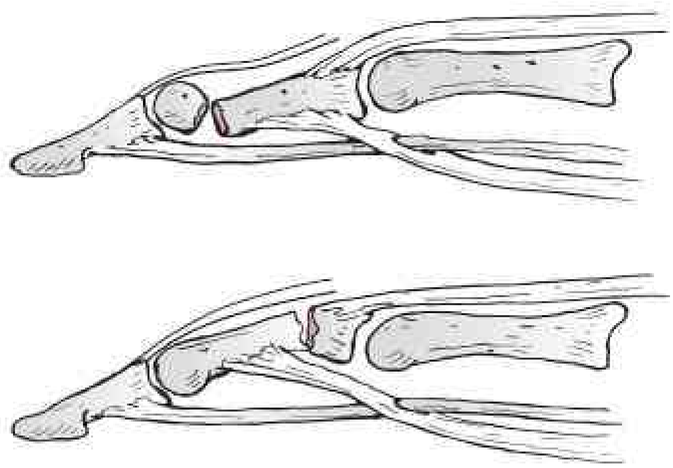
Neck Fractures:

Neck fractures (subcapital) of the phalanges are uncommon in adults and can usually be managed either in closed fashion by reduction and splinting or by percutaneous crossed kirschner pins.

Shaft fractures:

Spiral and oblique fractures are more common in the proximal phalanx, whereas tranverse fractures tend to be more common inthe middle phalanx. Proximal phalangeal fractures angulate volarly, theproximal fragment being flexed by the strong interosseous muscles.

The deformity in middle phalangeal fractures depend on the relationship of the fracture to the superficialis insertion. The flexion of the proximal fragment by the intact tendon in fractures distal to the superficialis insertion produced volar angulation. Fractures proximal to its insertion resulted in flexion of the distal fragment and dorsal angulation of the fracture.. Middle two-fourth fractures could angulate in either direction. In some cases, the type of deformity in displaced middle phalangeal fractures is related to the force and direction of trauma rather than the superficialis pull.



MANAGEMENT

VARIOUS METHODS

1. Closed Reduction with a Cast or Splint:

Earlier manual reduction over a roller bandage with or without the addition of a dorsal splint have been tried. Jahss reduced a proximal phalanx fracture by taping the MCP and PIP joints in full flexion. For fractures of the middle phalanx, the PIP and DIP joints were taped in flexion and left the MCP joint free to move. Later the reduction of fractured proximal phalanx and immobilisation of all the fingers in a flexed position in a plaster was done.

The plaster over the proximal and middle phalanges and proximalportion of the nail was removed to allow intermittent motion of the uninvolved fingers at 10 days and movement of the injured finger at 3 weeks.

The PIP joints are maintained in extension to prevent the collateral ligament contracture that occurs in flexion. Another advocated treatment of proximal phalangeal shaft fractures is by closed reduction and immobilisation in a short arm cast with the wrist held in 30 to 40 degrees of extension. The principle is relaxation of deforming forces through proximal joint positioning such as MP joint flexion to relax the intrinsics or wrist flexion to relax the digital flexor tendons A dorsal plaster extension block is added to hold the MP joints flexed 90 degrees and the IP joints fully extended.

If the immobilisation is prolonged over 3 weeks, 60 percent of the patients had significant loss of hand function. It is also observed that the return of function between 75 and 80 percent of normal in fractured digits mobilised within the first 4 weeks after fracture. However, when the mobilisation is initiated after 4 weeks, only 66 percent return of function resulted.

James' position, 70 degrees of MP flexion and nearly full IP extension, is also useful and should be used whenever possible in treating phalangeal fractures. A forearm-based splint with the wrist extended facilitates maintenance of this position. A rotational deformity is associated with spiral,oblique, comminuted fracture,which is detected clinically.

2.Traction:

Traction can be exerted through the nail plate, the skin or the skeleton. It has the advantage of being minimally invasive and simple; however, traction may be difficult to maintain and is cumbersome. There are excellent results in angulated proximal phalangeal fractures treated by traction . There were no complications, malunions, or nonunions. Traction can either be applied through nail or through a hook on the nail with the MP joint flexed 70 to 90 degrees and the PIP joint in full extension.Complications are relating to the method of application, joint stiffness, difficulty in controlling fracture alignment,and counterpressure problems. Traction has a definitive role in the management of comminuted phalangeal fractures which are not amenable to other treatment options.

3. External Fixation:

External fixation is indicated for open fractures, especially those with concomitant soft-tissue injury such as gunshot wounds, highly comminuted diaphyseal fractures, severely comminuted articular fractures, and fractures with significant loss of bone stock. Advantage include ease of insertion, minimal dissection, preservation of bony length, and it provides access for additional soft-tissue care.

4. Percutaneous Pining:

Percutaneous Kirschner pin fixation has the advantage of stabilizing the fracture and allowing early motion while minimising injury to the soft-tissue sleeve. This technique is particularly useful in shaft fractures that are transverse, spiral or oblique in orientation.

METACARPAL FRACTURES

CLASSIFICATION

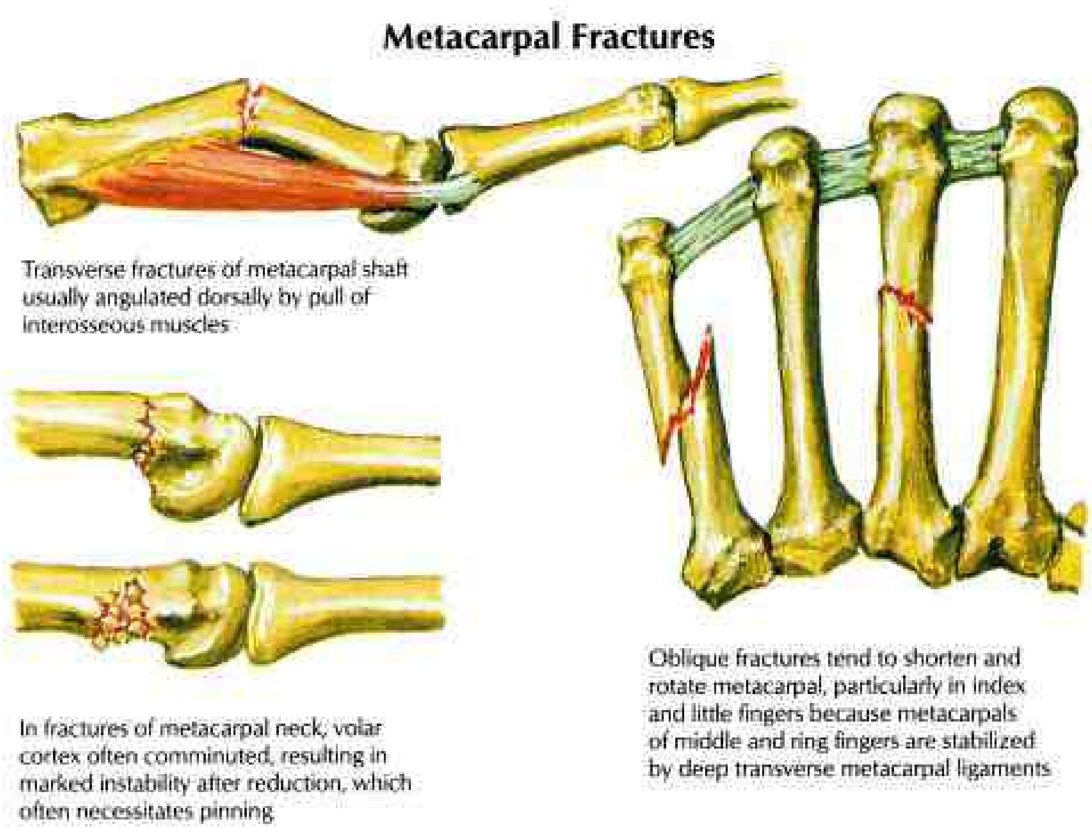
Based on location of fracture,it is classified into

1) Metacarpal head,
2) Neck, and
3) Shaft.
4) Intra-articular fractures

Based on the pattern of fracture ,it is classified into

1) Transverse
2) Oblique
3) Spiral
4) Communited

Aim is to restore a smooth congruent joint surface. Transverse metacarpal neck and shaft fractures will produce apex dorsal angulation. The normal anatomic neck to shaft angle is 15 degrees . Pseudoclawing is produced by dynamic imbalance manifested as a hyperextension deformity of the MP joint and a flexion deformity of the PIP joint as a result of compensatory response to the apex dorsal angulation of the metacarpal fracture (usually at the neck) and it is a indication for correcting the fracture angulation.



Oblique and spiral fractures tend to shorten and rotate more than angulate . As with all hand fractures, evaluation of rotation remains one of the most critical assessments to avoid a functionally disabling malunion.Ten degrees of malrotation (which risks as much as 2 cm of overlap at the digital tip) should represent the upper tolerable limit.

Specialized Radiographic views

1) The Brewerton and Mehara views may show otherwise occult fractures at the metacarpal bases.
2) The Reverse oblique projection allows a more accurate estimation of angulation at the second metacarpal neck.
3) The Skyline view may show vertical impaction fractures of the metacarpal head

Surgical access to the metacarpals is easily achieved through incisions placed over the intermetacarpal valleys and curved distally to avoid entering the digital web commissures.The metacarpals are held tightly bound to each other by strong interosseous ligaments at their bases and by the deep transverse intermetacarpal ligaments distally. These connections help to maintain the transverse arches of the hand, but flattening can occur with multiple metacarpal fractures or crushinginjuries. Shortening of individual metacarpal fractures is limited by these same ligaments (more effectively for the central metacarpals than for the border metacarpals). For each 2 mm of metacarpal shortening, 7 degrees of extensor lag can be expected. One of the weakest points in the metacarpal is the volar aspect of the neck, where comminution is often present. In the sagittal plane, the primary deforming forces are the intrinsic muscles, which can be counteracted through MP joint flexion, an important component of the reduction maneuver for metacarpal fractures. Correction of apex dorsal angulation and rotational control is achieved indirectly by grasping the finger to exert control over the distal metacarpal fragment.

TREATMENT

NON OPERATIVE

An externally applied splint exerts indirect (but not direct) control over fracture position through positioning and reduction of myo tendinous deforming forces. A splint is able to preserve a fracture position that is inherently stable but is not capable of reducing and maintaining an unstable position.

The stability of a metacarpal fracture depends on

1) Periosteum,

2) Adjacent metacarpals,

3) Deep transverse intermetacarpal,

4) Proximal interosseous ligaments,and

5) Degree of initial displacement and comminution.

Splinting should be directed at pain control and neutralization of deforming forces. Surface contact should be as broad as possible with an appropriate amount of padding. The splint may be discontinued as soon as the patient can comfortably perform ROM with the hand and not later than 3 weeks. IP joint motion should begin immediately following injury. A dorsal splint in full MP joint flexion meets the patient's needs well but may be more than is required. Functionally, pseudoclawing is unacceptable. Also, the patient may be troubled by the appearance of a dorsal prominence at the fracture site or a shift in the metacarpal head from its dorsally visible position toward the palm. Only rarely will the shift toward the palm create a functional problem. Each patient may have different degrees of deformity that he or she is willing to tolerate. Greater degrees of angulation are tolerable in neck fractures than in shaft fractures. Greater angulation is tolerable in the ring and small metacarpals than in the index and long metacarpals because of the increased mobility of the ulnar-sided CMC joints .Flexor tendon efficiency is decreased because of slack in the flexor digiti minimi and third volar interosseous occurs with angulations over 30 degrees in the fifth metacarpal neck, at which greatest allowable angulation is possible

OPERATIVE

Metacarpal fractures with significant rotation or shortening cannot be effectively controlled through entirely non operative means

CLOSED REDUCTION AND INTERNAL FIXATION

CRIF is the mainstay of treatment for isolated metacarpal fractures not meeting the criteria for nonoperative treatment.CRIF is done using K wires or external fixation. CRIF may be used for both extra-articular and intra-articular fractures provided that the fracture is anatomically reduced.

INTRAMEDULLARY FIXATION

Intramedullary fixation strategies are used for transverse and short oblique fracture patterns

1) Single large diameter rod such as a Steinmann pin,
2) Expandable intramedullary device,
3) Multiple prebent K-wires, or
4) Specially manufactured devices inserted at the metacarpal base designed to achieve three-point intra medullary fixation

A single Steinmann pin may be inserted open through the fracture site with the two fragments then impacted over it. Rotational control is achieved by fracture fragment interlock, and motion can be started immediately. The wires are prebent so that three point-contact is obtained dorsally at the proximal and distal ends of the metacarpal and volarly at the mid- diaphysis. This bow opposes the natural dorsal convexity of the metacarpal and is the basis for the apparently secure fixation achieved with this technique. The pins are stacked into the canal, filling it and imparting improved rotational control as many as three to five 0.045-inch K wires may be required.

OPEN REDUCTION AND INTERNAL FIXATION

ORIF is the treatment of choice for intra- articular fractures that cannot be reduced and held by closed means. Internal fixation is also required for multiple fractures without inherent stability and for open fractures especially when associated with tendon disruptions. Techniques include

1) Intraosseous wiring,

2) Composite wiring,

3) Screws only, or

4) Screws and plates .

Wiring techniques have traditionally held the advantage over plate and screw application in terms of technical ease and availability of materials. However, with the modular plating systems now available specifically for use in hand surgery, lower profile fixation can be achieved with greater rigidity

EXTERNAL FIXATION

External fixator is used in certain conditions

1) Open metacarpal fractures

2) Communited fractures either intraarticular or extraarticular to maintain length and alignment

3) Metacarpal fractures with bone loss

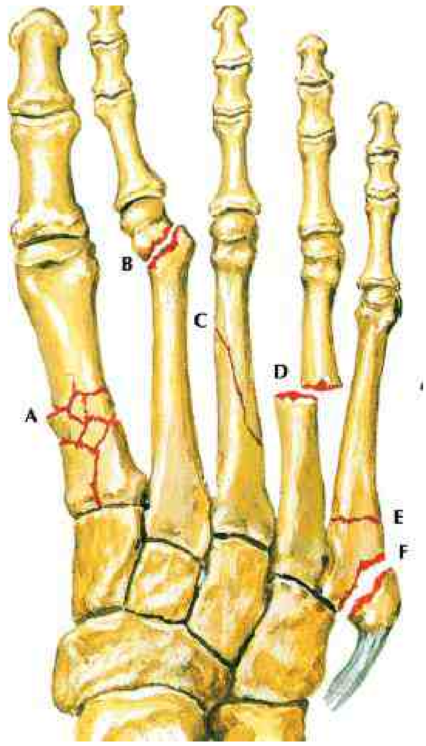
FRACTURES OF METATARSALS AND PHALANGES OF FOOT

METATARSAL FRACTURES

Management of the metatarsal on the site of the fracture in the metatarsal, especially whether the metatarsal is one of the middle metatarsals, which behave differently than the first and fifth. Similarly, multiple metatarsal fractures are treated differently than an isolated metatarsal fracture. Apart from Jones' fracture, there has not been much scientific study of metatarsal fractures, and authors have varied significantly in recommendations about management. A variety of opinions exist on the indications for reduction and internal fixation of these fractures

Based on the fracture pattern

1) Transverse
2) Oblique
3) Spiral
4) Comminuted



First Metatarsal Fractures

The first metatarsal is less commonly fractured, but it requires special consideration. Any shortening of the first metatarsal or plantar or dorsal displacement of the metatarsal head will have an adverse affect on foot function . Intra articular fracture causing loss of movement in the first MTP joint will interfere with the normal progression of gait. Therefore, any displaced fracture of the first metatarsal that allows shortening or angular displacement or impacts the MTP joint requires reduction, either closed or open reduction and fixation.Treatment option depends on the site and comminution of the fracture and possibly related soft-tissue injuries.

FIFTH METATARSAL FRACTURES

Fractures of the fifth metatarsal are common (23% of metatarsal injuries), particularly those associated with inversion injuries. Jones' fracture, although less common, is of clinical and academic interest because of its poor prognosis. The fifth metatarsal is the most mobile of the five, so a small amount of shortening or angular deformity may be less problematic because the fifth metatarsal itself is more adaptable.

Two common fracture patterns that usually do not require surgery are the fracture of the tuberosity of the fifth metatarsal, an avulsion fracture, and the spiral fracture of the fifth metatarsal shaft. Nonoperative treatment of metatarsal fractures, includes

1) Stiff-soled shoe
2) Strapping
3) Short-leg non-weight-bearing cast for 4 to 6 weeks.

Spiral fractures of the fifth metatarsal shaft produce significant pain and swelling, and benefit by a few days of rest, elevation, splinting, and crutches. Once the acute pain and swelling have subsided in both of these injuries , a removable cast device, preferably with some means to control swelling, will enable the patient to walk relatively pain free. A hard-sole shoe does not give sufficient support for the ankle and is moderately uncomfortable for walking. For low-demand patients, if seen immediately after the injury, treat non-weight bearing for 6 weeks in a short-leg cast. Immobilization may be needed for 3 months or more with still no guarantee that the fracture will unite. For those patients with an established nonunion or those who are considered high demand, particularly athletes, it is recommended to peform intramedullary fixation of the fifth metatarsal shaft . In the acute instance, internal fixation alone may be sufficient. In established nonunions, opening the fracture site, debridement of the sclerotic bone, and bone grafting combined with internal fixation are warranted.

SECOND, THIRD, AND FOURTH METATARSAL FRACTURES

If a single metatarsal fracture occurs, it is usually of lower violence, and if the transverse metatarsal ligament is intact, most often there is minimal displacement and closed management is indicated. Displacement of more than 3 to 4 mm or more than 10Â° of angulation requires open reduction and internal fixation. Higher level of energy leads to multiple metatarsal fractures in the foot. More than likely, the ligaments are disrupted and significant shortening or displacement will occur. These metatarsal fractures are often associated with other injuries in the foot and, as previously noted, the amount of morbidity associated with the metatarsal fractures has been underestimated. Dorsal displacement of the metatarsal head or shortening produces transfer metatarsalgia , which can lead to significant disability. It is not clear whether medial or lateral displacement will cause interference with the adjacent metatarsal or inter digital nerve , although anatomically it is certainly feasible. If palpation of the forefoot demonstrates enough displacement of the affected metatarsal head to alter the mechanics of weight bearing, then reduction and fixation are indicated. Closed reduction of a metatarsal without some form of fixation is unlikely to be stable .Closed reduction and pinning of multiple metatarsal fractures rarely results in anatomical position therefore it often requires open reduction.

Open Reduction and K- Wire Fixation

Metatarsal shaft fractures often require open reduction and internal fixation. Fractures of the first metatarsal may require fixation with screws or a plate and screws.Metatarsal neck fractures, particularly of the middle metatarsals, usually can be reduced and fixed with K-wires.

Postoperatively, do not allow patients to bear weight in a splint. K-wires can be removed at 4 to 6 weeks, and weight bearing is then permitted.

External fixation

Compound metacarpal fractures often requires external stabilization for maintainance of length and promote wound healing.It also helps in maintaining length of the column in case of bone loss ,which later may require bone graft.

PHALANGES OF FOOT

They are most common fractures encountered in forefoot. Most of these injuries are neglected .They can be transverse ,oblique, communited intraarticular or extraarticular fractures , avulsion fractures.

Most of these fractures are treated conservatively and hence study regarding the open reduction and internal fixation of phalangeal fractures is not adequate.

Various treatment options are

1) Buddy strapping
2) Short leg cast
3) Open reduction and internal fixation
4) External stabilisation

AIM OF THE STUDY

To evaluate "Functional outcome analysis of mini external fixator in short long bones of hand and foot "in Department of Orthopaedics, Tirunelveli Medical College Hospital, over aperiod of two years from August 2013 to August 2015.

MATERIALS AND METHODS

This is a prospective study of 120 patients carried out in the Department of Orthopaedics ,Tirunelveli Medical College Hospital,Tirunelveli from October 2013 to August 2015

INCLUSION CRITERIA

1) Closed metacarpal and phalangeal fractures of hand
2) Closed metatarsal and phalangeal fractures of foot
3) Open metacarpal and phalangeal fractures of hand
4) Open metatarsal and phalangeal fractures of foot

EXCLUSION CRITERIA

Associated vascular injury

Mode of injury includes road traffic accident, accidental injury,assault, blast injury ,animal bite .Open fractures are managed with thorough wound debridement,antibiotics,and emergency external fixation .Among 50 open wounds 18 patients had tendon injury for whom tendon repair done. 38 patients got primary wound cover . 12 patients required further raw area management.

Closed fractures of hand are evaluated with radiographs and either open or closed reduction with external fixation done under fluoroscopic guidance.Post operative mobilization is started from day 1 .

Finger mobilization and wrist mobilization exercises started from day 1.Post operative radiograph taken and assessed for fracture reduction . patients are followed up at weekly interval for 8 weeks.

External fixator are removed at an average period of 24 days .Functional outcome in hand fractures is analysed using DUNCAN score at the end of 6 weeks.Functional outcome in fractures of foot are analysed using Foot Ankle Disability Index(FADI) at 8 weeks

IMPLANTS AND INSTRUMENTS

1.8mm threaded pins

Mini external fixator (Hinge or Non hinge)

JESS clamps and rods

K wires

Allen key

General instruments

OPERATIVE TECHNIQUE

ANAESTHESIA

For Hand - Supra clavicular block

Wrist block

For Foot - Spinal anesthesia

Ankle block

POSITION

Supine position

PROCEDURE

Closed reduction

Closed reduction is attempted using reduction manuovre and checked under image guidance for anatomical reduction .If the fracture is reduced then pins are applied for external fixator construct.

The position of the pins depends upon

1) Site of the fracture
2) Tendon course
3) Vascular status

Ideally Pins are applied sparing the joint to allow mobilization .But intraarticular communited fractures mandates spanning of involved joint for frame construct.

External fixator pins are applied on the dorsolateral aspect of bone to avoid tendon impingement to allow tendon sliding for active mobilization.Intraarticular placement of Pins are avoided to possible extent to decrease stiffness secondary to synovitis or capsular inflammation

After fracture reduction is achieved ,it is temporarily stabilized using k wires or bone clamps. Pins are then placed .Most distal and most proximal pin is inserted first using T handle after predrilling. Pins are inserted parallel to the joint line and should have adequate bicortical purchase .

Mini external fixator is then fitted to the inserted pins,additional pins are then inserted using fixator as drill guide with adequate bicortical purchase .Once pins are inserted frame is fixed to the pins at 1 cm distance from skin surface.

In Communited fractures of shaft or communited intraarticular fractures ,pins are applied after correcting rotation deformity and external frame applied maintaining length .

OPEN REDUCTION

Open reduction of closed fractures are done if closed reduction failed.Phalanges ,metacarpals and metatarsals are approached using standard approaches and fracture reduction done .Once reduction achieved ,it is stabilized using external fixator.In our study 12 cases of closed fractures are stabilized by open reduction .

OPEN FRACTURES

Thorough wound wash and debridement done immediately with appropriate Antibiotic coverage.As the fracture site is exposed ,fracture is reduced if there is no bone loss and fixed in the same way using external fixator.Post operative antibiotics are continued for an average period of 14 days

4 patients had bone loss and external fixator applied to maintain rotation and length .2 patients required delayed bone grafting .

POST OPERATIVE PROTOCOL

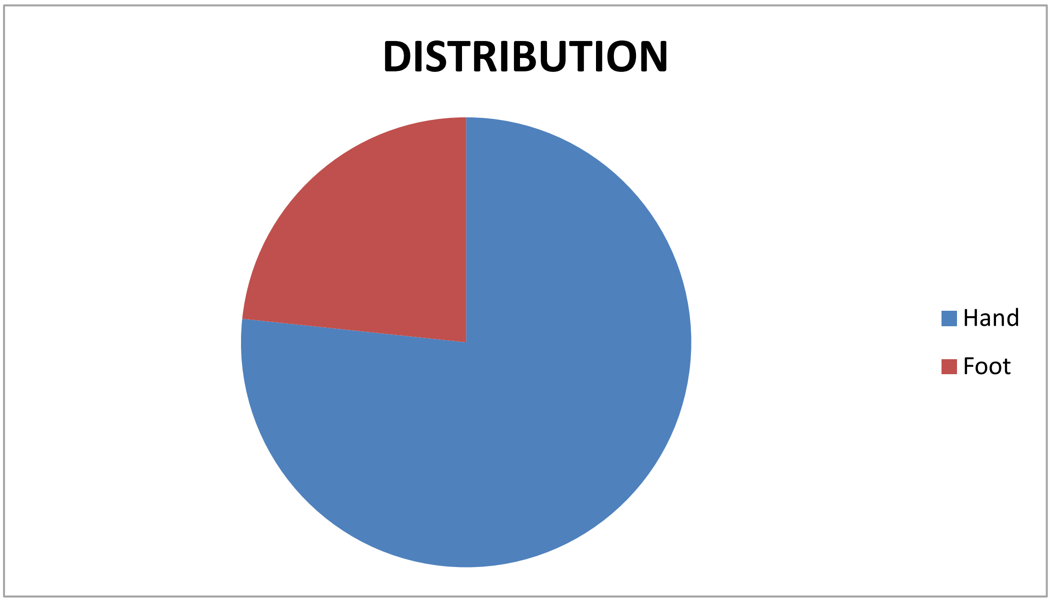
1. Immediate limb elevation on day of surgery
2. Finger and wrist mobilization exercises from day 1 as pain is tolerable
3. Antibiotics for open fractures
4. Daily Pin site dressing
5. Suture removal on 10^{th} day
6. External fixator removed at 3-4 weeks

OBSERVATIONS OF THE STUDY

In the study which consisted of 120 patients of fractures of miniature long bones, conducted from August 2013 to August 2015, the following observations were made.

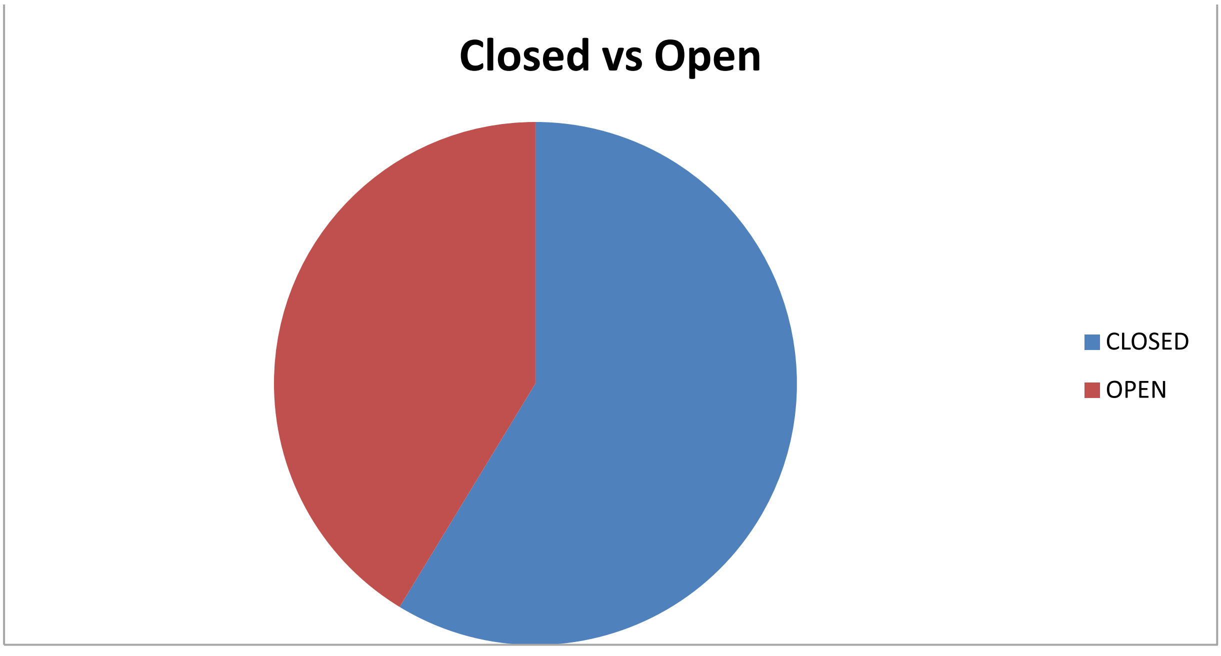
DISTRIBUTION OF FRACTURE

HAND	92	76.6%
FOOT	28	23.3%



HAND FRACTURE

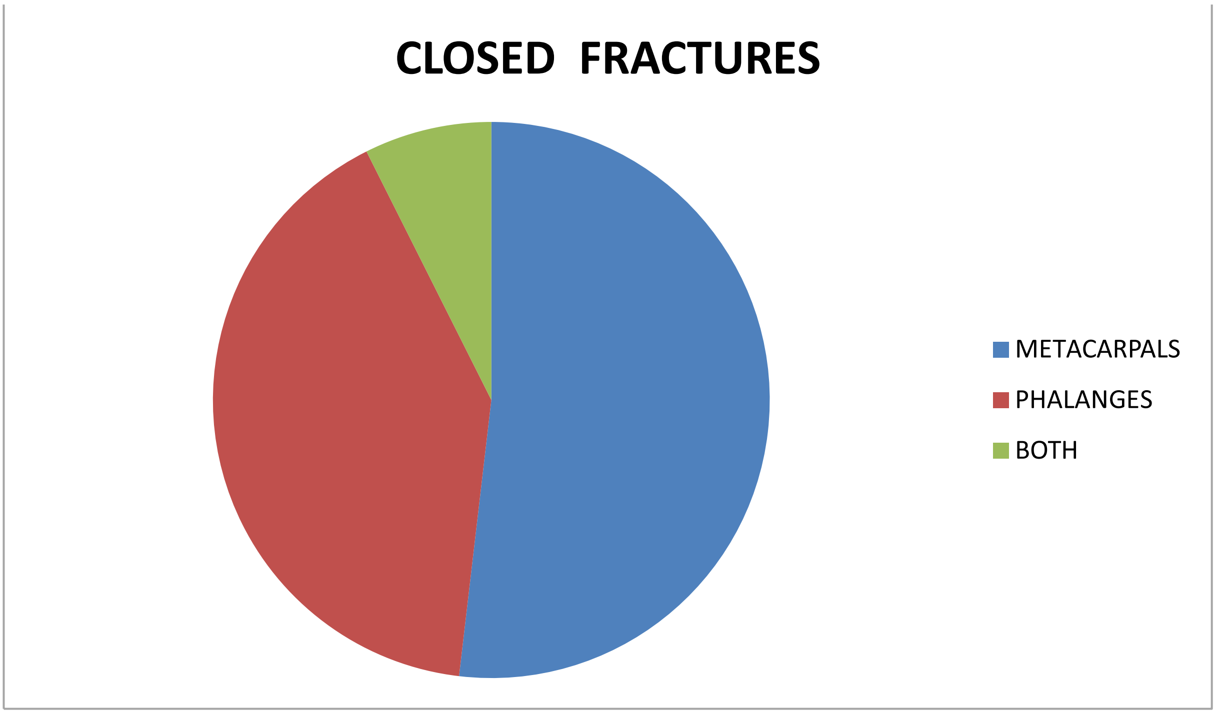
Closed fractures	54	58.7%
Compound fractures	38	41.3%



BONE INVOLVEMENT

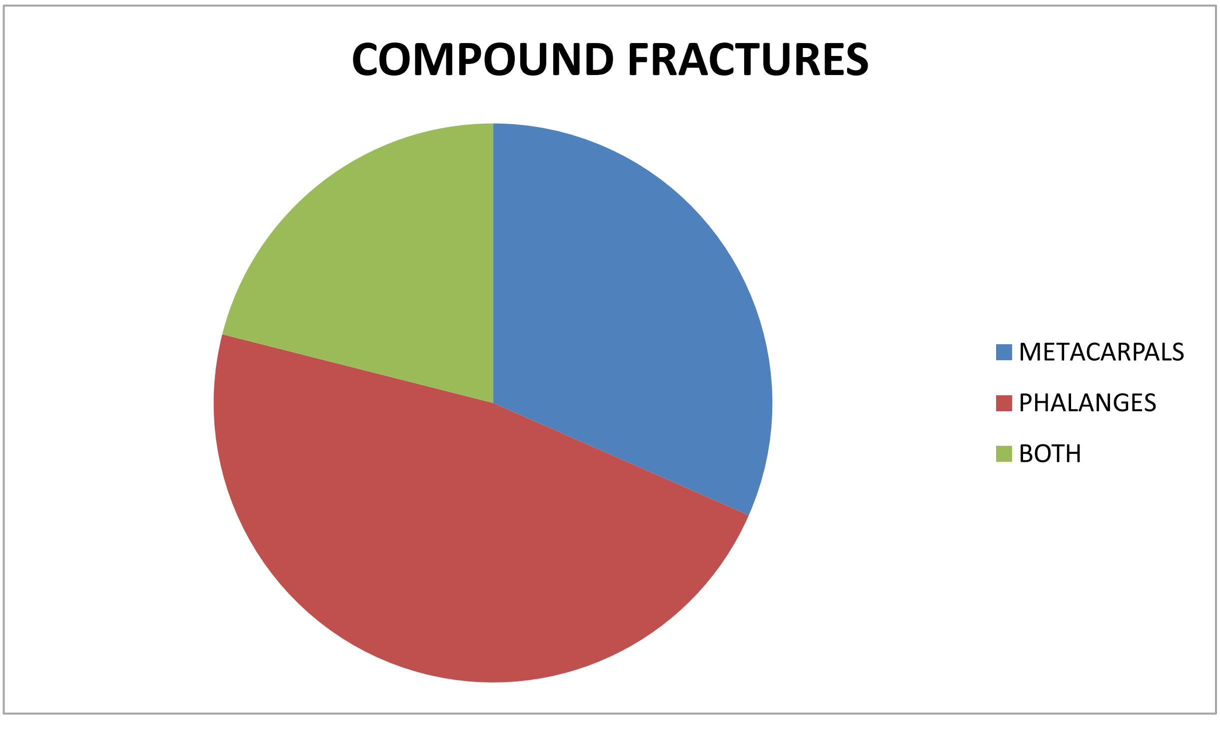
CLOSED FRACTURES

METACARPAL	28	51.9%
PHALANGES	22	40.7%
BOTH	4	7.4%



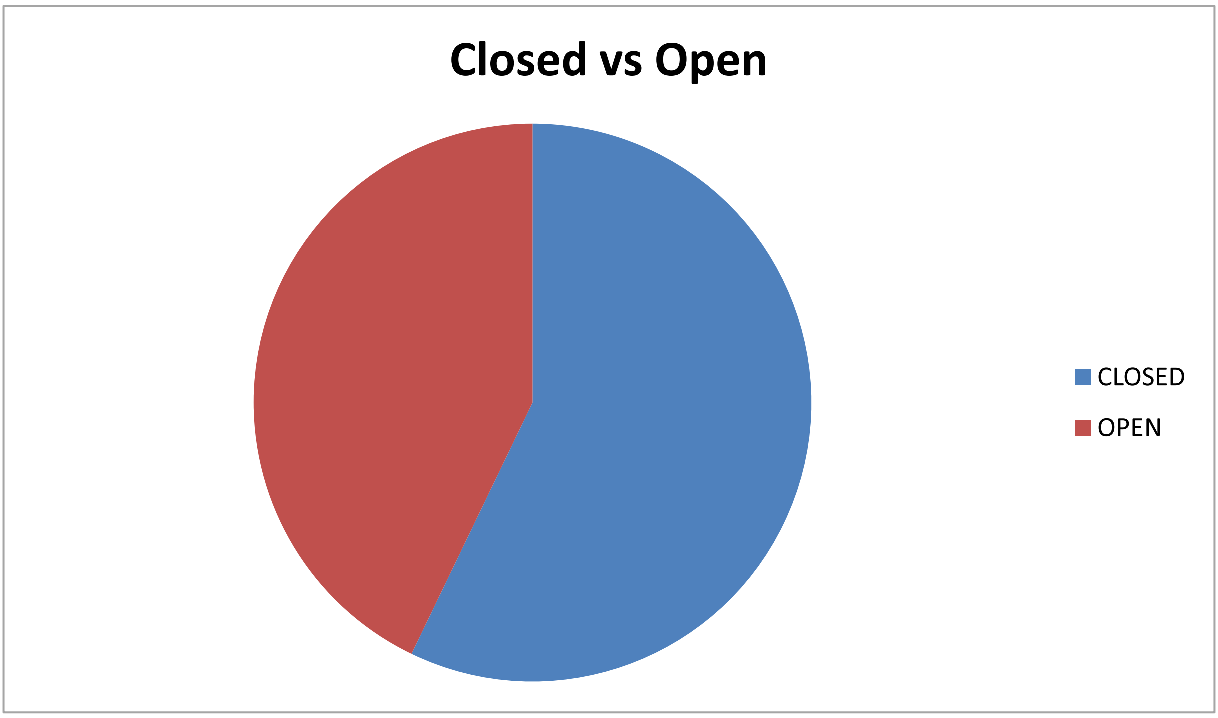
COMPOUND FRACTURES

METACARPALS	12	31.6%
PHALANGES	18	47.4%
BOTH	8	21%



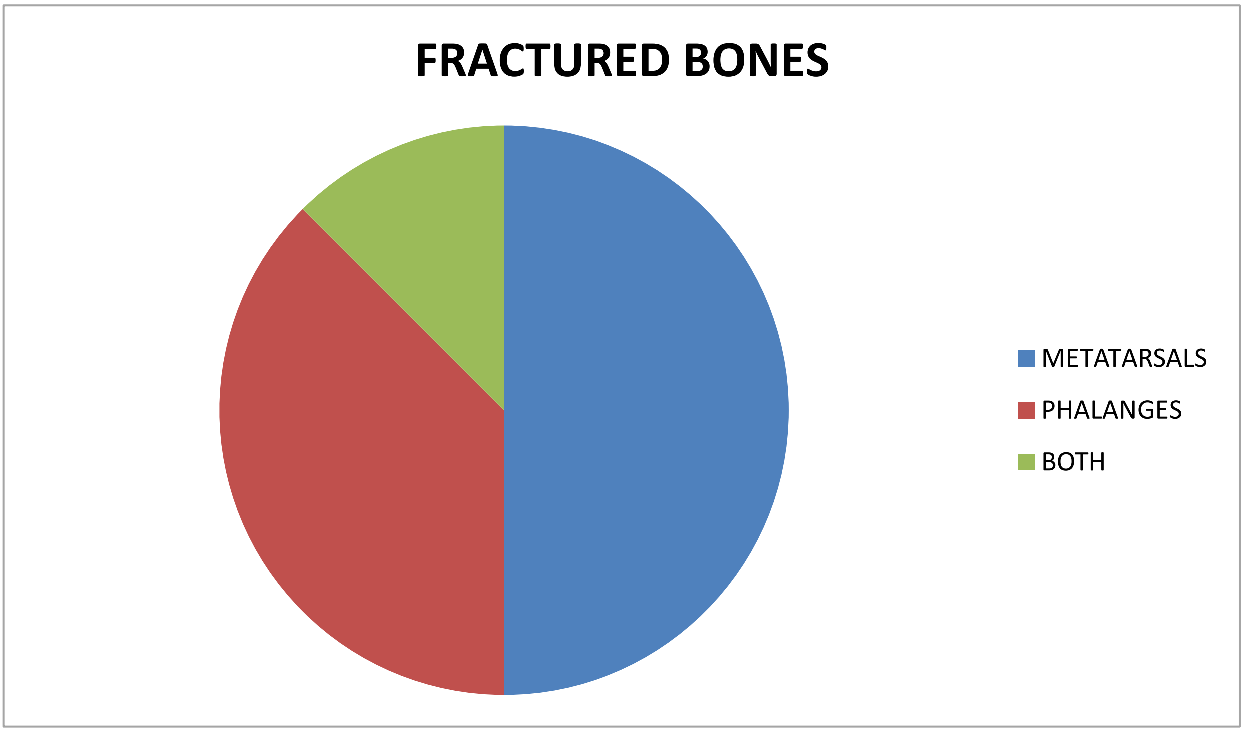
FRACTURES OF FOOT

CLOSED	16	57.1%
OPEN	12	42.9%



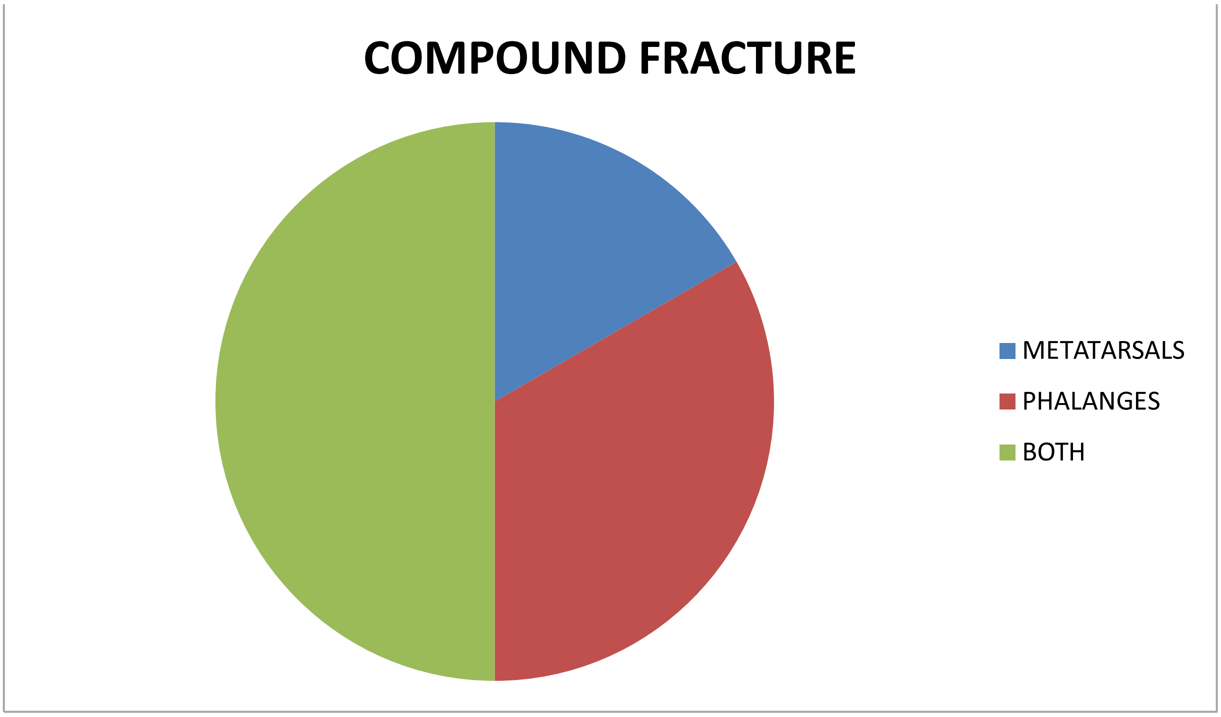
CLOSED FRACTURES

METATARSALS	8	50%
PHALANGES	6	37.5%
BOTH	2	12.5%



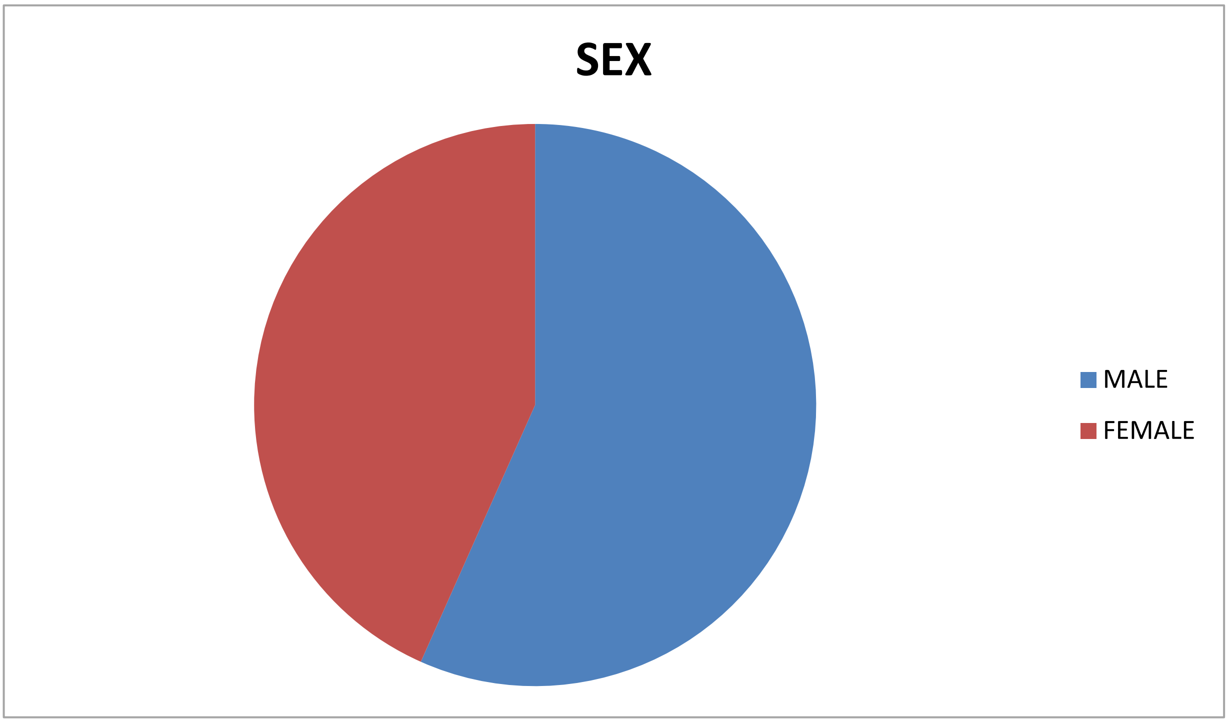
COMPOUND FRACTURES

METARTARSALS	2	16.7%
PHALANGES	4	33.3%
BOTH	6	50%



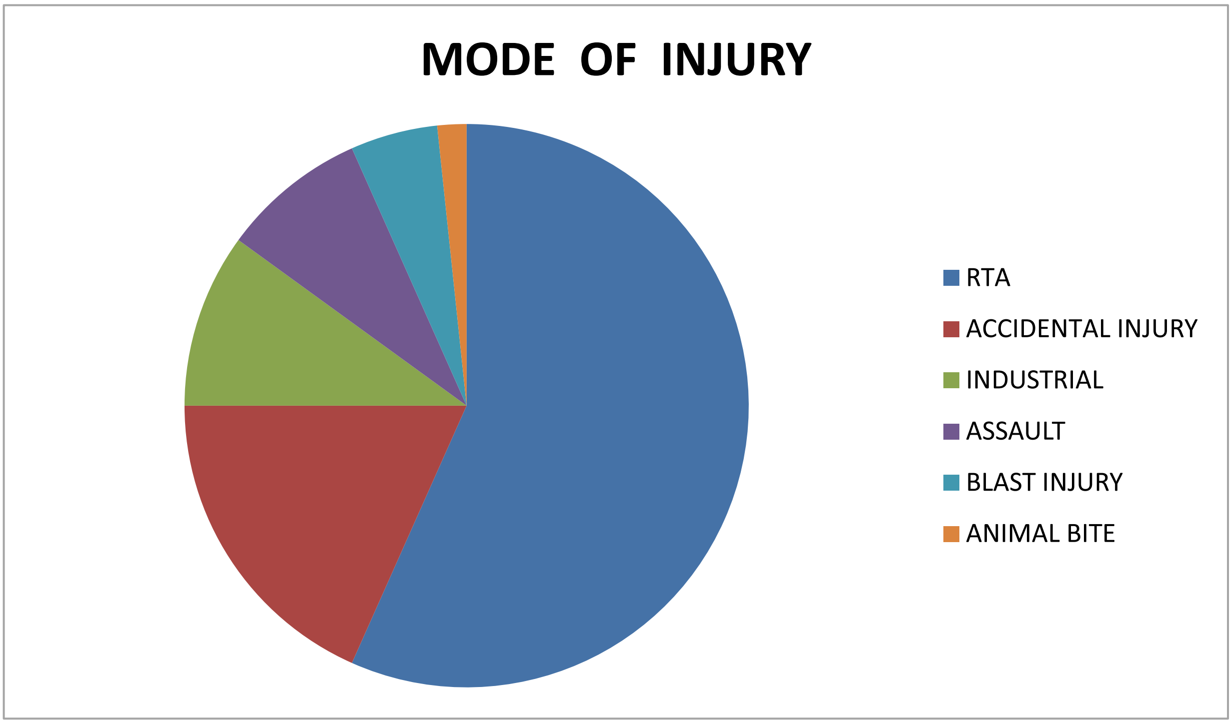
SEX DISTRIBUTION

MALE	68	56.7%
FEMALE	52	43.3%



MODE OF INJURY

RTA	68
ACCIDENTAL INJURY	22
INDUSTRIAL	12
ASSAULT	10
BLAST INJURY	6
ANIMAL BITE	2



MEAN OPERATIVE TIME

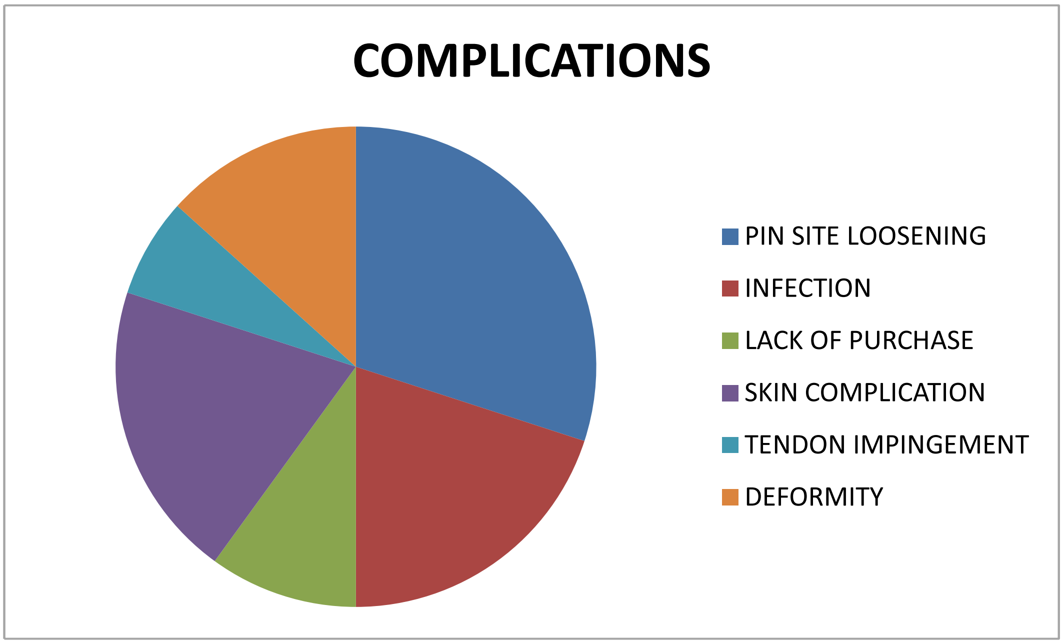
25 mins

MEAN PERIOD OF REMOVAL

23 days

COMPLICATIONS

Pin site loosening	9
Infection	6
Lack of purchase	3
Skin complications	6
Deformity	4
Tendon impingement	2



RESULTS OF THE STUDY

FUNCTIONAL OUTCOME MEASURES IN HAND FRACTURES

Functional outcome in terms of total range of movements of injured finger is calculated using the scoring system of Duncan et al. Scores are applied to 92 patients in our study at follow up period of 6 weeks.

DUNCAN'S SCORE

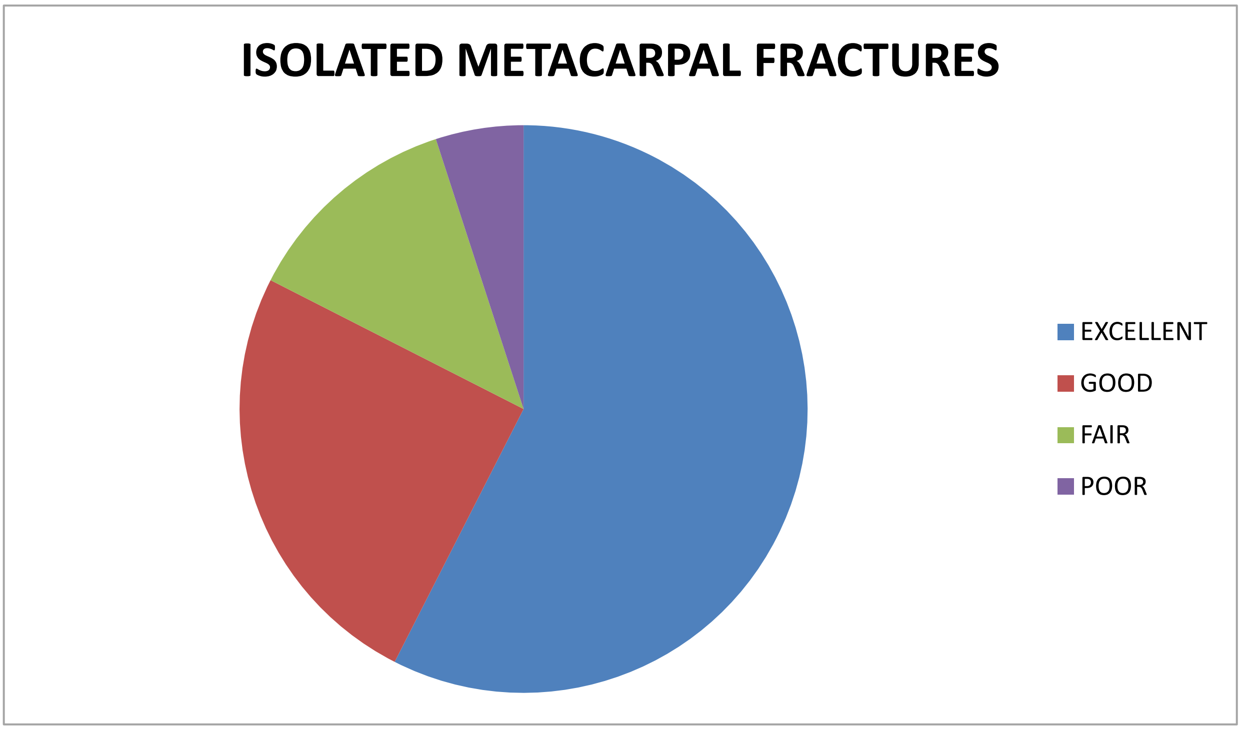
FINGER	THUMB	RESULTS
220-260	119-140	EXCELLENT
180-219	98-118	GOOD
130-179	70-97	FAIR
<130	<70	POOR

Score is calculated by summation of active flexion present in MCP And IP joints of injured finger subtracting the summation of extensor deficits present in these joints

IN OUR STUDY ,RESULTS OBTAINED AMONG 92 PATIENTS ARE

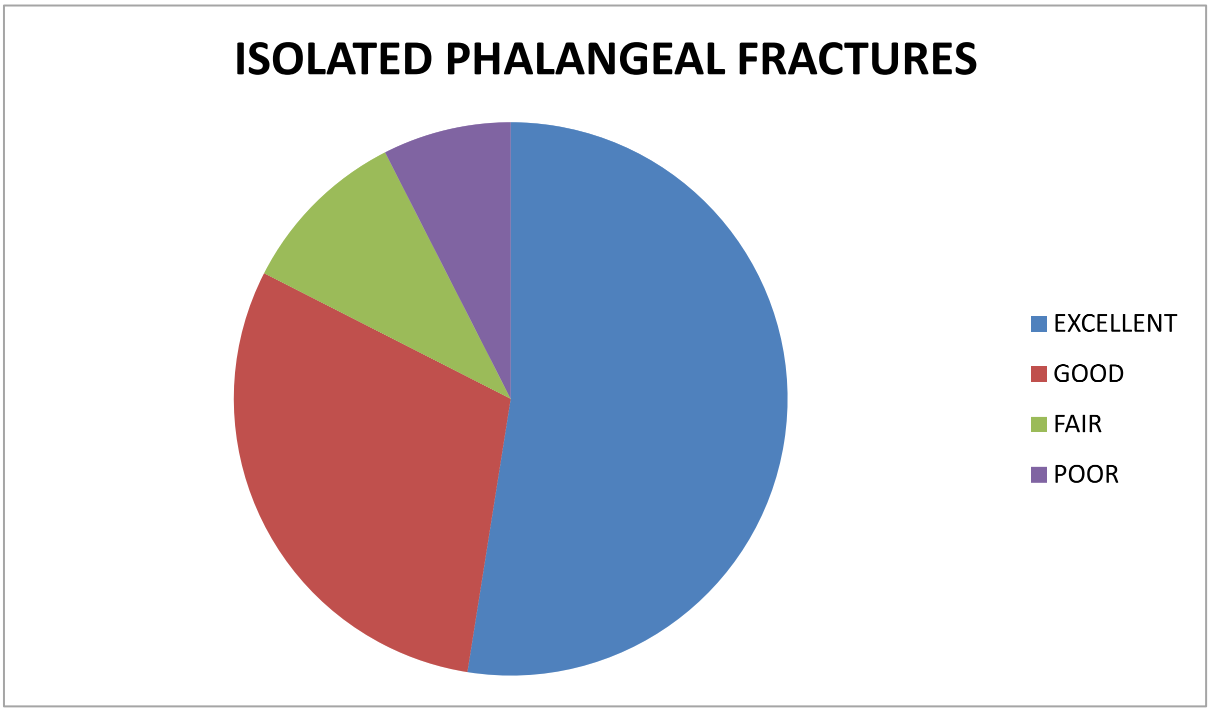
FUNCTIONAL OUTCOME IN PATIENTS WITH ISOLATED METACARPAL FRACTURES

OUTCOME	NO OF PATIENTS	PERCENTAGE
EXCELLENT	23	57.5%
GOOD	10	25%
FAIR	5	12.5%
POOR	2	5%



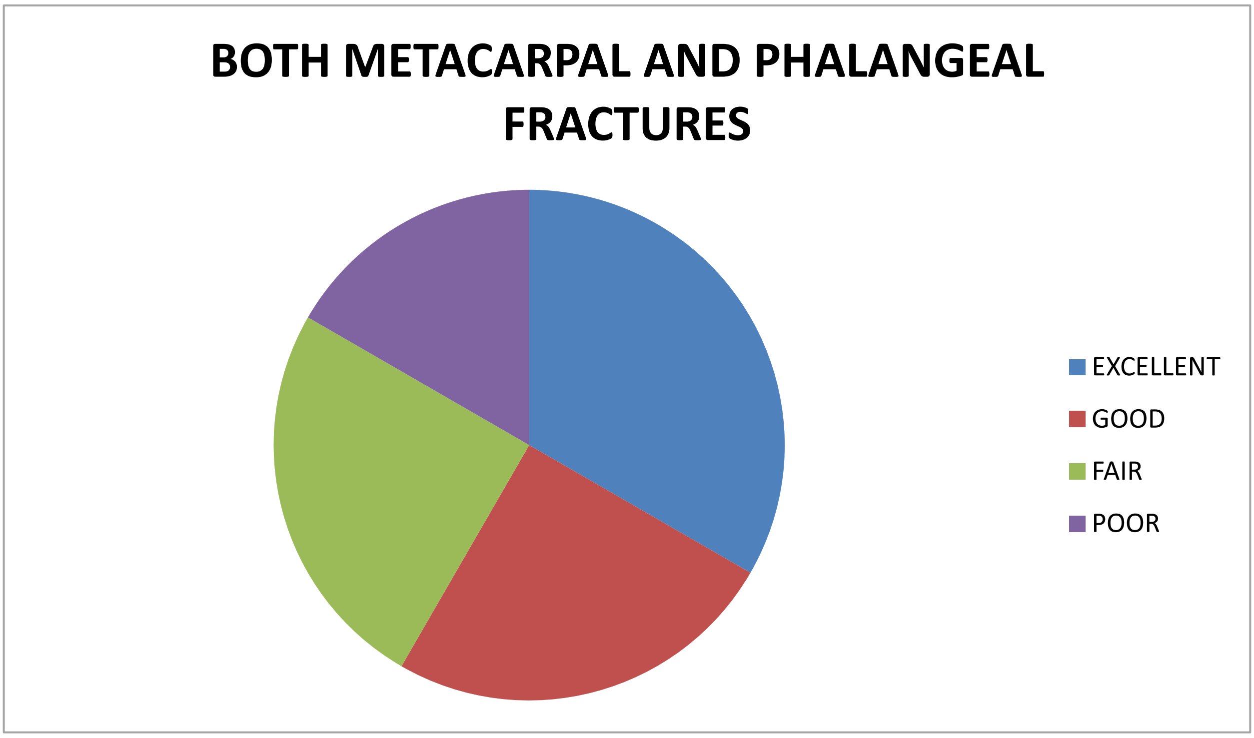
FUNCTIONAL OUTCOME IN PATIENTS WITH ISOLATED PHALANGEAL FRACTURES

OUTCOME	NO OF PATIENTS	PERCENTAGE
EXCELLENT	21	52.5%
GOOD	12	30%
FAIR	4	10%
POOR	3	7.5%



FUNCTIONAL OUTCOME IN PATIENTS WITH BOTH METACARPAL AND PHALANGEAL FRACTURES

OUTCOME	NO OF PATIENTS	PERCENTAGE
EXCELLENT	4	33.3%
GOOD	3	25%
FAIR	3	25%
POOR	2	16.6%



FUNCTIONAL OUTCOME ANALYSIS OF FRACTURES OF FOOT

In our prospective study which includes 28 patients with fractures involving metatarsals and phalanges of foot,functional outcome is analysed using Foot Ankle Disability Index(FADI)

FADI score is a questionnaire that consists of two determinants

1) Limitation of activity
2) Pain related to foot and ankle

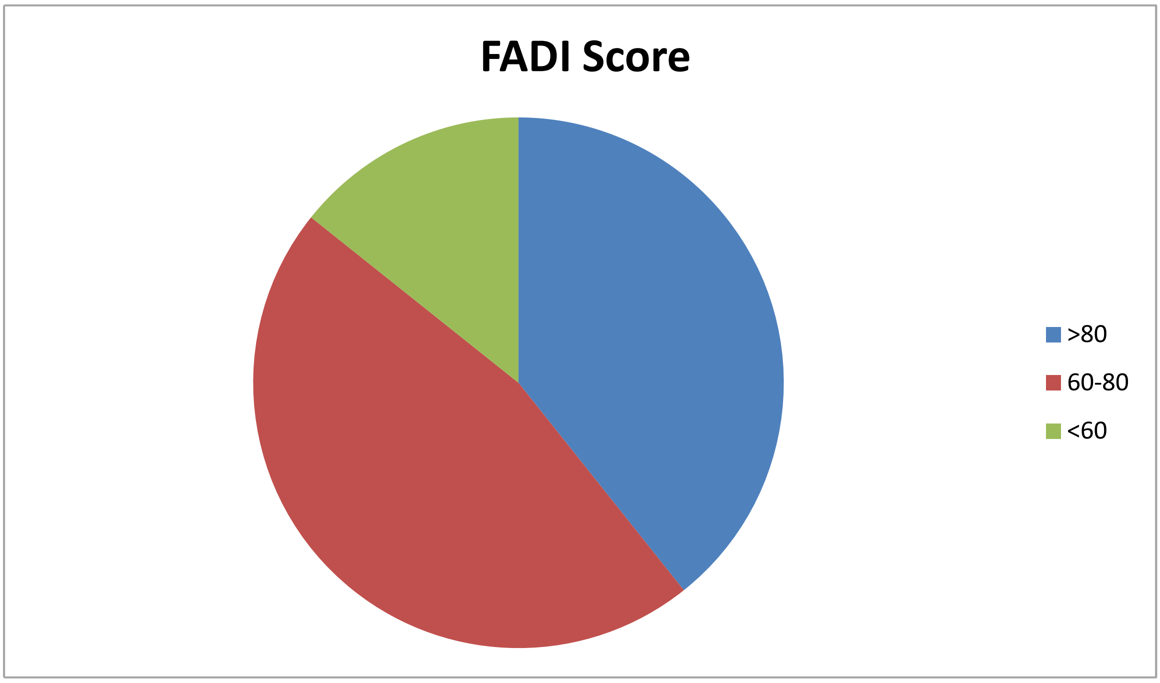
It includes 26 questions and each are scored in Likert's scale from 0 to 4.Maximum score is 104 which is full functional ability

If the activity in the questionnaire is limited by causes other than related to foot and ankle ,it is marked as N/A

In our study ,questionnaire is filled by 28 patients following removal of mini external fixator at 8 weeks and functional outcome is analysed based on FADI. Our results are

FOOT ANKLE DISABILITY INDEX

SCORE	NO OF PATIENTS	PERCENTAGE
>80	11	39.2%
60-80	13	46.5%
<60	4	14.3%



FADI SCORE

Patient Name: ______________________________ Date: __________

Please answer every question with one response that most closely describes your condition within the past week by marking the appropriate number in the box. If the activity in question is limited by something other than your foot or ankle, mark N/A.

0 Unable to do 2 Moderate difficulty 4 No difficulty
1 Extreme difficulty 3 Slight difficulty

Standing		Walking up hills	
Walking on even ground		Walking down hills	
Walking on even ground without shoes		Going up stairs	
Walking on uneven ground		Going down stairs	
Stepping up and down curves		Squatting	
Sleeping		Coming up to your toes	
Walking initially		Walking 5 minutes or less	
Walking approximately 10 minutes		Walking 15 minutes or greater	
Home responsibilities		Activities of Daily Living	
Personal Care		Light to moderate work (standing, walking)	
Heavy work (push/pulling, climbing, carrying)		Recreational activities	

Pain related to the foot and ankle:

0 Unbearable 2 Moderate Pain 4 No Pain
1 Severe Pain 3 Mild Pain

General level of pain		Pain at rest	
Pain during your normal activity		Pain first thing in the morning	

Annexure: Foot and Ankle Disability Index (FADI).[9]

DISCUSSION

Most of the fractures of miniature bones are treated conservatively. Open reduction and internal fixation is performed for unstable fractures for absolute stability,thereby promoting early union and movement of joints. But open reduction and internal fixation cannot be achieved in all cases due to nature of injury. Also open reduction and internal fixation requires additional soft tissue stripping which sometimes hinders union or leads to adhesion preventing active movement of digits.

In our study, mini external fixator is applied to all types of fractures ,both closed and compound fractures of hand and foot except those associated with vascular injury .External fixator avoids additional injury to the soft tissue. It also promotes wound healing in case of compound fractures.Operative technique is simple with the use of image intensifier.

Initially ,we used JESS clamps and pins for external frame construct. Later , Mini External fixator with compression distraction unit is used.In our study of 120 patients involving 92 hand fractures and 28 foot fractures,incidence of closed fractures are high compared to open fractures.RTA is the most common mode of injury followed by accidental inury and assault.

Mini external fixator is applied with two pins proximally and two pins distally.Most common complication encountered is pin site loosening which may be due to poor quality bone . Other complications are infection ,deformity due to malunion,skin complications.

In our study among hand fractures functional outcome is analysed using DUNCAN score .It measures total range of motion in injured finger.Functional result obtained among metacarpal fractures is better compared to phalangeal fractures which in turn is better than combined fractures.

The results obtained in our study is better than the study conducted in 33patients that includes 29 phalangeal and seven metacarpal fractures **J Bone Joint Surg [Br] 1998;80-B:227-30. Received 7 July 1997; Accepted after revision 10 November 1997,** where the study group is small.

Excellent to good results are obtained in 82.5% of patients with metacarpal and phalangeal fractures in our study which is far better than 69% and 71.4% with phalangeal and metacarpal fractures respectively,obtained in the above mentioned study.

In our study involving 28 patients involving fractures of metatarsals and phalanges of foot, functional outcome is analysed using FADI (Foot Ankle Disability Index). Closed and compound fractures are almost equal in frequency. Distribution of fractures in foot cannot be determined with this small patient group.FADI is questionnaire measuring patient's functional ability after intervention. Results are excellent to good in majority of patients treated with external fixator especially compound fractures.

Limitations of our study is sample for fractures of foot is minimal compared to hand fractures.

CONCLUSIONS

From our prospective study carried out in miniature long bones of hand and foot among 120 patients in our institution ,following conclusions have been made

Mini External fixator is one of the ideal treatment modality in the management of fractures of short long bones especially in

a) Open fractures
b) Communited fractures
c) Intraarticular fractures
d) Fractures with bone loss

Advantages of mini external fixator are

a) Promote wound healing in open injuries
b) Allows mobilization in nonfractured digits
c) Indirect reduction of intraarticular fractures using distraction
d) Aids in reduction of fractures through manipulation of pins
e) Allows room for secondary procedure like skin cover
f) Preserves fracture haematoma and aids in union
g) Simple surgical technique
h) Preservation of soft tissue

Mini external fixator helps in preservation of movements and gives best functional results by providing stable fixation.Simple surgical technique will minimize complications and an aggressive rehabilitation regime will ensure the best possible result

In general,mini external fixator is a alternative treatment for management of fractures of miniature long bones especially in certain situations with best functional outcome .

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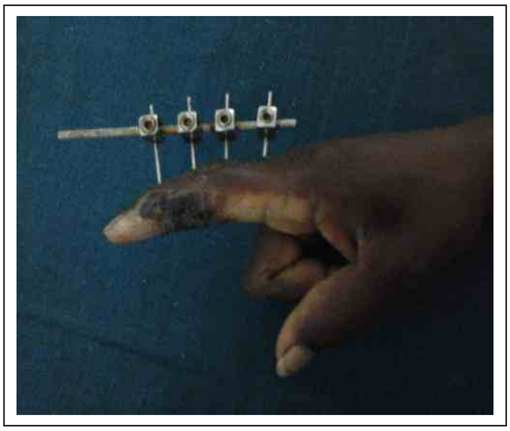
CASE 1

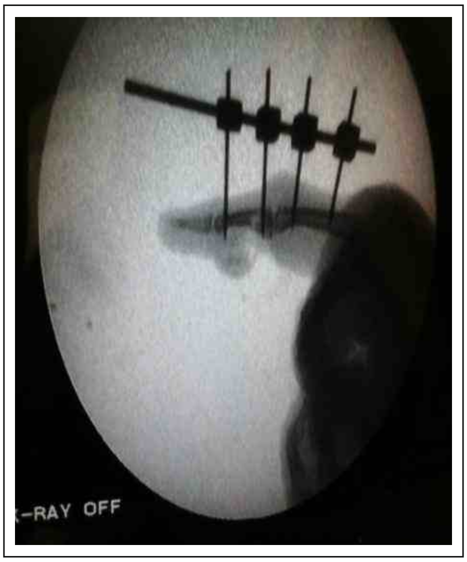
CLINICAL PICTURE

X -RAY

JESS FIXATOR



UNDER IMAGE INTENSIFIER

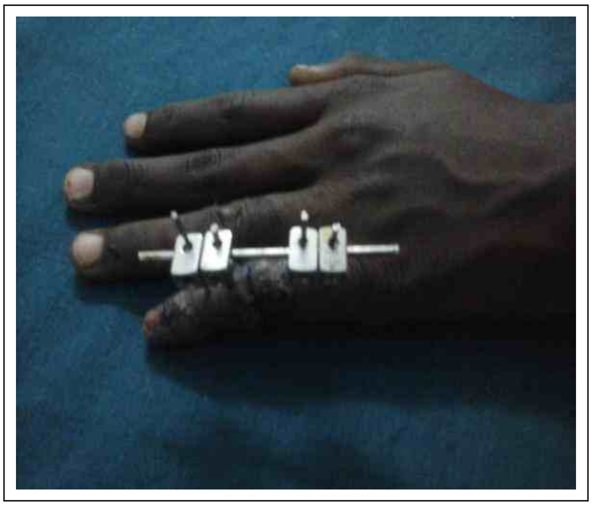


CASE 2

CLINICAL PICTURE

XRAY

JESS FIXATOR



POST OP X RAY

CASE 3

CLINICAL PICTURE

MINI EXTERNAL FIXATOR

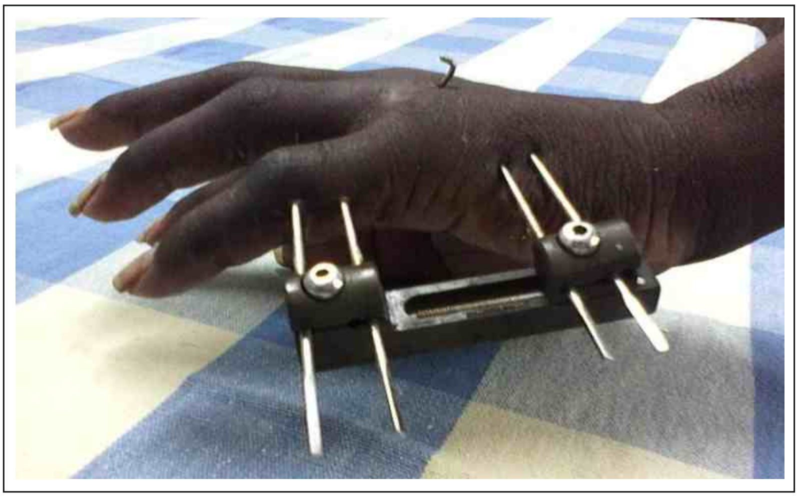
PREOP X RAY

POST OP XRAY

CASE 4

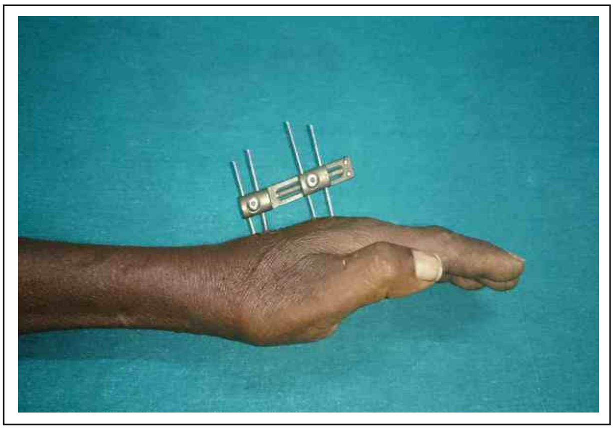
POST OP XRAY

CASE 5



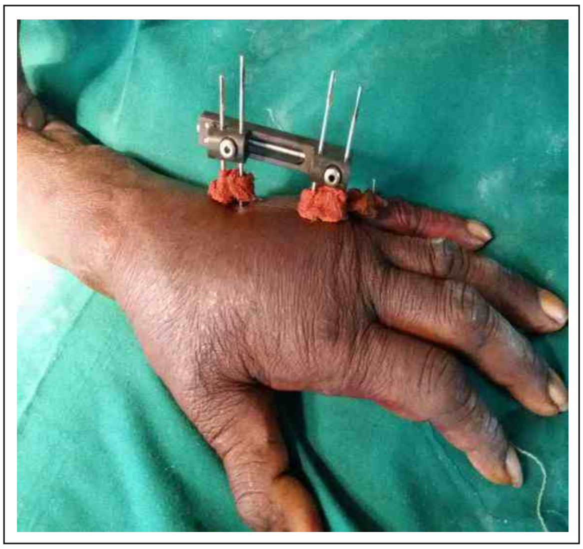
XRAY

CASE 6



UNDER IMAGE GUIDANCE

CASE 7



UNDER IMAGE GUIDANCE

1 MONTH FOLLOW UP

2 MONTH FOLLOW UP XRAY

MASTER CHART

S. NO	NAME	AGE/ SEX	IP.NO	HAND/FOOT	BONES INVOLVED	TYPE OF FRACTURE	MODE OF INJURY	OPEN/ CLOSED	ANAESTHESIA	OPERATING TIME IN MINS	REMOVAL IN DAYS	DUNCAN SCORE	FADI score
1	Lakshmanan	44/M	15322	Hand	Metacarpal	Oblique	RTA	Closed	Supraclavicular block	26	30	Excellent	
2	Maharajan	31/M	16842	Foot	Metatarsal	Transverse	Accidental Injury	Closed	Spinal	29	28		88
3	Sankaran	64/M	19542	Foot	Metatarsal	Transverse	Industrial	Open	Spinal	25	26		75
4	Subbiah	51/M	18754	Hand	Metacarpal	Oblique	RTA	Closed	Supraclavicular block	32	30	Good	
5	Sundaram	29/M	16854	Foot	Metatarsal	Transverse	Accidental Injury	Closed	Spinal	34	28		92
6	Selvam	33/M	13258	Hand	Metacarpal	Oblique	RTA	Closed	Supraclavicular block	30	31	Excellent	
7	Ramesh	44/M	17845	Hand	Phalanx	Communited	Blast	Open	Wrist block	33	28	Poor	
8	Baseer	74/M	12654	Hand	Metacarpal	Oblique	RTA	Closed	Supraclavicular block	28	30	Excellent	
9	Raman	62/M	16325	Hand	Phalanx	Oblique	RTA	Closed	Wrist block	31	29	Excellent	
10	Arumugham	39/M	15626	Foot	Metatarsal	Communited	Assault	Open	Spinal	34	31		78
11	Muthuvel	45/M	15478	Hand	Metacarpal	Communited	Blast	open	Supraclavicular block	35	28	Excellent	
12	Sattanathan	48/M	2E+05	Hand	Phalanx	Transverse	Accidental Injury	Open	Wrist block	28	30	Good	
13	Siva subbu	30/M	12596	Hand	Phalanx	Oblique	Industrial	Closed	Wrist block	26	28	Excellent	
14	Senthil	25/M	12548	Hand	Metacarpal	Oblique	RTA	Closed	Supraclavicular block	31	31	Good	
15	Kannan	49/M	18624	Foot	Phalanx	Communited	Assault	Open	Spinal	28	29		74
16	Sangeetha	24/F	13589	Hand	Phalanx	Transverse	RTA	Closed	Wrist block	33	31	Excellent	
17	Vadivu	55/F	18624	Hand	Metacarpal	Communited	Accidental Injury	Open	Supraclavicular block	26	29	Fair	
18	Seetha	48/F	15741	Foot	Metatarsal	Oblique	RTA	Closed	Spinal	29	30		97
19	Indra	52/F	19657	Foot	Metatarsal	Oblique	RTA	Closed	Spinal	34	28		89

20	Gomathy	31/F	16584	Hand	Metacarpal	Transverse	RTA	Closed	Supraclavicular block	30	30	Excellent	
21	Anthony	30/M	12548	Hand	Metacarpal	Oblique	RTA	Open	Supraclavicular block	27	28	Excellent	
22	Kathar	18/M	16845	Hand	Metacarpal	Transverse	Accidental Injury	Closed	Supraclavicular block	31	31	Excellent	
23	Krishnamoorthy	35/M	18654	Foot	Phalanx	Communited	RTA	Open	Spinal	26	29		71
24	Umar kathap	72/M	12654	Hand	Metacarpal	Communited	Industrial	Closed	Supraclavicular block	32	28	Excellent	
25	Murugan	66/M	17954	Hand	Phalanx	Communited	Accidental Injury	Closed	Wrist block	25	30	Good	
26	Asirvatham	25/M	18654	Hand	Metacarpal	Communited	RTA	Closed	Supraclavicular block	28	31	Excellent	
27	Kalanthar masthan	35/M	17952	Hand	Metacarpal	Transverse	Accidental Injury	Open	Supraclavicular block	29	29	Good	
28	Durai	66/M	13598	Hand	Phalanx	Oblique	RTA	Closed	Wrist block	35	27	Excellent	
29	Chidambaram	42/M	15786	Hand	Metacarpal	Oblique	RTA	Closed	Supraclavicular block	32	29	Excellent	
30	Dharvish mydeen	41/M	17548	Foot	Metatarsal	Oblique	RTA	Closed	Spinal	28	31		86
31	Velusamy	53/M	16895	Hand	Phalanx	Oblique	RTA	Closed	Wrist block	26	28	Good	
32	Shanmugam	50/M	13529	Hand	Metacarpal	Transverse	RTA	Closed	Supraclavicular block	32	27	Excellent	
33	Vetrivel	63/M	16854	Foot	Phalanx	Communited	Accidental Injury	Open	Spinal	34	29		74
34	Essaki	50/M	19875	Foot	Metatarsal	Communited	RTA	Closed	Spinal	29	32		78
35	Siva	69/M	12358	Foot	Metatarsal	Transverse	Assault	Closed	Spinal	26	31		89
36	Saravanan	34/M	19875	Hand	Metacarpal	Oblique	RTA	Open	Supraclavicular block	28	29	Good	
37	Pandi	54/M	13258	Hand	Phalanx	Communited	Industrial	Closed	Wrist block	33	27	Poor	
38	Petchimuthu	63/M	15486	Hand	Phalanx	Communited	RTA	Closed	Wrist block	30	31	Excellent	
39	Kamaraj	59/M	17984	Hand	Metacarpal	Spiral	Accidental Injury	Open	Supraclavicular block	25	29	Excellent	
40	Sathish	36/M	15875	Hand	Phalanx	Transverse	RTA	Closed	Wrist block	29	32	Good	

41	Prabhakaran	28/M	16548	Hand	Metacarpal	Communited	Blast	Open	Supraclavicular block	31	28	Excellent	
42	Mani	65/M	15872	Hand	Both	Communited	Accidental Injury	Closed	Supraclavicular block	33	29	Excellent	
43	Paramasivam	47/M	10326	Hand	Phalanx	Transverse	RTA	Closed	Wrist block	27	31	Excellent	
44	Natarajan	55/M	10596	Hand	Metacarpal	Transverse	Assault	Open	Supraclavicular block	25	28	Excellent	
45	Senthil	37/M	14520	Hand	Metacarpal	Oblique	RTA	Closed	Supraclavicular block	29	26	Excellent	
46	Sivaraj	66/M	14952	Foot	Phalanx	Communited	Accidental Injury	Open	Spinal	31	31		72
47	Karnan	52/M	10845	Hand	Metacarpal	Oblique	RTA	Closed	Supraclavicular block	34	30	Excellent	
48	Pushparajan	34/M	13025	Foot	Metatarsal	Transverse	RTA	Closed	Spinal	32	28		98
49	Murugesan	27/M	18520	Hand	Metacarpal	Oblique	Blast	Open	Supraclavicular block	35	29	Fair	
50	Rathinasamy	58/M	14780	Hand	Phalanx	Oblique	RTA	Closed	Wrist block	26	32	Good	
51	Baskaran	22/M	16250	Hand	Metacarpal	Communited	Industrial	Closed	Supraclavicular block	28	28	Good	
52	Mahalingam	39/M	19850	Foot	Phalanx	Oblique	RTA	Closed	Spinal	25	31		75
53	Kandasamy	43/M	13520	Hand	Phalanx	Transverse	Assault	Open	Wrist block	31	27	Excellent	
54	Annamalai	62/M	16320	Hand	Metacarpal	Transverse	RTA	Closed	Supraclavicular block	35	29	Excellent	
55	Essakimuthu	26/M	18450	Hand	Phalanx	Oblique	RTA	Closed	Wrist block	29	31	Excellent	
56	Elango	36/M	12654	Hand	Phalanx	Oblique	RTA	Open	Wrist block	27	26	Excellent	
57	Ulagamani	60/M	16250	Foot	Phalanx	Oblique	RTA	Closed	Spinal	25	29		90
58	Shanmuga sundaram	56/M	17840	Hand	Metacarpal	Transverse	Accidental Injury	Open	Supraclavicular block	35	30	Good	
59	Kumar	31/M	12654	Hand	Phalanx	Oblique	RTA	Closed	Wrist block	32	28	Good	
60	Ramaselvam	33/M	16982	Hand	Both	Communited	RTA	Closed	Supraclavicular block	28	29	Excellent	
61	Saraswathi	38/F	17542	Hand	Metacarpal	Transverse	RTA	Open	Supraclavicular block	26	31	Excellent	
62	Rajesh	54/M	10325	Foot	Both	Communited	RTA	Open	Spinal	31	27		59

63	Shanmugaiah	64/M	18620	Hand	Metacarpal	Oblique	RTA	Closed	Supraclavicular block	34	30	Excellent	
64	Pandiyaraj	38/M	16250	Hand	Phalanx	Oblique	RTA	Closed	Wrist block	32	29	Good	
65	Selvamani	70/M	19630	Foot	Both	Communited	Industrial	Open	Spinal	28	32		56
66	Essakiammal	66/F	17520	Hand	Metacarpal	Oblique	RTA	Closed	Supraclavicular block	30	27	Good	
67	Pitchammal	45/F	19852	Hand	Phalanx	Transverse	RTA	Open	Wrist block	27	29	Good	
68	Marimuthu	26/M	13250	Hand	Phalanx	Transverse	RTA	Open	Wrist block	29	31	Good	
69	Dharmaraj	63/M	19632	Foot	Phalanx	Communited	Assault	Closed	Spinal	32	28		73
70	Mohammed ali	51/M	19785	Foot	Both	Oblique	RTA	Open	Spinal	35	30		68
71	Petchiammal	63/F	16302	Hand	Metacarpal	Communited	Industrial	Open	Supraclavicular block	31	26	Poor	
72	Usha	55/F	18962	Hand	Phalanx	Transverse	Assault	Closed	Wrist block	28	28	Excellent	
73	Rani	28/F	17542	Hand	Phalanx	Transverse	Accidental Injury	Open	Wrist block	26	31	Excellent	
74	Mudhar mydeen	29/M	10325	Hand	Phalanx	Oblique	RTA	Closed	Wrist block	25	27	Good	
75	Nagarajan	36/M	16980	Hand	Phalanx	Transverse	Animal bite	Open	Wrist block	27	29	Fair	
76	Annadurai	68/M	18620	Hand	Phalanx	Oblique	RTA	Open	Wrist block	31	31	Excellent	
77	Selvi	45/F	13026	Hand	Phalanx	Transverse	RTA	Closed	Wrist block	35	26	Excellent	
78	Ganesan	32/M	18602	Hand	Both	Transverse	Accidental Injury	Closed	Supraclavicular block	32	28	Good	
79	Mohammed fazil	65/M	18420	Hand	Phalanx	Transverse	Industrial	Closed	Wrist block	28	30	Good	
80	Sornam		16302	Foot	Phalanx	Oblique	RTA	Closed	Spinal	26	31		96
81	Suresh	44/M	12035	Hand	Phalanx	Transverse	Accidental Injury	Open	Wrist block	29	29	Excellent	
82	Veera pandiyan	24/M	17852	Foot	Both	Transverse	RTA	Open	Spinal	31	27		53
83	Sivagurunathan	63/M	16305	Hand	Phalanx	Oblique	Animal bite	Open	Wrist block	35	30	Excellent	
84	Uma	34/F	13065	Hand	Phalanx	Spiral	Assault	Closed	Wrist block	27	28	Excellent	
85	Shenbagam	58/F	10865	Hand	Phalanx	Transverse	RTA	Open	Wrist block	33	26	Excellent	
86	Chellammal	63/F	10586	Hand	Both	Communited	Industrial	Closed	Supraclavicular block	31	29	Good	

87	Arulammal	66/F	16207	Hand	Metacarpal	Communited	Blast	Closed	Supraclavicular block	35	27	Poor	
88	Samuel	54/M	19830	Hand	Metacarpal	Oblique	RTA	Closed	Supraclavicular block	26	31	Excellent	
89	Pitchaiappan	35/M	18304	Hand	Phalanx	Transverse	Accidental Injury	Closed	Wrist block	29	26	Excellent	
90	Tamilselvan	48/M	10967	Hand	Metacarpal	Oblique	RTA	Closed	Supraclavicular block	35	32	Excellent	
91	Sooriyakala	35/F	13086	Hand	Phalanx	Transverse	Assault	Open	Wrist block	27	27	Good	
92	Nallamuthu	66/M	10359	Hand	Phalanx	Transverse	Accidental Injury	Open	Wrist block	29	26	Excellent	
93	Parvathy	49/F	14993	Hand	Phalanx	Transverse	RTA	Open	Wrist block	31	29	Excellent	
94	Thangakali	56/M	16330	Hand	Phalanx	Oblique	Accidental Injury	Closed	Wrist block	28	32	Excellent	
95	Thilagam	41/M	17550	Hand	Phalanx	Communited	RTA	Closed	Wrist block	26	30	Fair	
96	Ravichandran	24/M	16994	Hand	Phalanx	Communited	RTA	Open	Wrist block	32	27	Poor	
97	Mariappan	37/M	13008	Foot	Both	Communited	Accidental Injury	Open	Spinal	34	29		59
98	Essakithai	58/F	14772	Hand	Metacarpal	Oblique	Industrial	Closed	Supraclavicular block	31	30	Fair	
99	Manikka devi	43/F	19630	Foot	Phalanx	Transverse	RTA	Closed	Spinal	28	28		98
100	Jebamalai	68/F	10095	Hand	Phalanx	Oblique	RTA	Open	Wrist block	26	26	Fair	
101	Petchiammal	49/F	13690	Hand	Metacarpal	Oblique	Accidental Injury	Closed	Supraclavicular block	33	30	Excellent	
102	Arumugam	55/M	15560	Foot	Phalanx	Oblique	RTA	Closed	Spinal	28	31		96
103	Pushpam	65/F	18766	Hand	Metacarpal	Oblique	RTA	Closed	Supraclavicular block	26	27	Good	
104	Muthumari	45/F	19622	Hand	Both	Communited	RTA	Open	Supraclavicular block	27	30	Fair	
105	Karuppasamy	48/M	18633	Hand	Metacarpal	Communited	Blast	Closed	Supraclavicular block	32	28	Fair	
106	Uchimagali	56/F	19866	Hand	Both	Communited	RTA	Open	Supraclavicular block	35	26	Fair	
107	Porul selvi	34/F	17522	Foot	Both	Communited	RTA	Closed	Spinal	29	27		65

108	Gopalakrishnan	48/M	19600	Hand	Both	Oblique	RTA	Open	Supraclavicular block	33	31	Poor	
109	Muthamil	69/F	18622	Hand	Metacarpal	Transverse	RTA	Closed	Supraclavicular block	27	29	Excellent	
110	Raja	28/M	16900	Hand	Both	Transverse	Assault	Open	Supraclavicular block	29	28	Poor	
111	Manickam	57/M	18433	Foot	Both	Oblique	RTA	Open	Spinal	31	29		72
112	Chokkalingam	49/M	19633	Hand	Both	Communited	Accidental Injury	Open	Supraclavicular block	35	31	Fair	
113	Kaaliraja	64/M	18644	Foot	Both	Oblique	RTA	Closed	Spinal	29	29		74
114	Nandhakumar	35/M	19854	Hand	Both	Communited	Industrial	Open	Supraclavicular block	28	27	Good	
115	Krishnan	54/M	13985	Hand	Metacarpal	Transverse	RTA	Closed	Supraclavicular block	26	30	Good	
116	Kanagalakshmi	45/F	12598	Hand	Both	Communited	RTA	Open	Supraclavicular block	35	28	Excellent	
117	Srinivasan	24/M	15620	Hand	Metacarpal	Oblique	Industrial	Closed	Supraclavicular block	27	31	Fair	
118	Muthuraman	45/M	18752	Hand	Both	Communited	RTA	Open	Supraclavicular block	33	29	Excellent	
119	Rajesh	23/M	16259	Hand	Phalanx	Transverse	Accidental Injury	Open	Wrist block	29	27	Fair	
120	Meenatchi	20/F	13056	Hand	Metacarpal	Oblique	RTA	Closed	Supraclavicular block	26	30	Good	