ANALYSIS OF FUNCTIONAL OUTCOME OF ANTEROLATERAL PLATING IN TIBIAL PILON FRACTURES.

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CERTIFICATE

This is to certify that this dissertation in **"ANALYSIS OF FUNCTIONAL OUTCOME OF ANTEROLATERAL PLATING IN TIBIAL PILON FRACTURES"***is a bonafide work done by Dr.A.THIRUMURUGAN under my guidance during the period 2011–2014. This has been submitted in partial fulfilment of the award of M.S. Degree in Orthopedic Surgery (Branch–II) by The Tamilnadu Dr.M.G.R. Medical University, Chennai.*

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DECLARATION

I, **Dr.A.THIRUMURUGAN,** solemnly declare that the dissertation titled **“ANALYSISOF FUNCTIONAL OUTCOME OF ANTEROLATERAL PLATING IN TIBIAL PILON FRACTURES.”** was done by me at the Rajiv Gandhi Government General Hospital, Chennai-3, during 2011-2014 under the guidance of my unit chief **Prof.M.R.RAJASEKAR, M.S(Ortho), D.Ortho.**

The dissertation is submitted in partial fulfilment of requirement for the award of M.S. Degree (Branch –II) in Orthopaedic Surgery to **The Tamil Nadu Dr.M.G.R.Medical University.**

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CONTENTS

ANALYSIS OF FUNCTIONAL OUTCOME OF ANTEROLATERAL PLATING IN TIBIAL PILON FRACTURES.

ABSTRACT

Introduction:

Tibial pilon fractures account for 1% to 10% of all lower extremity injuries. The difficulty in managing these injuries is primarily due to the precarious vasculature around the ankle. Subcutaneous location of tibia adds to the difficulty. It encompasses a spectrum of skeletal injury ranging from low energy injury due to simple falls to high energy explosive injury due to road traffic accidents and fall from height. Fibula is fractured in 85% of the tibial pilon injuries. Fixation of fibula fracture is crucial to the reduction of pilon fracture. Complication rates were higher in the high energy explosive fracture pattern. Medial plating using LCP on the subcutaneous medial border of distal tibia resulted in a significant rate of wound dehiscence and deep infection. Plating on the lateral surface of tibial plafond is a new entity and the anterolateral approach is gaining popularity for the fixation of tibial pilon fractures.

Materials and Methods:

This retrospective and prospective study analyzes the functional outcome of Anterolateral distal tibia LCP for treatment of distal tibia fracture. The period of study was from June 2013 to December 2013 with a total duration of 7 months. In our study 30 cases with a minimum follow up of 4 months and

maximum of 12 months with an average of 9 months was carried out. Fibula fixation is performed initially to restore length and achieve indirect reduction of tibia fracture using posterolateral approach. Anterolateral approach to ankle was used to fix tibia. Anterolateral locking compression plates are placed through the interval between the anterior and lateral compartments of leg. All cases were assessed postoperatively using the Kaikkonen clinical ankle score and Teeny wiss radiological score.

Results:

27 fractures united with a mean duration of 12 to 24 weeks. In our study we were able to achieve anatomic reduction in 32% (7 cases) of the patients. Good reduction was achieved in 50% (11 cases) of the patients. Fair reduction was achieved in 18% (4 cases). There was no case of poor fracture reduction in our study according to Teeny Wiss Score. In our study we had excellent functional outcome in about 30% of cases, good functional outcome in 50% of cases fair and poor outcome 10% of cases each based on Kaikkonen Clinical Ankle Score. In our study the complication we met were 6 cases (20%) of wound dehiscence and superficial infection which healed by secondary intention, 2 cases (7%)of flap necrosis, 3 cases(10%) of nonunion, extensor tendon exposed in 1 case(3%), implant failure in one of the three non union cases. In our study we had no deep infection (0%).

Conclusion:

Distal tibia fractures with high grade of soft tissue injury are to be internally fixed after a delay of 21 days for the edema to settle down and the wrinkle sign appears. The posterolateral incision to fibula provides a larger skin bridge between this incision and the tibial incision. A 7 cm skin bridge between two incisions is recommended to avoid wound complication. Restoration of the articular surface and reestablishing its relationship to the tibial shaft is the primary goal of treatment. Good functional result depends on reasonable anatomic reduction of the articular surface and meticulous soft tissue handling. From our study, 3.5mm Anterolateral Distal tibia Locking Compression Plating for tibial pilon fractures were found to be safe and effective. For AO type A fractures, can be fixed either using MIPPO or ORIF technique. For AO type C fractures Open reduction of the articular fragment is mandatory and then stabilize with locking compression plate for added up stability.

Keywords: dual incision technique, anterolateral approach for tibia, wound problems, skin bridge

INTRODUCTION

INTRODUCTION

Tibial Pilon (Tibial Plafond) is a descriptive term for distal tibia fracture suggesting that the talus acts as a hammer, impacting and injuring the distal tibia[1]. Treatment of these fractures remains challenging for orthopaedic surgeons[2].Tibial pilon fractures account for 1% to 10% of all lower extremity injuries[2]. The difficulty in managing these injuries is primarily due to the precarious vasculature around the ankle. Subcutaneous location of tibia adds to the difficulty.Tibial pilon encompasses a spectrum of skeletal injury ranging from low energy injury due to simple falls to high energy explosive injury due to road traffic accidents and fall fromheight[3].

Low energy tibial pilon fractures occur in older age group and mechanism of injury is usually rotation. It causes a spiral fracture of the distal tibia with or without extension into ankle joint. Status of surrounding soft tissue is good. As a result risk of post surgical wound healing problems and chance of infection are minimal[4].

High energy tibial pilon fractures occur in younger age group and the usual mechanism of injury is axial loading. Here the hard dome of talus impacts against the relatively soft tibial articular surface. As a result distal tibial articular surface and the metaphyseal region crumbles. Foot position during impact heavily influences the fracture pattern of the articular surface[1,4]. This pattern is associated with severe soft tissue injury with edema and skin blisters around the ankle [1,4].

Fibula is fractured in 85% of the tibial pilon injuries [3] . Fixation of fibula fracture is crucial to the reduction of pilon fracture.

Decision making is tough only in the high energy pilon fractures. Some complex questions arise, whether to treat the fracture conservatively or operatively? If operative, whether immediate or delayed fixation? Fixation of fibula? Internal or external fixation? Choice of approach? Implant choice? [2]. Answers to these questions and hence decision making should be made on an individual basis.

Comorbid illness complicates this delicate situation. Peripheral vascular disease, diabetes mellitus, smoking and alcoholism should be considered[3].

Internal fixation was considered gold standard in 1980 by Ruedi of the AO group. It was the standard of care. The enthusiasm was soon lost due to wound breakdown, deep osteomyelitis and sepsis associated with the open reduction and plating technique. Complication rates were higher in the high energy explosive fracture pattern[1].

Because of the severity of the soft tissue injury and the reported soft tissue complication rate attributed to extensive surgical exposures and bulky internal fixation devices approximating 40% to 50%, external fixation emerged as a successful technique for decreasing significant septic complications that had been previously attributable to open surgical management[1] .

Minimal internal fixation to reconstruct the articular surface of tibia supported with ankle spanning external fixators became the popular modality of treatment in late 1990s. Fibula fractures were secured using one third tubular or reconstruction plate to maintain length and axis alignment. Hybrid fixators later replaced monolateral external fixators because of advantage of stability and early weight bearing.Definitive management of pilon fracture by external fixation has its own complications. They are pin tract infection, secondary loss of reduction and ankle stiffness.

The lack of consistent results with the use of external fixation techniques and an improved understanding of the associated soft tissue injury with pilon fractures gave way to the reconsideration of open reduction and internal fixation but after a period of soft tissue recovery[1].

Role of non-surgical treatment should have a mention. It is possible for stable fractures with minimal shortening to be treated by traction or plaster of paris in a medically unfit patient , but malunion, shortening , limited range of movement and early secondary osteoarthritis of ankle have all been reported following conservative treatment of pilon fractures[21,25,26]. Complications of recumbency such as deep vein thrombosis, pressure sores and pneumonia are a problem.

Open Reduction and Internal Fixation has regained popularity largely due to better assessment of soft tissue envelope. Tscherne soft tissue injury classification was expanded by the AO group to create a more objective system that evaluates and grades each component of soft tissue envelope, including the skin, musculotendinous components and neurovascular tissue[1].

With regards to closed intramedullary nail, a stable fixation with nail in distal tibia may be difficult to achieve because the hourglass shape of the intramedullary canal prevents a tight endosteal fit and compromises torsional and angular stability. Secondary displacement of the fracture on insertion of nail, breakage of nail and locking screws, limited applicability in severe intra articular fracture and malunion of the tibia are potential risks.

Various modalities of internal fixation for tibial pilon by plating have been described. These include conventional AO medial plating using medial buttress plate, anterior plating using T plates, Cloverleaf plate or occasionally simple dynamic compression plates[5].AO medial plating has its own drawbacks. One of the major disadvantages of this approach is the risk of wound break down over the subcutaneous border, with the potential need for flap cover. In addition this approach limits visualization of the lateral chaput fragment[7].

Locking compression plating (LCP) is the most widely used implant for tibial pilon fractures at present. It can be performed by minimally invasive technique or standard open reduction and internal fixation methods. These are anatomically contoured to the bone surface to which it is applied. For pilon fracture the gold standard was medial LCP, a low profile plate placed through medial approach. The low profile nature tends to address the problem of bulky implant used in standard AO plating techniques. Medial plating using LCP on the subcutaneous medial border of distal tibia still resulted in a significant rate of wound dehiscence and deep infection, although at a lower rate compared to standard AO plates.

Surgeons preferred Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO) technique to decrease the wound complication using medial LCP. MIPPO technique achieved union rates ranging between 80% and 100%. These techniques aim to reduce surgical trauma and to maintain a more biologically favourable environment for fracture healing. Nevertheless, complications such as angular deformities greater than 7°, articular mal reduction, hardware failure and non-unions have been reported.

How to overcome this problem? Why not use the lateral surface of tibia? Attempts were made in the past to treat pilon fractures by open articular reduction and lateral buttress plating, but it failed. This was attributed to the complex bony contour of the lateral surface of the distal tibia as it blends with the tibial plafond distally. Contouring a semi tubular, one third tubular or reconstruction plate to this surface was challenging and also resulted in inadequate screw purchase. All this resulted in unstable fixation and secondary loss of reduction.

Locking Compression Plates designed to contour the lateral surface of distal tibia were developed recently. These plates were fixed using the anterolateral approach to the distal tibia. Although anterolateral approach has been described in the past, it was not popularized. Plating on the lateral surface of tibial plafond is a new entity and the anterolateral approach is gaining popularity for the fixation of tibial pilon fractures. Early studies have shown it offers the benefit of improved soft tissue coverage and the potential for a lower rate of wound healing complications[7].

If it is so, then anterolateral plating for tibial pilon fractures could well be a milestone in the management of pilon fracture.

AIM AND OBJECTIVE

AIM AND OBJECTIVE

Aim of our study is to analyze the functional outcome of Tibial pilon fractures treated by Anterolateral Distal Tibial Locking Compression Plate in the Institute of Orthopaedics and Traumatology, Madras Medical College and Rajiv Gandhi Government General Hospital Chennai over a period of six months from June 2013 to November 2013.

The primary objective of the study is to analyze the outcome in terms of fracture union using radiographs and surgical wound healing.

The secondary objective of the study is to analyze the functional outcome after surgery.

HISTORY AND

REVIEW OF LITERATURE

REVIEW OF LITERATURE

First described by French radiologist **Destot** in the year 1911, as ankle fractures that involve the weight bearing distal tibial articular surfaces. The term *Pilon* was coined by Etienne Descot to describe fractures occurring within 5 cm of the ankle joint.

The term *Pilon*was derived from French language and refers to a pestle, which is a club shaped tool used for mashing or grinding substance in mortar, or a large bar which is moved vertically to stamp.

In **1950 Bonin J.G.** coined the term *Plafond* which means ceiling in French. It describes the distal tibial articular surface to the roof of the ankle joint.

In 1968 Ruedi performed early open reduction and internal fixation for all tibial plafond fractures and demonstrated satisfactory results with few complications.This was supported by subsequent studies performed by **Heim** and later by **Ovadia** and **Beals.**

In 1980 and 1990s , early open reduction and internal fixation became the standard of care for tibial pilon fractures.

Wrysch pointed out that Ruedi's study included mostly low energy spiral fracture pattern of tibial pilon. This resulted in superior results in early open reduction. In late 1990s, studies showed early open reduction caused severe wound complications and sepsis. This was attributed to more cases of high velocity axial compression injury pattern in his series.

Because of this high rate of soft tissue complications due to open reduction and bulky implants, external fixation emerged as treatment of choice. Later **Bone and colleagues,** used combined minimal internal fixation with external fixation.

Maisonneuve (1840), compares ankle with a mortise and tenon.

Sir Robert Jones described that, the most injured joint of the body was that of ankle, but it was treated least.

In 1968 it was **Reudi** who published a paper on this topic, describing the fracture, principles of treatment and a classification system. His experience with immediate fixation of tibial fractures demonstrated durable results and few complications[41,42].

Kellam and **Waddeli** divided pilon fractures in two types based by the mechanism of injury as either rotational or axial loading or both[22].

Tornetta et.al described combined open stabilization of the articular fractures and neutralization of the metaphyseal fractures with hybrid external fixation without spanning the ankle joint withpotential benefit of allowing cartilage nutrition through the use of early ankle range of motion.

Pugh and colleagues and **Angen** pointed out the complictaions of external fixation such as malunion, nonunion and lower clinical scores and slower return to function when they compared with their own ORIF group[37].

Understanding the need for better managementof the soft tissue**, Schatzker and Tile** in 1996 developed a distinction between the soft tissue that is adequate for immediate fixation and the soft tissue that is not suitable for surgery because of swelling. In the second group a delay of 7 to 10 days was suggested prior to surgery, for the skin and soft tissues to return to a reasonable state.

Mast et.al recommended that if the definitive surgery cannot be performed within 8 to 12 hours, plan for a temporary treatment and definitive procedure is delayed till the resolution of the swelling. He also recommended that length stable injuries can be treated temporarily by casting and for fractures with shortening calcaneal traction was applied to restore the length, before any definitive procedures.

Sirkin and colleagues, and **Patterson** and **Cole,** in **1999**, popularized the staged management of tibial plafond injuries. They concluded that performing immediate open reduction in the swollen and compromised soft tissue envelope contributed to high rate of wound complication and sepsis.

This staged management protocol remains the foundation for the basis of tibial pilon fracture management in current practice.

Helfet DL et.al in 2004 developed the minimally invasive percutaneous plate osteosynthesis for distal tibia with low profile plate, following better understanding of the osseous fracture anatomy.

EVOLUTION OF LOCKING COMPRESSION PLATE

1890-1910	Lane (Open Fracture treatment)[23] Lane plate Lambotte's series W.Sherman (Metal alloys) Hey-Groves (Locking Screws)
1950-1960	Danis (Osteosynthesis)[23]
1980	Internal fixator system (Polish Surgeon)[23]
1990-2000	Blatter and weber (Wave plate)[23] Minimally invasive percutaneous osteosynthesis Schuhli nut Locking Plate
2000-2010	Locking and minimally invasive percutaneous plate osteosynthesis[23]

DEVELOPMENT PRINCIPLE

AND RULES OF LCP

DEVELOPMENT OF LOCKING COMPRESSION PLATE

During the last decade, tremendous advances have been made in the internal fixation of fractures by plating. The internal fixator system was first developed by Polish surgeon in the 1980’s. They developed the **ZESPOL** system. They based the design of their implant on a number of principles[23].

1. The screw should be fixed to the plate.
2. Compression between the plate and the bone should be eliminated.
3. The number of screws necessary for stable fixation should be optimal.
4. Plate stability and Inter fragmentary compression should be preserved.

The following devices lead to the development of the so called locked internal fixator.

1. **Schuhli locked plate**: This was developed by J. Mast.Schuhli, nuts keep the plate away from the bone. It has three sharp projections. As it makes less direct contact between the plate and bone it acts as a low profile internal fixator. In addition, if in case of missing cortical bone, Schuhli nuts can act as proximal cortices and bicortical fixation is feasible.[23]
2. **Point contact fixator (PC-FIX)**: These devices preserve the blood supply of the periosteum by point contact. These fixators are secured by unicortically inserted screws and hence have minimal contact. The

tapered head of the screw ensures that it lodges firmly in the plate hole and provides the required angular stability. PC-FIX was the first plate in which angular stability was achieved. PC-FIX was the basis for the further development of LISS[23.]

3. The angled blade plate devised by AO is the strongest implant providing that fixed angles gives improved stability.
4. Interlocking nail used in comminuted diaphyseal fracture proved that open anatomical reduction of the fragment is not necessary and close treatment of the comminuted fragments with splinting by intramedullary nail produces abundant callus and solid healing. These four developments, Schuhli nut, point contact plate, fixed angled blade plate and locked intramedullary nail naturally lead to the development of internal fixator by locked head plate[23].
5. During the last decade, bridge plating and less invasive and minimally invasive surgery developed.
6. Finally **M. Wagner and R.Frigg** developed the locking compression plate (LCP), with combi holes and functionality of both locking and conventional plate. This development revolutionized operative fracture fixation[16,17,18,53].

PRINCIPLES OF LCP

Locked plates rely on a different mechanical principle to provide fracture fixation and in so doing they provide different biological environments for healing.

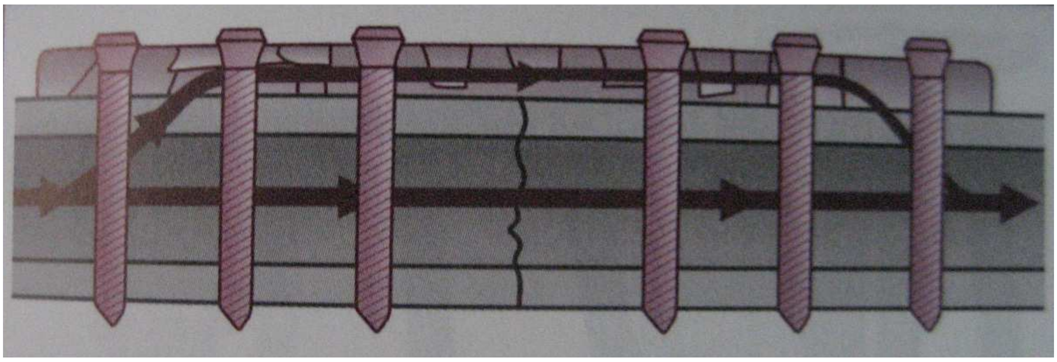
In conventional plates the strength of fixation, depends on the frictional force between the plate bone interface and the axial stiffness or pull out strength of the screw bone interface of the single screw farthest away from the fracture site during axial loading. Conventional plate creates contact stress at bone plate interface, compromising the periosteal blood supply.

Under axial load, there is secondary loss of fixation post-operatively due to toggling of the screws in the plate as screws are not locked to the plate.In the locked plates, they behave biologically and mechanically differently from that of conventional plate.

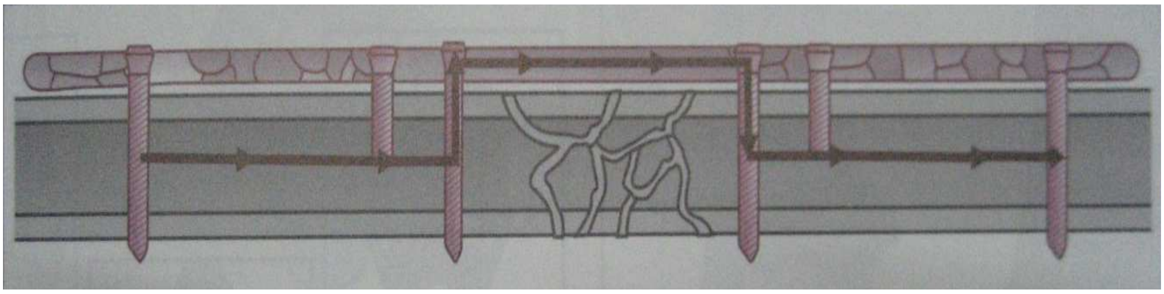
Single Beam Construct:

Locked plate is a single beam construct by design. Plate and screws act as a single unit. Locked plate controls the axial orientation of the screw to the plate, thereby enhancing the screw-plate-bone construct by creating a single beam construct. In this construct there is no motion between the components of the beam that is the plate or the screw or the bone. This construct is four times stronger than load sharing construct which allows motion between the components of the beam[2,23].

Load transfer in conventional plate:



Load transfer in locking compression plate:

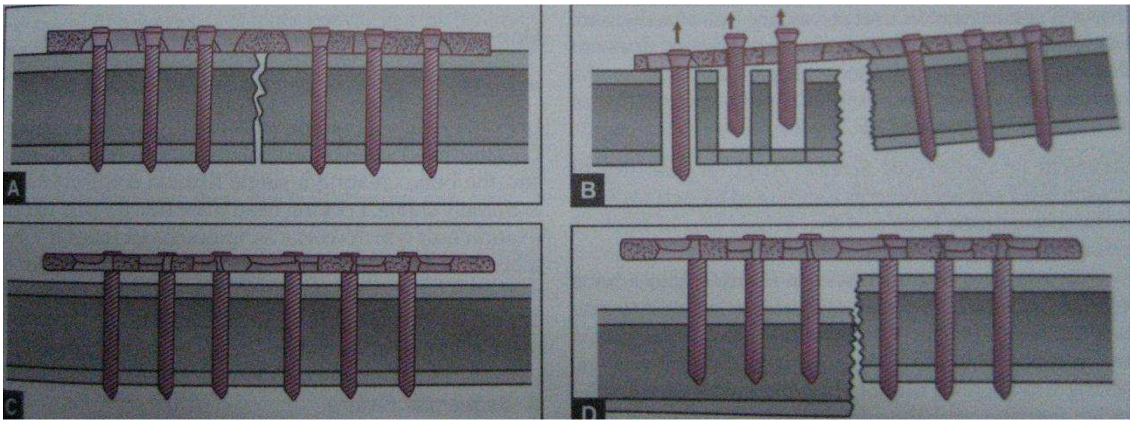


Fixed angled device:

The basic and important principle of locked fixator is its angular stability. It doesn't rely on compression of the screws. As the bone fragments are connected to the fixator through all screws, stability is gained. Each screw acts as fixed angled blade plate. So this multiple fixed angular stability system is very stable. The primary anchorage of the screw in the bone is therefore ensured even in poor bone quality[13,16,17,18].

In the locked head plate load transfer from one fragment of bone occurs through the locked screw head to the plate and from the plate to screw of other fragment and finally to the opposite fragment without loading the bone, not like that of the conventional plate.

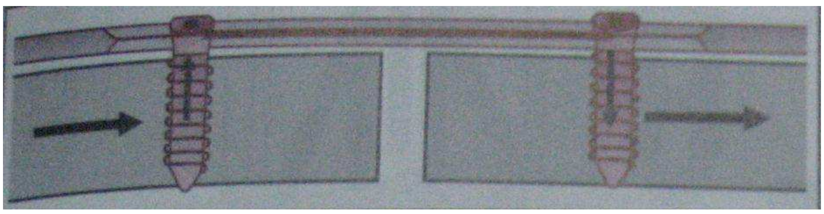
Conventional screws fail one by one



Locking head screws fails en bloc

<u>Load Transfer:</u>

In the locked head plate the principle load transferring element are the screws[2,16,53].



Load transfer through screws and not through bone in LCP

En block fixation:

In locked plates, the strength of fixation is equals to the sum of all screw-bone interfaces compared to that of the single screw's axial stiffness or pull-out resistance as seen in the conventional plates[13,16,23].

Internal Fixator:

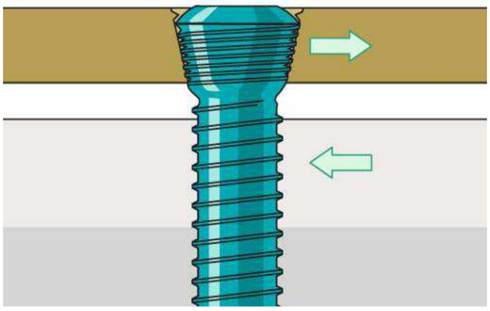
Locked plate acts as "internal-external fixator" and are extremely rigid because of their close proximity to the bone. In the external fixator closer the bar to bone, more rigid is the construct[2,23].

Elastic Fixation:

Locked head plate increase the elasticity when uni-cortical screws are used. Strain is optimized at the fracture site. Hence secondary bone healing occurs with callus formation[23].

As an "internal fixator", locked head plate no longer relies on the frictional force between the plate and the bone to achieve absolute stability and compression. **No Contact Plate:**

In locked head plate as the screw gets locked into the hole, there is no contact between the plate and the bone. Hence the periosteal blood supply of the bone underneath the plate is maintained, whereas in the compression plate, there is disruption of periosteal blood supply and leads to non union [23].



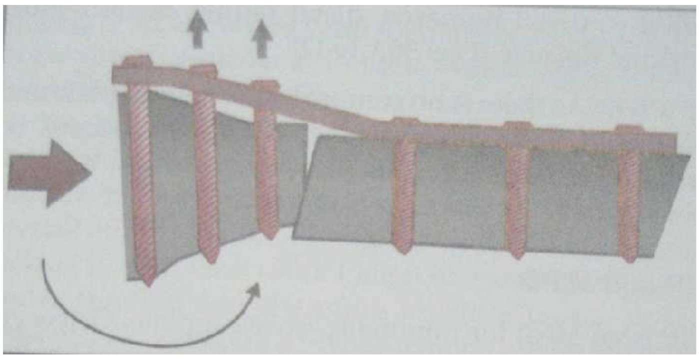
Contouring:

Precise contouring of the plate is not necessary. These plate are anatomical plates which are available for specific bones.

Primary Displacement:

As these plates are precontoured to the bony anatomy to where it is applied, it doesn't require any further contouring. Hence primary displacement does not occur. Whereas in conventional plates, if the plate is not contoured to that of the bone, primary displacement occurs[40,53].

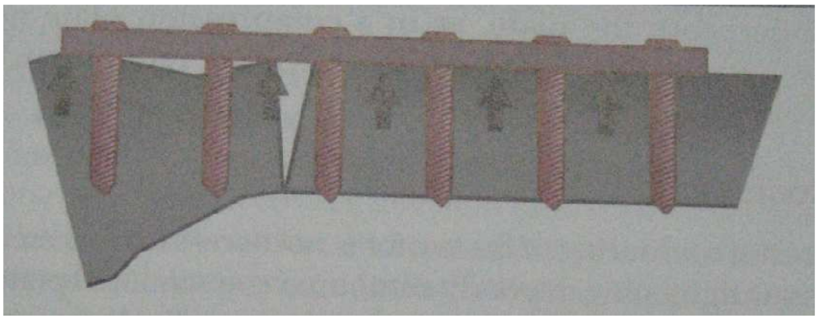
Primary loss of reduction due to improper contouring of conventional plate



Secondary Displacement:

As the screws are locked to the plate providing fixed angular stability, toggling doesn't occur and therefore, secondary displacement does not occur[40,53].

Secondary loss of reduction due to toggling



ADVANTAGES OF LOCKED INTERNAL FIXATOR[17,40,53]

1. As they require no precontouring, primary displacement does not occur.
2. Internal fixator is a biological plate and is an elastic stable fixation. Therefore, natural secondary healing allows abundant callus and faster healing at the fracture site.
3. The screws are incapable of sliding, togging or becoming dislodging. Therefore there is no loss of secondary reduction.

4. Locking the screws ensures angular, as well as axial stability and eliminates unwanted movement of the screws.
5. Blood supply to the bone is preserved as the plate is away from bone.
6. Ideally suited in osteoporotic bones, with less pull-out of screws.
7. Screws with multiple angular stability in the epiphyseal and metaphyseal fragments make the construct very stable.
8. Locked internal fixators are noncontact plates, hence no disturbances in periosteal blood supply, and therefore there is no risk of refracture after removal of plate.
9. No need to contour the plate and also no need to the compress the plate to bone.
10. Also there is no need for reconstruction of the opposite deficient cortex.
11. Polyaxial screws have an advantage. It can be angled in any desired direction.

RULES OF SCREW PLACEMENT IN A LOCKING COMPRESSION PLATE[17, 40, 53]

1. Conventional screws are inserted before any locking screws.
2. Conventional screws will bring the plate closer to the bone.
3. Conventional screws can be used to lag fracture fragment through plate or individually.
4. Locking screws will not reduce the bone to the plate.
5. Locking screws form a fixed angle construct with plate to increase the stability in osteoporotic bone.
6. Lag before lock. After placing locking screws no additional compression or reduction of the fragments are possible.
7. Locking screws should be placed as the final step of plate osteosynthesis.

ANATOMY

ANATOMY

Tibia acts as the major weight bearing bone of the leg through which neurovascular bundle to the foot also traverse. Subcutaneous location of tibia in the anterior and medial aspect makes it more susceptible to injury and especially vulnerable to open fractures.

The **Osseous anatomy**[40] of ankle joint includes the distal tibia, the distal fibula and the talus. Ankle mortise is formed when the distal ends of tibia and fibula meets the superior dome of the talus. The articular surface of distal tibia is broader anteriorly and gradually narrows posteriorly. Also the articular surface is more concave from anterior to posterior.

The medial malleolus is a bony projection from the medial end of distal tibia. It extends more distal and slightly anterior. The articular surface of medial malleolus is oriented perpendicular to tibial plafond and articulates with medial articular portion of talar body[40].

The distal end of fibula also known as the lateral malleolus articulates with the lateral articular portion of the talar body. Ariculation of the distal tibia with the distal fibula forms the tibio fibular syndesmosis distally. The subchondral bone of the distal tibia represents the strongest cancellous bone and provides secure screw purchase for fixation devices.

Regarding the anatomic axis of tibia, the tibial plafond is oriented in slight valgus in the frontal plane (2 degrees), and the anatomic axis passes just medial to midline of the talus. The tibial plafond is slightly extended in sagittal plane (approximating 5 to 10 degrees) and the mid-diaphyseal line of the tibia passes through the lateral process of the talus[40].

Knowledge about the **ligamentous attachments at the ankle joint** is useful for understanding the fracture anatomy and displacement patterns[40].

The irregular convex surface of the medial aspect of distal fibula meets the irregular concave surface on the lateral aspect of tibia to form the distal tibiofibular syndesmosis. The components of the distal tibio fibular syndesmosis include anterior tibiofibular ligament, posterior tibiofibular ligament and the strong interosseous tibiofibular ligament[40].The posterior tibiofibular ligament has superficial and deep component, the latter is called as the transverse tibiofibular ligament. This ligament projects below the margin of distal tibia to form a labral articulation for the posterolateral talus.

The deltoid ligament is also called the medial collateral ligament of the ankle. It is a strong, flat broad triangular band composed of superficial and deep layers. The superficial layer has three attachments distally. They are the tibio calcaneal, tibio navicular and superficial tibio talar ligaments. The deep portion of the deltoid ligament consists of deep anterior tibio talar ligament and deep posterior tibio talar ligament. Deep posterior component is the strongest and clinically more important. It originates from posterior colliculus and travels posterolaterally and inserts to the entire nonarticular medial surface of the talus[40].

For uncomplicated and safe internervous plane, basic knowledge about **muscular and tendinous anatomy of distal tibia** is required. Tibia has four muscular compartments. They are Anterior, Medial, Superficial and Deep Posterior compartments.

The contents of anterior tibial compartment from medial to lateral are the Tibialis anterior, Extensor hallucis longus, Extensor digitorum longus and peroneus tertius muscles. These muscle receive nerve supply from the deep peroneal nerve. Neurovascular bundle of anterior tibial artery and deep peroneal nerve runs between extensor hallucis longus and extensor digitorum longus. The anterior compartment is relatively unyielding compartment bounded by the tibia medially, fibula laterally and interosseous membrane posteriorly and tough crural fascia anteriorly[40].

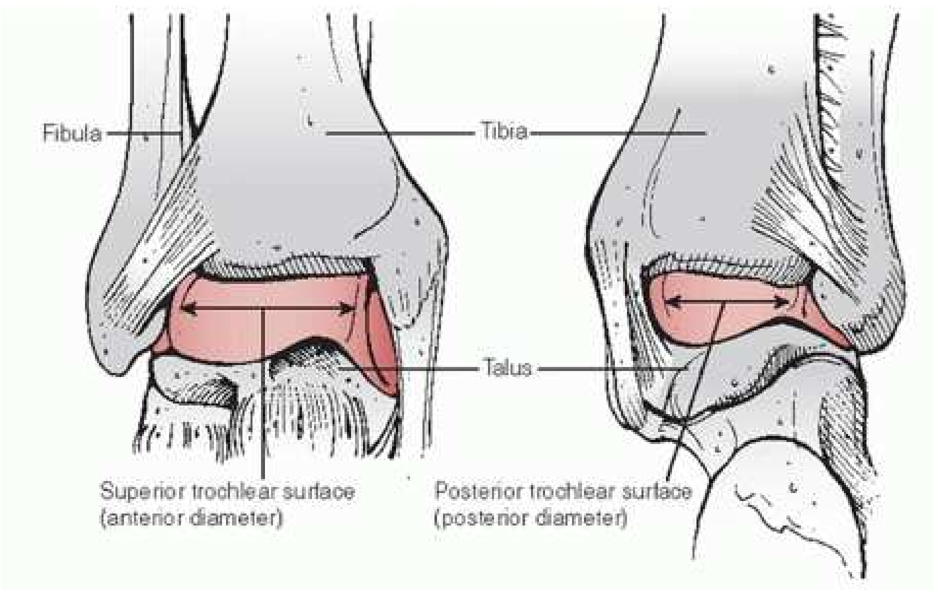
The lateral compartment of the leg contains the peroneus longus and peroneus brevis muscles. These muscles are innervated by superficial peroneal nerve which runs in the intermuscular septum between peroneal muscles and extensor digitorum longus[40]. In the distal third of the leg, the superficial peroneal nerve is purely sensory, which pierces the lateral compartmental fascia, and travels in the subcutaneous fascia from posterior to anterior, typically encountered during the anterolateral surgical exposure[40].

A posterior septum intervenes between the superficial and deep posterior compartments. The superficial posterior compartment contains the gastrocnemius, soleus and plantaris muscle. It also serves as a source for local muscle flap for covering soft tissue defects which are encountered with internal fixation of tibial pilon fractures. These muscles are innervated by the tibial nerve[40].

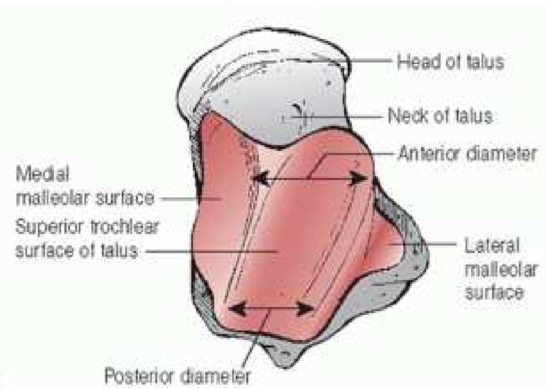
The deep posterior compartment is largely tendinous and includes Tibialis posterior, Flexor digitorum longus and the Flexor hallucis longus muscle. All these muscles are innervated by the tibial nerve[40].

OSSEOUS ANATOMY[40]

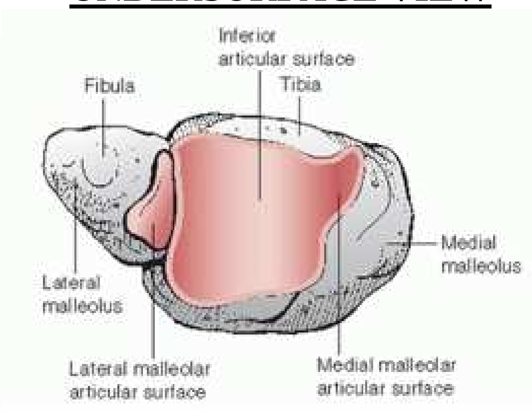
ANTERIOR AND POSTERIOR VIEW



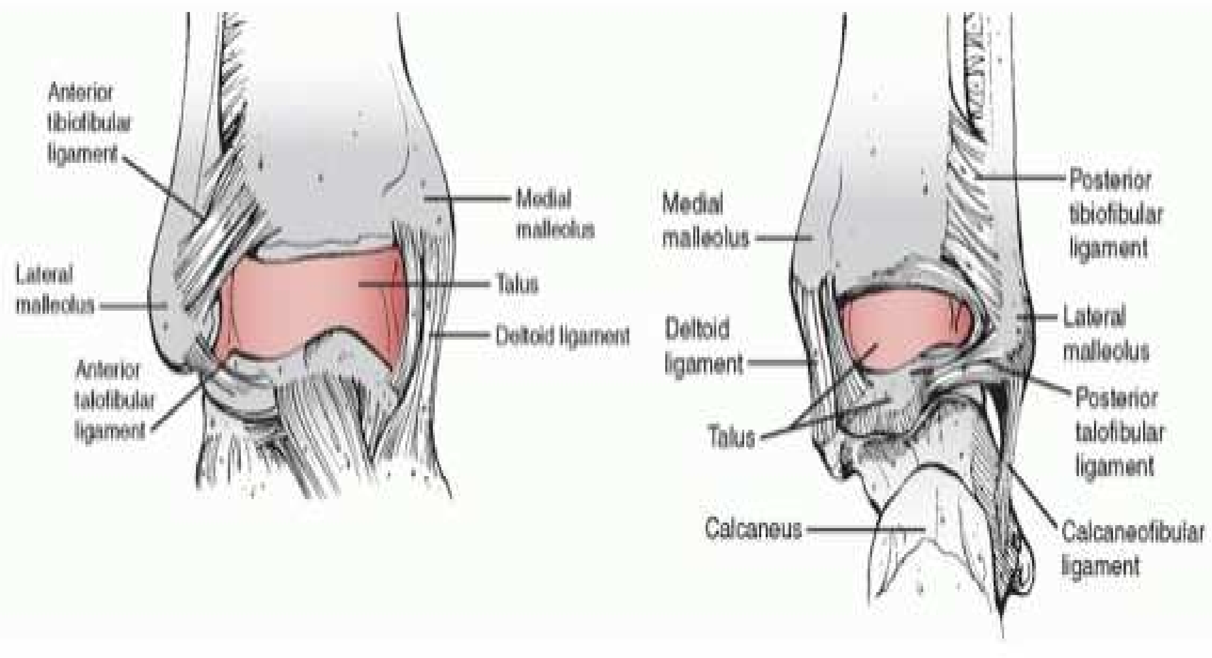
SUPERIOR VIEW



UNDERSURFACE VIEW



LIGAMENTOUS STRUCTURES: ANT AND POST VIEW



CLASSIFICATION

CLASSIFICATION

There are many classification system followed from the early days such as Mast, Speigl and Pappas, Bohler classification, Weber classification, Ruedi and Allgower and AO/OTA types.

Of all the classification systems most commonly followed are Ruedi and Allgower and AO/OTA classification.

MAST, SPEIGL, & PAPPAS CLASSIFICATION[28]

Type-1: Supination-external rotation fracture with vertical loading at the time of injury.

Type-2: Spiral extension fracture

Type-3: Vertical compression fracture

AO/OTA CLASSIFICATION[1,28]

The AO/OTA classification system provides a comprehensive description of distal tibial fractures. The distal tibia is assigned numeric code of 43. Injuries of the tibial plafond are then categorized as extra-articular (43 type A), partial articular (43type B) and total articular (43type C).

AO Type A – fractures are extra-articular distal tibial fractures

A1 – Metaphyseal simple

A2 – Metaphyseal wedge

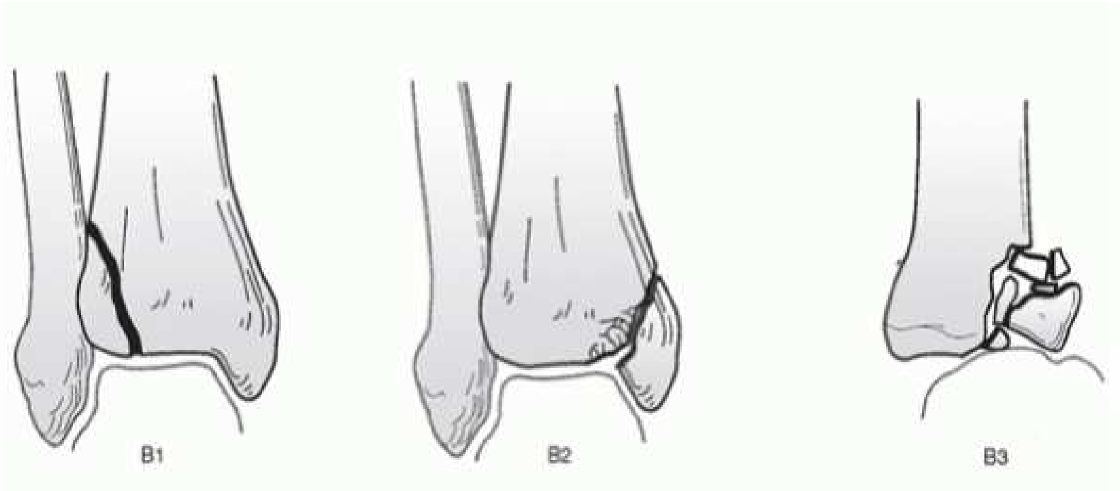
A3 – Metaphyseal complex

AO Type B – Partial articular fractures in which a portion of the articular surface remains in continuity with the tibial shaft

B1 – Pure split

B2 – Split depression

B3 – Multi fragmentary depression

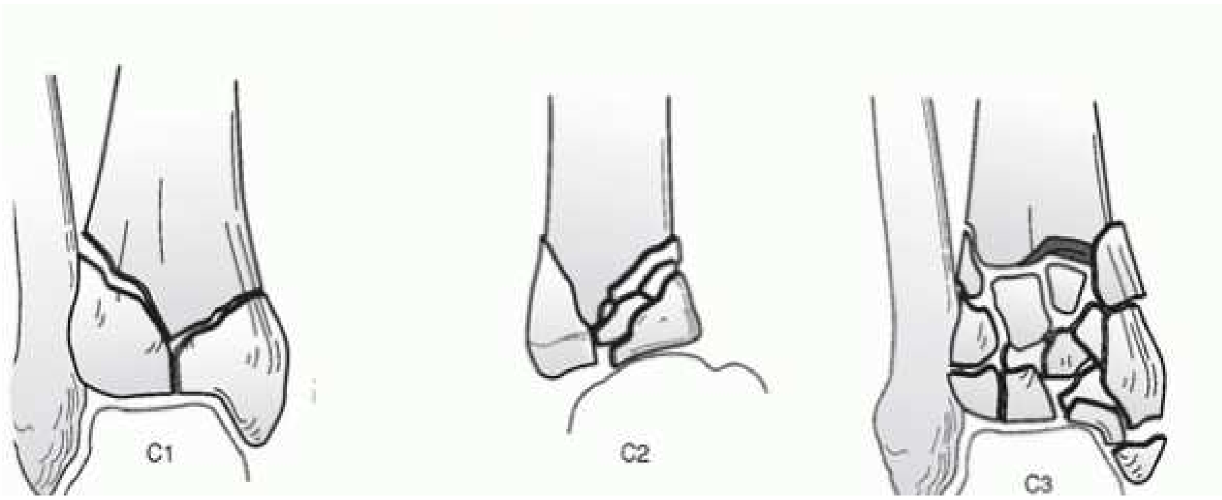


AO Type C – fractures are complete metaphyseal fractures with articular involvement.

C1 – Simple articular with simple metaphyseal fracture

C2 – Simple articular with multifragmentary metaphyseal fracture

C3 – Articular multifragmentary



RUEDI AND ALLGOWER CLASSIFICATION[1]

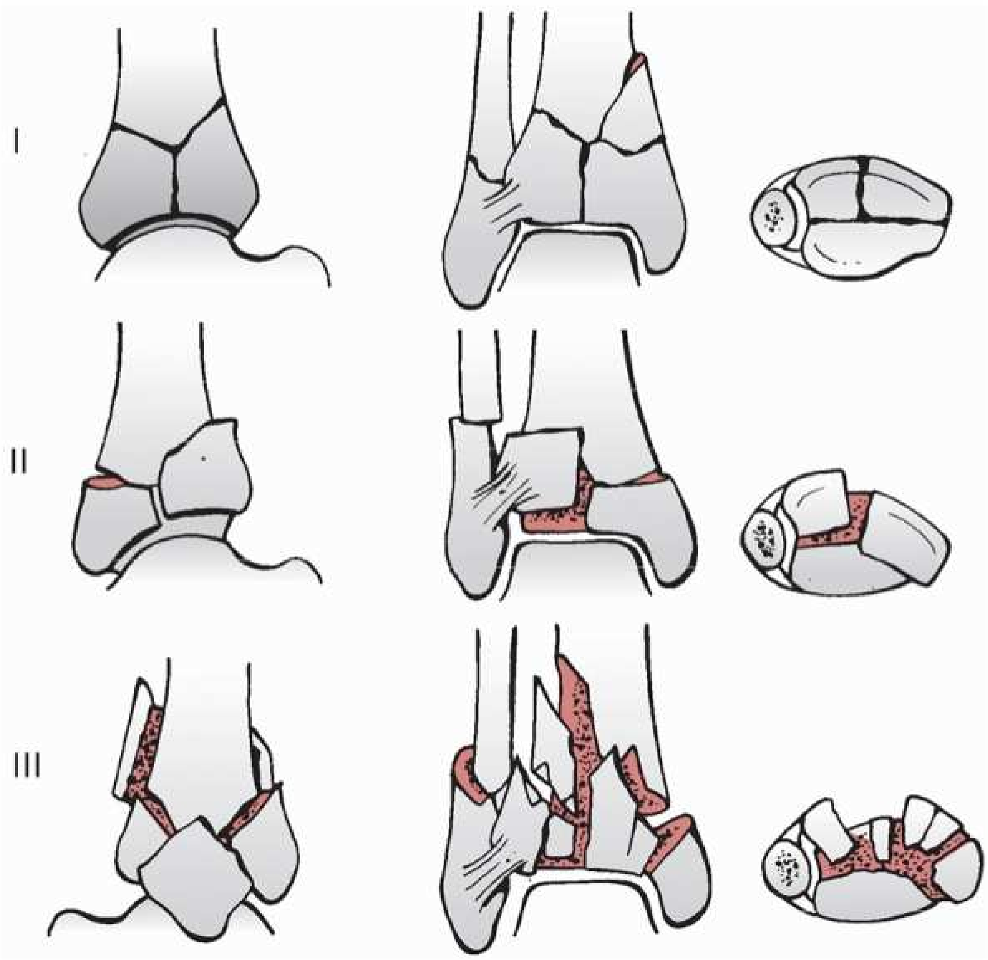
Ruedi and Allgower, classified plafond fractures into three categories.

Type I: cleavage fracture of the distal tibia without significant displacement of the articular surface.

Type II: significant fracture displacement of the articular surface without comminution.

Type III: Impaction and comminution of the distal tibial articular surface.

RUEDI AND ALLGOWER CLASSIFICATION



Reudi and Allgower Classification was modified by Ovadia and Beals

Type I: Undisplaced articular fracture

Type II: Minimally displaced articular fracture

Type III: Displaced articular with large fragments

Type IV: Displaced articular fracture with multiple fragments and large metaphyseal defect

Type V: Displaced articular fracture with severe communition.

Soft Tissue Injury Classification:

The recognition of the soft tissue injury associated with tibial plafond fractures has resulted in the evolution of their surgical treatment. A thorough evaluation of the soft tissue envelope and surgeon’s experience and judgment remains the mainstay. The soft tissue injury classification system of Tscherne and Goetzen is subjective and grades soft tissue injuries of closed fractures into one of four categories, organized from 0 to 3.

Grade 0 - Closed fractures with no appreciable soft tissue injuryand demonstrate an indirect injury simple fracture pattern.

Grade 1 - superficial abrasion or contusion of skin; simple or medium-energy fracture patterns

Grade 2 - deep abrasions and local contused skin; medium to severe fracture patterns

Grade 3 - extensive contusions or crushing, significant muscle destruction and subcutaneous tissue degloving injury.

Compartmental syndrome, vascular injuries, and severe fracture comminution are often identified.

MATERIALS AND METHODS

MATERIALS AND METHODS

This retrospective and prospective study analyzes the functional outcome of Anterolateral distal tibia LCP for treatment of distal tibia fracture depending on the type of fracture and to find out their prognosis.

The study included patients withdistal tibia fractures, who were treated in Rajiv Gandhi Government General Hospital by Anterolateral distal tibia Locking compression plate.

Period of Study:

The period of study was from June 2013 to December 2013 with a total duration of 7 months.

In this period patients already treated by 3.5mm anterolateral distal tibia LCP for distal tibia fracturesin our institution were identified and their data collected retrospectively after obtaining informed consent. These patients were followed up prospectively till fracture union and clinical outcomes were recorded.

In the same period patients admitted with distal tibia fractures with or without intra-articular extension were enrolled for this study after informed consent. The mean duration from hospital admission to definitive surgery was around 21days to 30 days in cases of closed fractures.

Inclusion Criteria

- Patients volunteering to participate in this study.
- Skeletally mature patients.
- Ruedi and Allgower type – I, II, III fractures.
- AO type 43 A, B and C fractures.
- Closed fractures.
- Minimum follow up of 4 months.

Exclusion Criteria

- Age below 18 years and above 80 years.
- Compound fractures
- Associated calcaneum fractures and talus fractures
- Severely mangled extremity and associated spinal and abdominal injuries

The total number of patients in our study was**30.**

CLINICAL EVALUATION

Patient presenting with injury to lower extremity around the distal 1/3rd of leg and ankle joint are suspected to have a tibial pilon fracture. After confirming that the general condition of the patient is stable, examination of the injured ankle is carried out. Thorough history is mandatory as it gives vital clue to the mechanism of injury, thereby we can assess the velocity of injury. Also history of comorbid illness should be elicited, as they are one of the factors determining the outcome of operative intervention.

On physical examination, signs of fracture such as swelling, tenderness, abnormal mobility, crepitus and deformity are noted. Systematic palpation to localize tenderness is done in a less severely injured ankle. A combination of tenderness, swelling or ecchymosis over the bone, ligament, or joint line suggests an injury.

Evaluation of skin status is important. The ankle should be inspected circumferentially for open wounds, soft tissue contusion and bruises.

Limb edema, palpation of the local skin temperature, development of skin blisters should be looked for. Capillary refill of the involved extremity is monitored periodically in the initial period of injury. Thorough neurovascular examination is carried out. Functions of the extensor tendons crossing ankle are assessed. It is necessary to assess the strength generated and not just the apparent motion of the part.

Examination of the ipsilateral knee joint to rule out associated injuries and also distal tibiofibular syndesmotic joint is necessary.

RADIOLOGICAL EVALUATION

PLAIN RADIOGRAPHS[11,40]

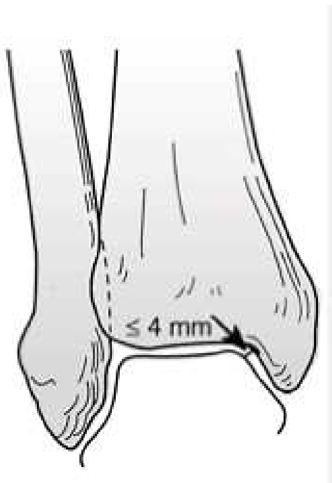
The initial radiographic evaluation consists of standard anteroposterior (AP), mortise, and lateral radiographs of the injured ankle. Full-length images of the tibia and fibula complete the radiologic examination of the injured leg and are used to diagnose more proximal and potentially noncontiguous fractures of the tibia and/or fibula. Additional radiographs include 45 degree oblique views to identify and assess articular involvement and anatomic details of fractures affecting the distal tibial metaphysis[29].

MORTISE VIEW[11,40]

It is taken by internally rotating the leg up to 15 degrees, so that x-ray beam passes perpendicular to the intermalleolar line. This view helps in evaluating the lateral talar shift (the medial clear space), fibular shortening and fibular rotation (tibiofibular line)[29].

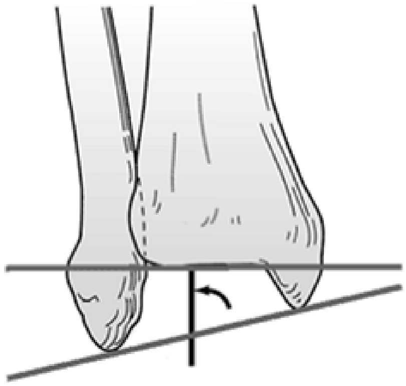
MEDIAL CLEAR SPACE[11,40]

On mortise view, the distance between the medial border of the talus and the lateral border of the medial malleolus is called medial clear space. It should be equal to the superior clear space which is the distance between the talus and the distal tibia. A space greater than 4 mm is considered abnormal and indicated a lateral shift of the talus[29].



THE TALOCRURAL ANGLE:

The talocrural angle is measured between a line perpendicular to the tibial plafond and a line connecting the tips of the medial and lateral malleoli. Normal range is 83 ± 4 degrees or a deviation from the talocrural angle measurement on the contralateral side. It helps in measuring the fibular length.



TILT MEASUREMENT[11,40]

Talar tilt is measured from mortise view by drawing one line parallel to articular surface of the distal tibia and the second line drawn parallel to talar surface. It should be parallel to each other in normal ankle. Any increase in the distance indicated significant talar tilt. Normal talar tilt is 0 degrees (range 1.0 to 1.5 deg).

In AP view talar tilt is measured by the difference in width of superior clear space between medial and lateral sides of joint and it should by <2 mm. These are the static measurements. The talus may tilt up to 5 degrees with respect to inversion stress.

TIBIOFIBULAR LINE:

It is formed by sub chondral surface of distal tibia and medial aspect of the fibula. It should be continuous indicating that the articular surface of the talus is congruous with that of distal fibula. Any disruption indicates shortening, rotation and lateral displacement of the lateral malleolus and also syndesmotic ligaments disruption.

EVALUATION OF SYNDESMOSIS:

The simplest method is to measure the distance between the medial wall of the fibula and incisural surface of the tibia. This tibiofibular clear space should be less than 6 mm on both AP and Mortise views.

CT SCAN[40]

Standard tomography is helpful in documenting articular surface involvement, fracture communition and osteochondral lesion of the talus. Computerized Tomography gives a clear cut idea of the number, size, position and shape of the various fracture fragments. It is important in all cases that are evaluated for open reduction and internal fixation. Three dimensional reconstruction cuts adds to more details and helps in better understanding of the fracture morphology.

MRI SCAN

This investigation provides excellent soft-tissue contrast resolution, has proved to be superior to CT for evaluation of soft tissue structures around ankle. The pathologic conditions of the ligaments and nerve entrapments are demonstrated clearly, so that appropriate treatment can be planned.

METHODS OF TREATMENT

NON-OPERATIVE TREATMENT

Non operative treatment includes long leg plaster cast technique. Casting is reserved for non-displaced fractures after thoroughly scrutinizing radiographs in two views and for those patients with displaced fractures who have relative or absolute contraindication to surgical management. Axially loading fractures of the distal tibia with metaphyseal and articular displacement are not indicated for this type of treatment.

OPERATIVE TREATMENT

The principles of operative treatment are anatomic restoration of articular surface, maintain proper length and axial alignment, stable fixation of fractures, early mobilization of joints. Displaced pilon fractures are managed operatively, particularly those with displaced intra-articular fracture fragments. The age, velocity of injury, condition of local soft tissue envelope, fracture pattern and comorbid conditions are the major determinants for proceeding with operative treatment[4,6,8,10,32].

PLATES AND SCREWS:

The 3.5 mm Anterolateral Distal tibia LCP[13,20,21]

Fixation with the 3.5 mm Anterolateral Distal tibia LCP is different from the traditional plate fixation methods of tibial pilon in that the plate is placed on the lateral surface curving anteriorly towards subchondral bone. The technical innovation of locking screws provides the ability to create a fixed angle construct while using familiar AO plating techniques. Locking capability is important for fixed angle constructs in osteopenic bone or multifragmentary fractures where screw purchase is compromised. These plates function similar to multiple, small, angled blade plates. The fixation of this implant can be done by MIPPO technique or open reduction technique.

3.5mm DISTAL TIBIA ANTEROLATERAL LCP

SURGICAL APPROACHES[46]

Skin incisions and surgical approaches to tibial pilon are many and they have been tested and modified over many decades in an attempt to decrease the incidence of wound complications. Extensile incisions are avoided in the distal tibia because of the precarious vascular supply and risk of wound dehiscence

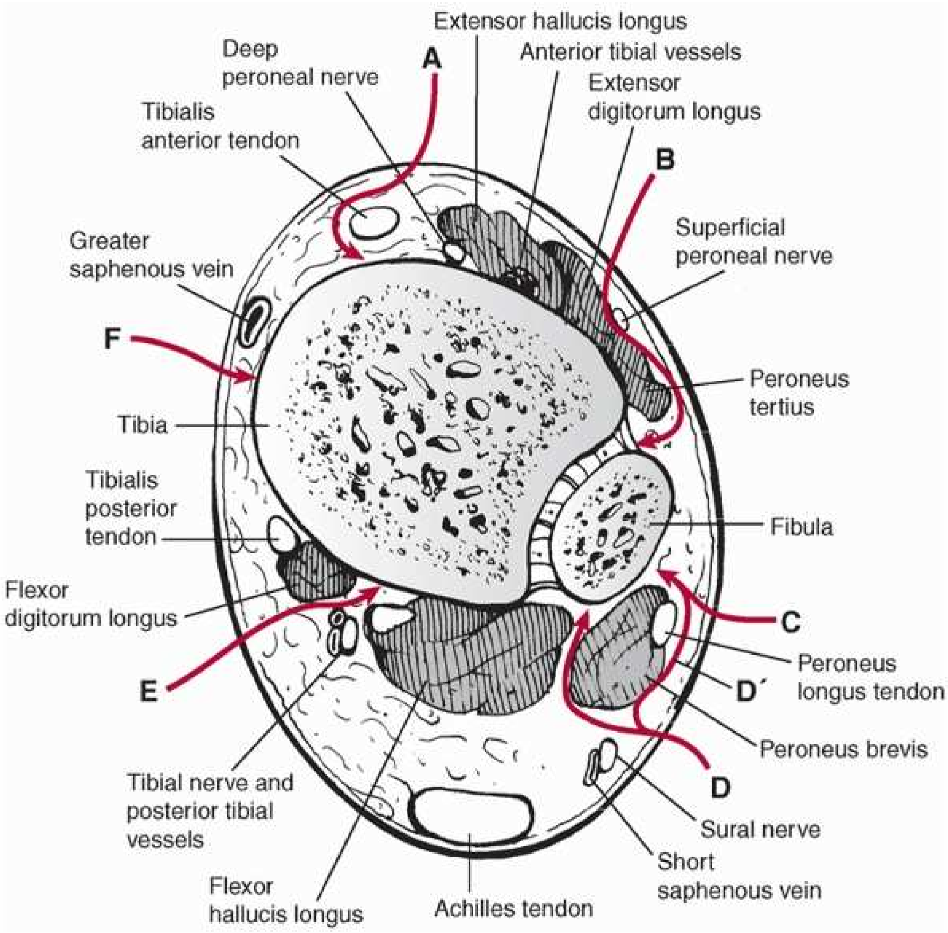
Although the indications to fix the fibula internally have been modified in recent years, it is still an integral part of fixing tibial plafond fractures, so that length and axial alignment can be maintained.

TIBIA

Surgical approaches[40,46] include

1. Anteromedial
2. Anterolateral
3. Modified anteromedial
4. Posterolateral
5. Posteromedial

SURGICAL APPROACHES



SURGICAL TECHNIQUE

Positioning:

- Regional Anaesthesia.
- Supine position on an operating table with a radiolucent extension. A small soft rolled towel is placed beneath the ipsilateral buttock to decrease the tendency to externally rotate.
- Ipsilateral limb is painted from groin to foot.

Surgical Exposure:

Fibula fixation is performed initially to restore length and achieve indirect reduction of tibia fracture. Fibula fractured is fixed by the following steps:

Fibula (Postero lateral approach of Henry):[40,46]

Skin incision begins 12 cm proximal to the tip of the lateral malleolus and extended distally along the posterior margin of the fibula to the tip of the lateral malleolus. It is curved anteriorly for 2.5 to 4 cm in the line of the peroneal tendons.

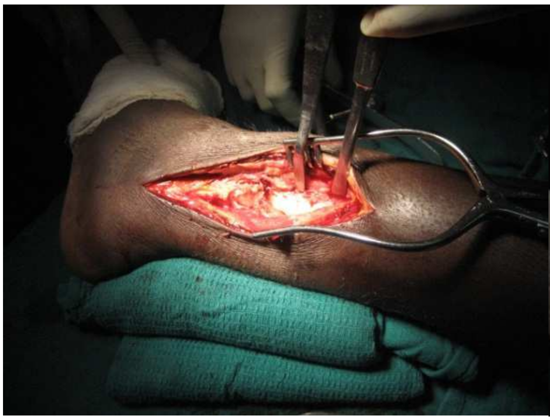
Fibula, including the lateral malleolus is exposed subperiosteally, and the sheaths of the peroneal retinacula and tendons are incised. This permits the tendons to be displaced anteriorly. Fibula reduction and fixation is carried out.

FIBULA FIXATION:

- Proximal and distal fracture ends are reached. Fragment ends are freshened using curette.
- Reduction of fracture achieved by inline traction and varus force to bring the overridden distal fragment beneath the proximal fragment.
- Reduction confirmed using image intensifier.
- One-third/Semi tubular plate secured to lateral surface of fibula using two plate holding forceps.
- After confirming fracture reduction again and ruling out plate offset to bone, three 3.5mm conventional cortical screws distally and , three 3.5mm conventional cortical screws proximally are inserted.
- Wound wash given and closed in layers over drain.

POSITION ***INCISION***

EXPOSURE ***FIXATION***



CLOSURE

This posterolateral incision provides a larger skin bridge between this incision and the tibial incision. A 7 cm skin bridge was routinely recommended. Howard recently demonstrated minimal soft tissue complications with skin incision bridges between 5 and 6 cm when treating tibial plafond fractures.

TIBIA FIXATION:

Surgical Exposure:

Anterolateral approach was used in our study. It allows excellent visualization of the anterior tibial, access to the medial ankle joint is limited and may require an additional medial incision for the reduction of any medial malleolar fragments. Anterolateral locking compression plates are placed through the interval between the anterior and lateral compartments.

The skin incision, which is centered at the ankle joint, parallels the fourth metatarsal distally and runs between the tibia and fibula proximally. The incision is usually not extended 7 cm above the ankle joint, because the origin of the anterior compartment muscle bellies is encountered. Full-thickness skin flaps should be maintained throughout. The superficial peroneal nerve is at risk for injury during the approach because it lies directly beneath the skin and crosses the surgical approach at the ankle. It must be identified, protected, and retracted during the surgical procedure.

With the superficial peroneal nerve mobilized and retracted, the fascia over the anterior compartment of the distal tibia and the extensor retinaculum are sharply incised. The anterior compartment tendons are then retracted medially. Proximally, the anterior compartment musculature, including the peroneus tertius, can also be mobilized and retracted medially. The location of the ankle joint arthrotomy should be carefully planned to avoid unnecessary devascularization of the fracture fragments.

<u>Application of Distractor:</u>

In addition, in order to place a femoral distractor, lateral surface of tibia is used. Distractor should be placed in such a manner not to obscure the tibial fixation. To place adistractor pin in the talus, the extensor digitorum brevis fascia can be incised and the muscle retracted medially, exposing the talar neck. 4.5mm schanz screw is inserted into talar body after predrilling. Tibial pin is placed on the lateral surface. Care to be taken not to injure the anterior tibial neurovascular bundle. This pin should be planned and placed proximal to the expected proximal end of the LCP.

<u>Fixation:</u>

Although fracture pattern dictates specific plate use, anatomically designed anterolateral plates are useful for fixation of common fracture patterns.

<u>Step 1:</u>

Fluoroscopy imaging done to check the anteroposterior and medial lateral axis alignment.

Step 2:

Articular fragment and main fracture fragments identified, reduced and fixed with temporary k – wires. Order of reduction of articular fragments is posterolateral--->posteromedial-->central-->anterior-->anterolateral.

Step 3:

Articular fragments reduced to proximal metaphyseal fragment and locking compression plate is slid and positioned over the anterior subchondral surface and lateral surface of tibia. Length of the plate is three times the span of fractured segment.

Step 4:

Plate position and offset checked using fluoroscopy and then definitive fixation carried out. First screw being 3.5mm conventional cortical screw predrilled with 2.7mm drill bit proximally followed by locking 3.5mm cortical screws proximally and distally.

For AO type A fractures we used the technique of MIPPO in six cases successfully. Here the distal part of the approach was used and it is a longitudinal incision. The fracture was reduced indirectly and the plate was inserted through the incision. Through separate incision, screws were inserted in the proximal fragment[17,26].

For AO type B and type C fractures and type A fractures in which MIPPO was not performed, we did open reduction of the fracture fragments and then fixed with 3.5 mm Anterolateral distal tibia LCP and locking screws.

TIBIA FIXATION:

INCISION

EXPOSURE OF SUPERFICIAL PERONEAL NERVE

Wound washed and closed in layers over suction drain. Sterile dressing applied.

LCP

CLOSURE (MIPO) **CLOSURE (OPEN)**

Post-operative protocol[37,39]

- Short leg plaster cast was applied in all cases immediately post surgery.
- Drain removed after 48 hrs.
- Ankle and knee mobilization exercises were started after drain removal.
- Non weight bearing walking with walker support initiated simultaneously.
- Plaster cast was changed to removable splint, to be worn by patient at bed time.
- Wound sutures removed on 12th post operative day.
- Patient discharged only after suture removal on 12th post operative day.
- Follow up clinical and radiological examination done at 6, 10 and 16 weeks and every month thereafter in cases of delayed union.
- Once signs of radiological union appear, partial weight bearing was allowed.
- Full weight bearing was allowed after fracture consolidation

- All cases were assessed using the Kaikkonen ankle score andTeeny wiss radiological scoring.

- **KAIKKONEN ANKLE SCORE**

I.Subjective assessment of the injured ankle:

No symptoms of any kind	15
Mild Symptoms	10
Moderate Symptoms	5
Severe Symtoms	0

II.Can you walk normally:

Yes	15
No	0

III.Can you run normally:

Yes	10
No	0

IV.Climbimg downstairs:

Under 18 seconds	10
18-20 seconds	5
Over 20 seconds	0

V.Rising on heels with injured leg:

Over 40 times	10
30-39 times	5
Under 30 times	0

VI.Rising on toes with injured leg:

Over 40 times	10
30-39 times	5
Under 30 times	0

VII.Single limbed stance with injured leg:

Over 55 seconds	10
50-55 seconds	5
Under 50 seconds	0

VIII.Laxity of the ankle joint:

Stable (<5mm)	10
Moderate instability	5
Unstable	0

IX.Dorsiflexion Range of motion:

>10 degrees	10
5—9 degrees	5
<5 degrees	0

Outcomes: Excellent >85 ; Good 70-80 ; Fair 55-65 ; Poor <50

SCORING CRITERIA FOR QUALITY OF REDUCTION ACCORDING TO TEENY AND WISS[47]

Anatomical site	Score		
Quality of reduction	1	2	3
Lateral malleolus displacement	0-1 mm	2-5 mm	5 mm
Medial malleolus displacement	0-1 mm	2-5 mm	5 mm
Posterior malleolus displacement	0-0.5 mm	0.5-2 mm	2 mm
Mortise widening	0-0.5 mm	0.5-2 mm	2 mm
Fibular widening	0-0.5 mm	0.5-2 mm	2 mm
Talar tilt	0-0.5 mm	0.5-2 mm	2 mm
Articular gap	0-0.5 mm	2-4 mm	4 mm

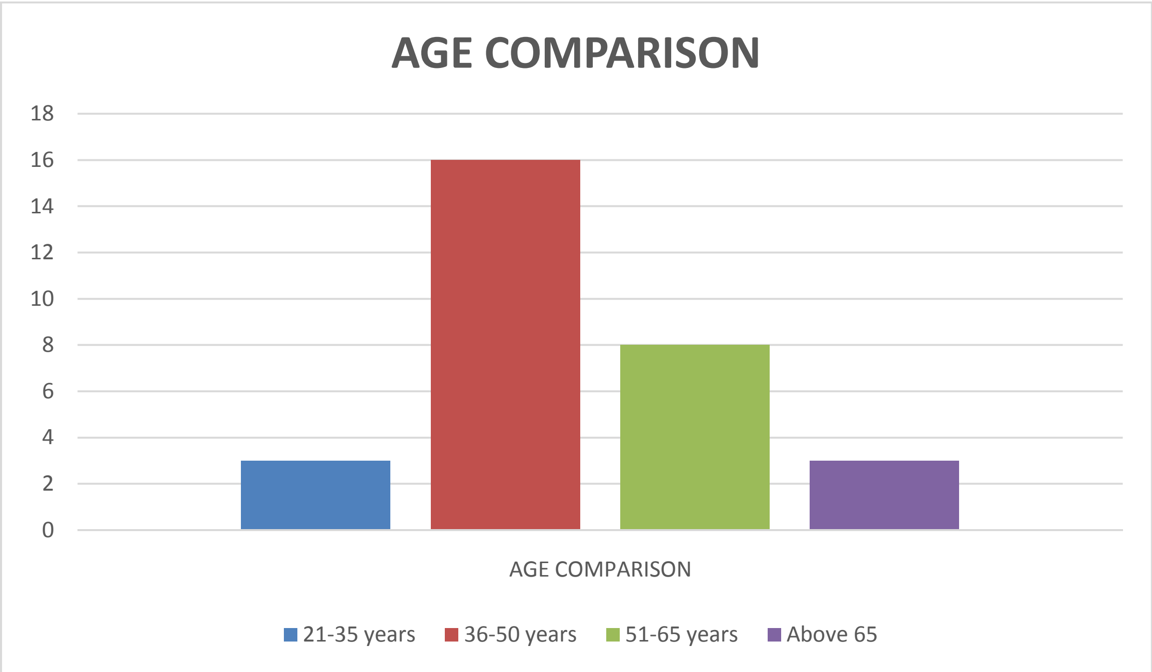
Rating	**Points**
Anatomic	**9**
Good	**10-12**
Fair	**13-16**
Poor	**> 16**

RESULTS

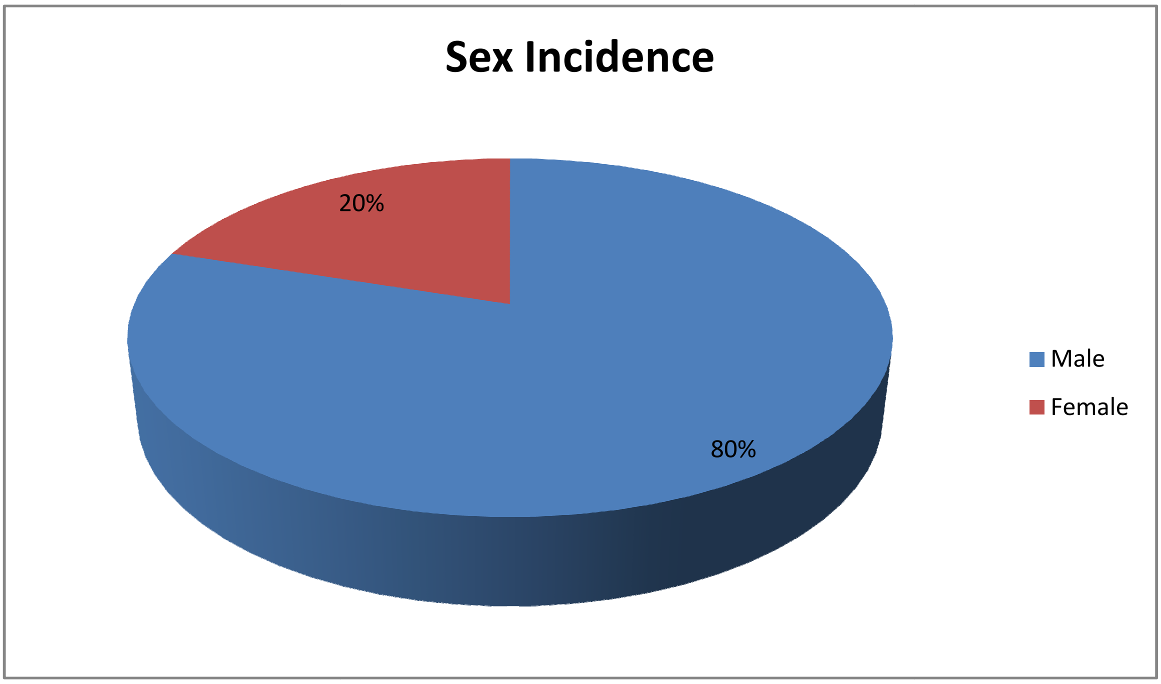
RESULTS

The following observations were made in our study. In our study of 30 cases, there is a minimum follow up of 4 months and maximum of 12 months with an average of 9 months.

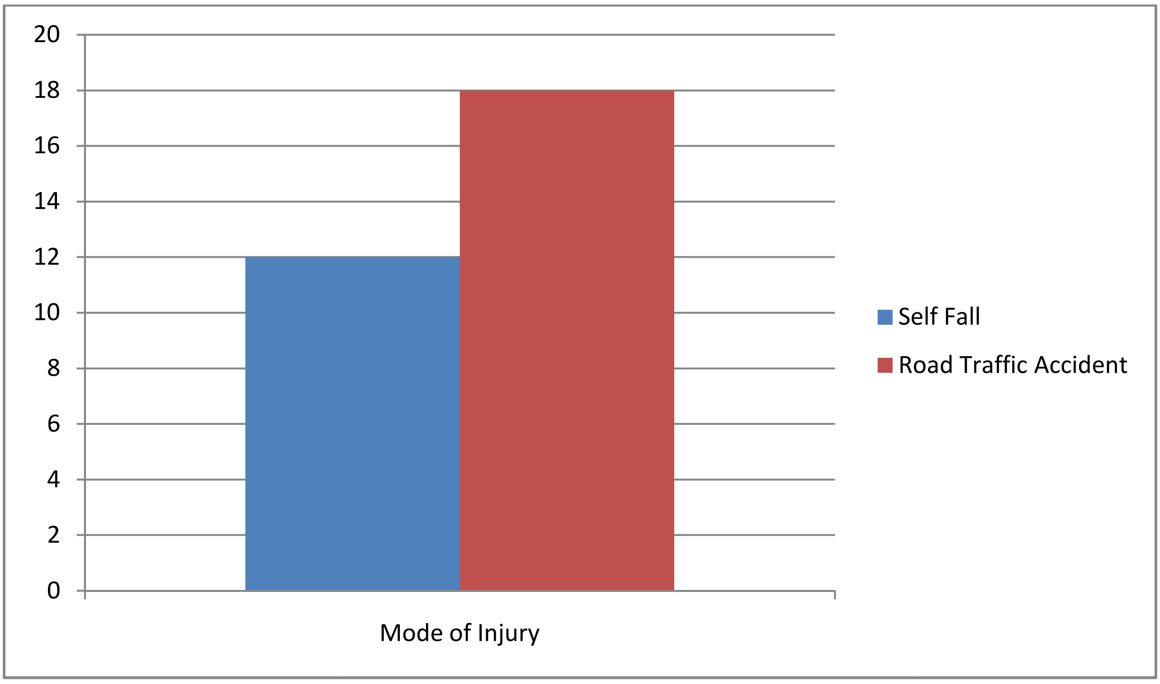
AGE INCIDENCE



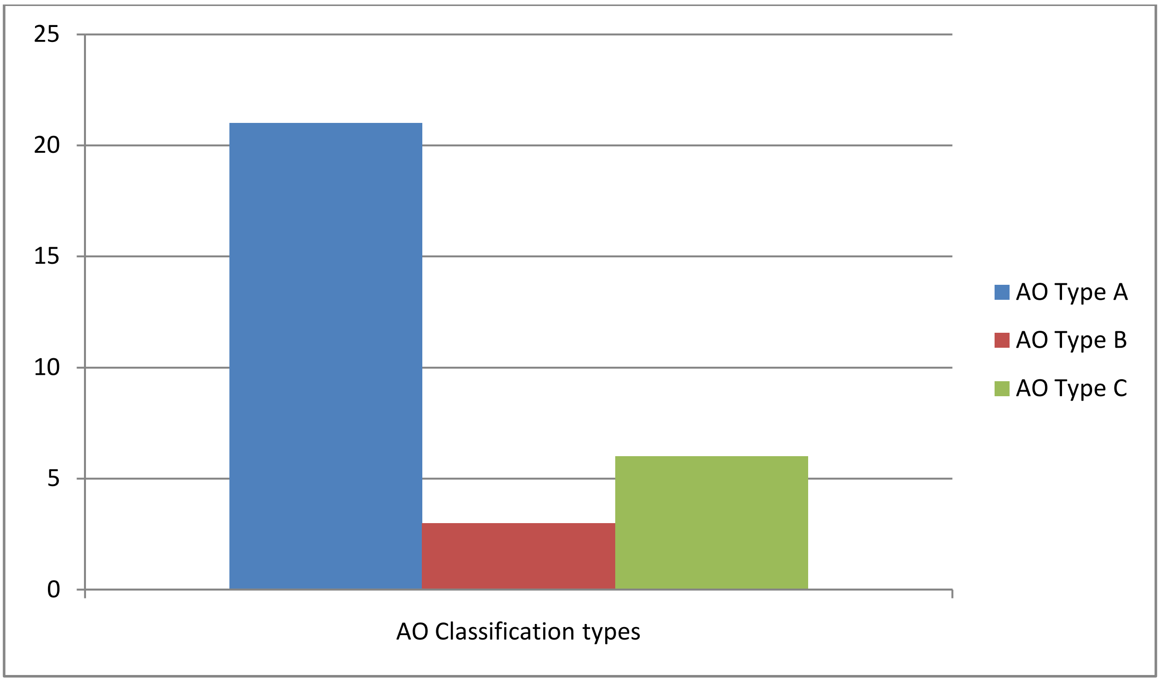
SEX INCIDENCE:



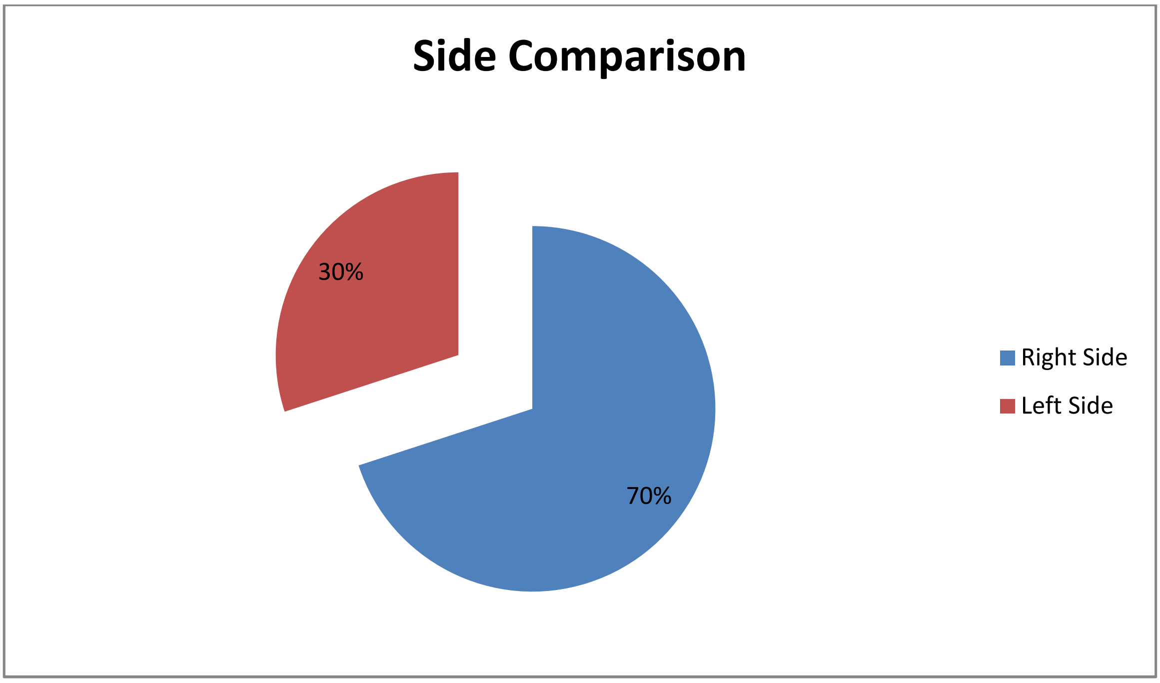
MODE OF INJURY:



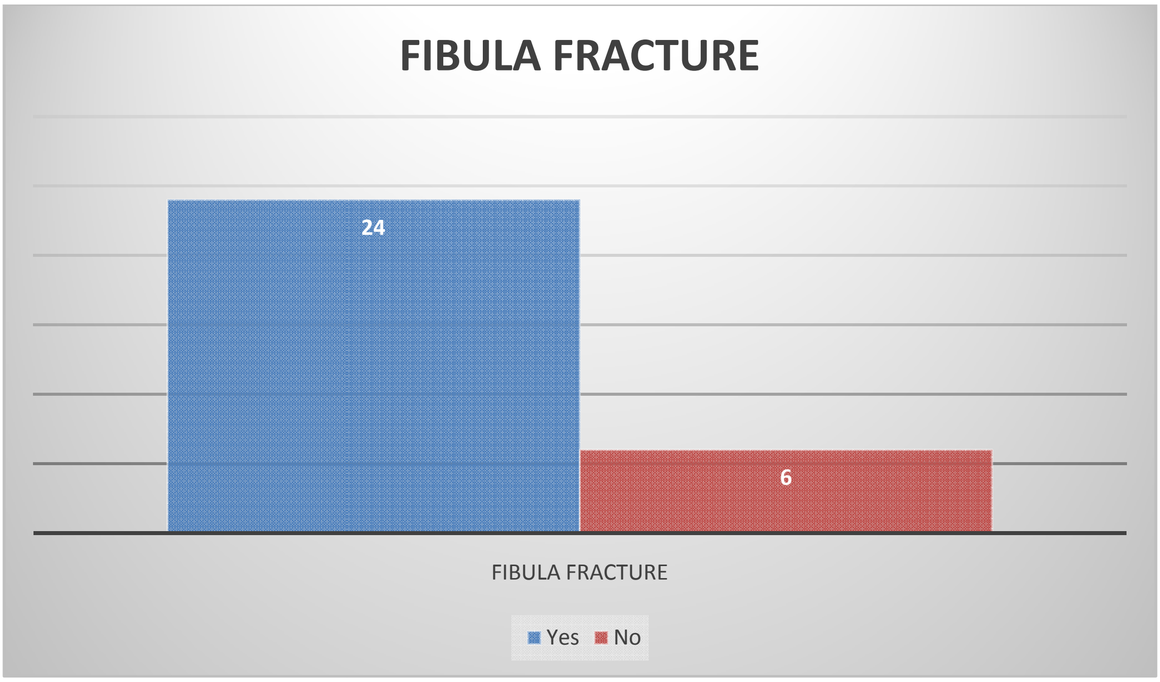
INCIDENCE BASED ON CLASSIFICATION: (AO)



INCIDENCE BASED ON SIDE INVOLVEMENT:



FIBULAR FRACTURE INCIDENCE:



Distal tibia fractures though can be treated by open reduction and internal fixation, carries a risk of wound complication and a potential for redo surgery. The outcome of an injury is best judged by how much it affects the patients, deformity, impairment or loss of function.

Ovoida and Beals[33] considered "***an excellent result to be pain free patient who has returned to all activities without limp***". A number of factors affect the outcome of distal tibial fractures. The single most important factor is the severity of the initial injury resulting in communition and displacement of the fragments and extensive soft tissue damage. Another is the extent to which reduction was achieved during surgery and also the post-operative complications.

FRACTURE UNION:

27 fractures united. Radiological union obtained in 27cases with a mean duration of 12 to 24 weeks. Three patients went in for non union and out of which one implant failure occured. All patients were started full weight bearing after signs of radiological union.

FUNCTIONAL SCORE:

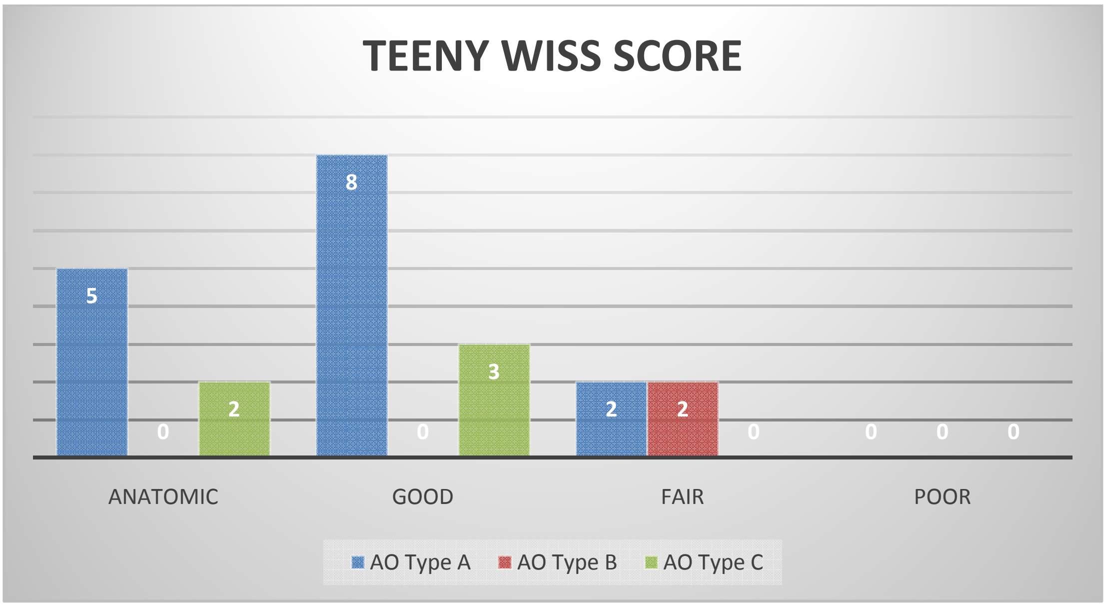
A variety of rating systems were proposed for subjective and objective components. We have used Teeny and Wiss Score for radiological evaluation of ankle and Kaikkonen ankle scoring for functional analysis. The mean functional ankle scores were 72 with a maximum of 95 and minimum of 40. Anatomic reduction was achieved in about 7 cases with good alignment.

TEENY WISS RADIOLOGICAL SCORING:

In our study we were able to achieve anatomic reduction in 32% (7 cases) of the patients. Good reduction was achieved in 50%(11 cases) of the patients[47]. Fair reduction was achieved in 18% (4 cases). There was no case of poor fracture reduction in our study.

Reduction	AO Type A	Type B	Type C
Anatomic	6	0	3
Good	12	0	3
Fair	3	3	0
Poor	0	0	0

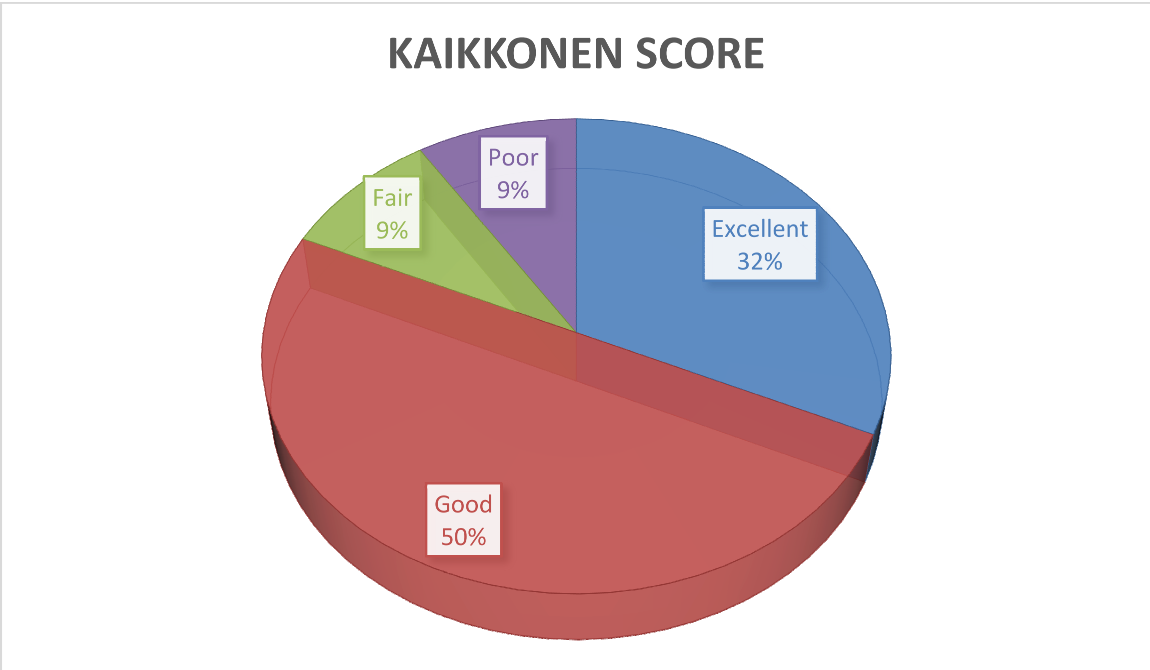
TEENY WISS RADIOLOGICAL SCORING



KAIKKONEN ANKLE SCORE :

Scoring	Excellent	Good	Fair	Poor
Type A	6	12	0	3
Type B	0	0	3	0
Type C	3	3	0	0

KAIKKONEN ANKLE SCORE :



COMPLICATIONS

COMPLICATIONS:

In our study the complication we met were 6 cases (20%) of wound dehiscence and superficial infection which healed by secondary intention, 2 cases (7%)of flap necrosis, 3cases(10%) of nonunion, extensor tendon exposed in 1 case(3%), implant failure in one of the three non union cases. In our study we had no deep infection(0%).

SUPERFICIAL WOUND DEHISCENCE

EXTENSOR TENDON EXPOSED

IMPLANT EXPOSED REQUIRING FLAP COVER

IMPLANT FAILURE AND NONUNION

COMPLICATION	NUMBER OF CASES	PERCENTAGE
Superficial wound dehiscence	6	20%
Flap Necrosis	2	7%
Tendon exposure	1	3%
Non union	3	10%
Implant Failure	1	3%

DISCUSSION

DISCUSSION

Distal tibia fractures result from low energy torsional or high energy axial-loading mechanisms. High energy fractures are commonly associated with severe soft tissue injury, comminution of metaphyseal and articular fracture fragments of tibial plafond and comminuted distal fibula fractures. Tibial pilon fractures account for <10% of lower extremity fractures and occur in adults owing to fall from height or from road traffic accidents. The optimal treatment for these fractures remains controversial. This is due tothe associated significant soft tissue injury and precarious vascular supply of distal tibia. The treatment of distal tibia fractures can be challenging because of its subcutaneous location, poor vascularity and limited soft tissue[3,4,12].

The main factor in treating these injuries is to estimate the degree of associated soft tissue injury. Since only closed fractures were included in our study, we used Tscherne soft tissue injury classification to assess and grade the severity of soft tissue injury. Definitive fixation is advisable and proceeded only when the soft tissue injury heals. This is indicated by the skin wrinkle sign, once limb edema subsides. In our study, internal fixation was carried out at an average of 3 to 4 weeks once wrinkle sign developed.

Minimally invasive plating techniques (MIPO) reduce the iatrogenic soft tissue injury and damage to bone vascularity, and also preserve the osteogenic fracture hematoma. But even MIPO techniques should be performed after soft tissues heal. And with a delay of three weeks, MIPO is not possible in some cases. This is why in our study too, MIPO couldnot be carried out even in some AO type A fractures.

The key principles in the management of these fractures are – 1)Restoration of the length and limb axis by open reduction and internal fixation of fibula fracture;

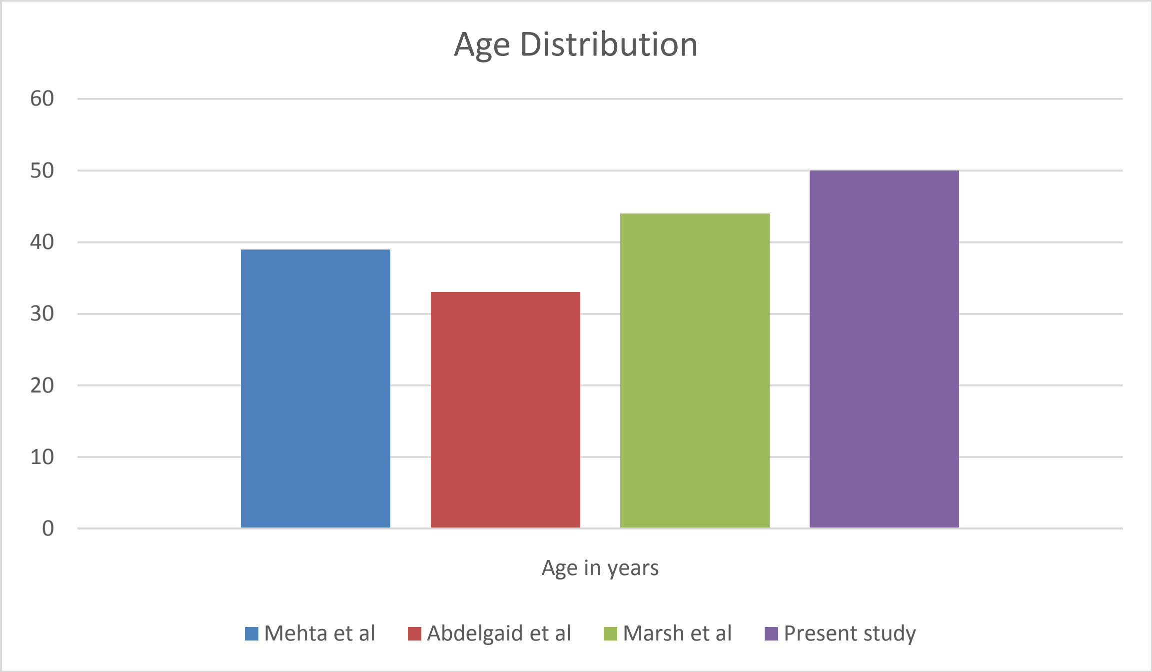
2) the anatomical reconstruction of the articular surface of tibial plafond; 3) the filling of the defect resulting from impaction and the support of the lateral side of tibia, by lateral plating to prevent the valgus deformity[32].

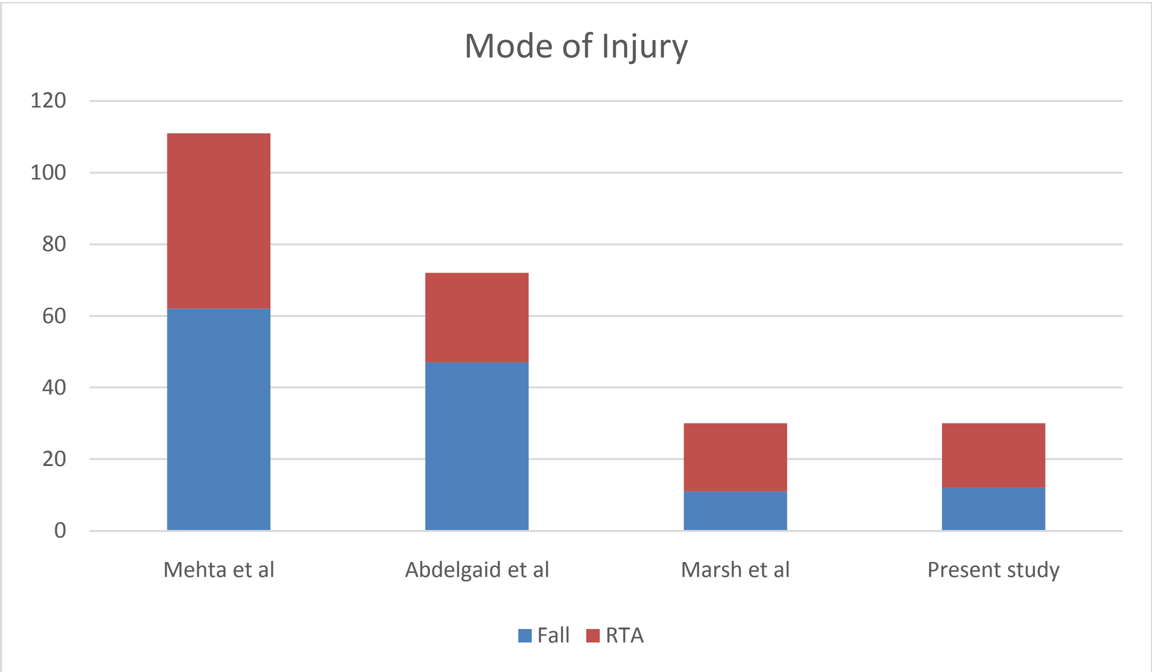
In our study we used a single-stage direct internal fixation technique of all distal tibia fractures. Average delay to fixation was 24 days. We used 3.5mm anterolateral distal tibia locking compression plate for all cases. This plate is a low profile plate of 3.5 mm system. The 3.5mm anterolateral distal tibia LCP is a pre-contoured plate to suit the lateral surface of tibial shaft and anterior surface of the tibial plafond abutting the subchondral bone. This design allows placement of the plate without disruption of fractures fragments. The thread holes in the plate locks to that of the screw head and minimize plate-bone interface and maintain the vascularity at the fracture site.

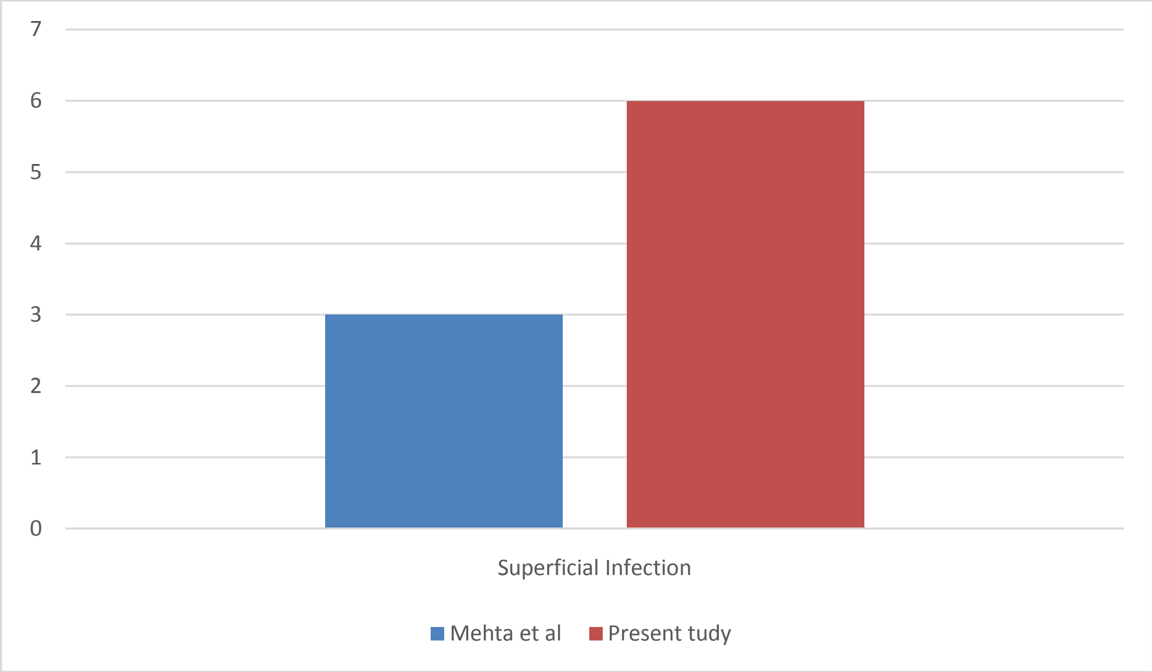
Among 30 patients, 6 AO type A fractures were managed with MIPPO technique. Rest of the AO type A, AO type B and AO type C fractures were managed with open reduction and fixation with locking compression plate.

Our study included a total of 30 patients. The peak incidence in our study was among the age group between 36-50 years. In our study we had excellent functional outcome in about 30% of cases, good functional outcome in 50% of cases fair and poor outcome 10% of cases each based on KAIKKONEN ANKLE SCORE. As per **TEENY WISS SCORE**[47] we had anatomic reduction in 9 cases, good reduction in 15 cases, fair reduction in 6 cases.

In the study by **Mehta et al**[27]of 131 patients, average age was 39 years (compared to 50 years in present study), most injuries were due to fall (compared to road traffic accident in our study), side involvement was almost equal (right side predominant in our study). They reported superficial infection in three patients (compared to 6 cases in present study). Superficial infection rate was higher in our study. Average delay to surgery was 14 day (compared to 24 days in present study).


Age Distribution
60
50
40
30
20
10
0
Age in years
Mehta et al
Abdelgaid et al
Marsh et al
Present study


Mode of Injury
120
100
80
60
40
20
0
Mehta et al
Abdelgaid et al
Marsh et al
Present study
Fall
RTA

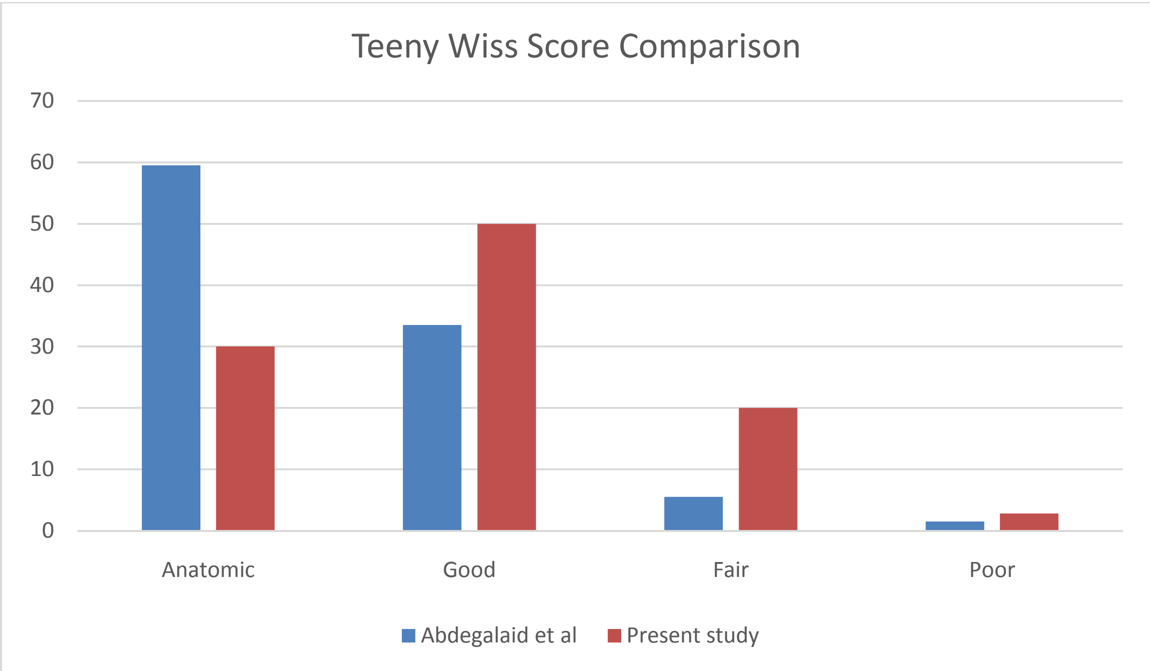


In the study by **Sherif Mohammad Abdelgaid et al**[28], average age was 33 years (in contrast to 50 years in our study), more males 43:29(comparable to 24:6 in present study), more cases were due to fall (in contrast to road traffic accident in our study),

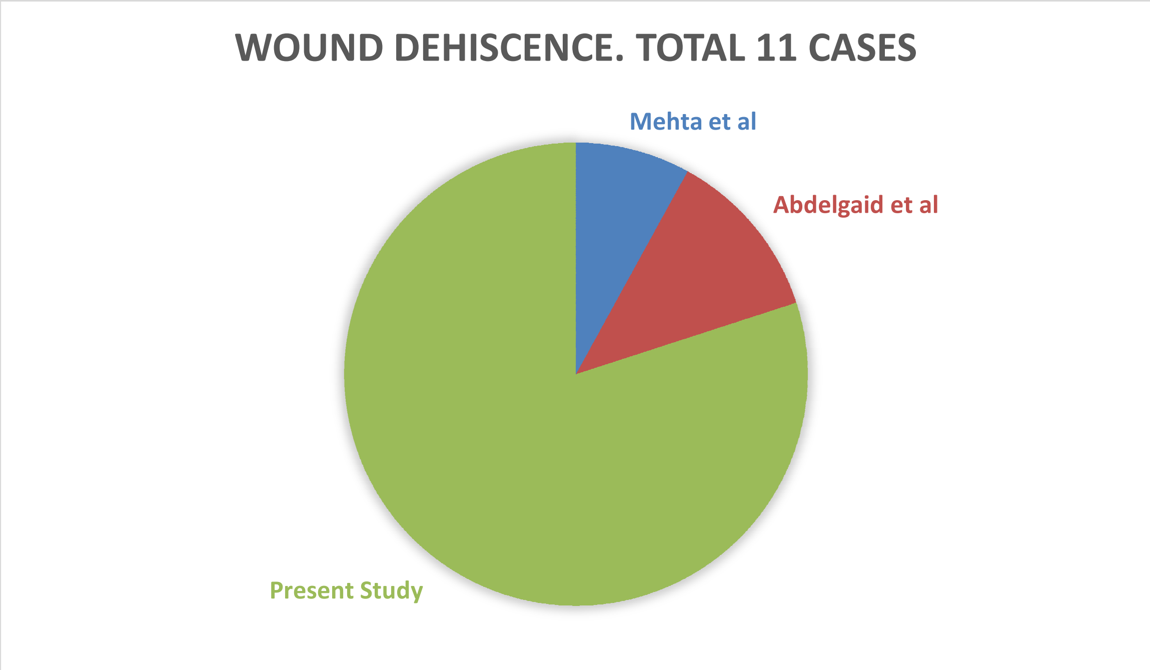
In this study, using Teeny and Wiss radiologic scoring system, 43 patients (59.5%) achieved anatomical reduction, 24 patients (33.5%) achieved good results, 4 patients (5.5%) with fair results and only one patient (1.5%) with poor results. In our study as per **TEENY WISS SCORE**[47] we had anatomic reduction in 9 cases, good reduction in 15 cases, fair reduction in 6 cases. According to Tornetta clinical scoring system 35 (48.5%) patients were assessed as excellent, 29 patients with good results (40.5%), 5 patients

(7%) assumed fair results and 3 patients (4%) had poor results. In present study excellent functional outcome in about 30% of cases, good functional outcome in 50% of cases fair and poor outcome 10% of cases each based on KAIKKONEN ANKLE SCORE.

	Mehta et al	Abdelgaid et al	Marsh et al	**Our study**
Age distribution (years)	39 (17-66)	33(19-66)	44	**50(27-80)**
Sex distribution M:F	--	43:29	8:23	**24:6**
Mode of Injury	Fall-62 RTA-49	Fall-47 RTA-25	Fall-11 RTA-19	**Fall-12** **RTA-18**
Side involvement Right:Left	65:66	--	8:17	**21:9**
AO Fracture type	Type A-0 Type B-53 Type C-78			**Type A-21** **Type B-3** **Type C-6**



Complication rates include two cases of wound dehiscence compared to 6 cases in present study.



Marsh et al[29] had an average age distribution of 44 years (comparable to 50 years in present study), more females 8:17(in contrast to more males in present study), more cases were due to road traffic accident (comparable to 18 cases in our study).

In this study, according to the criteria of Burwell and Charnley, the quality of the reduction was rated as good in fourteen ankles, fair in fifteen, and poor in six. In our study as per **TEENY WISS SCORE**[47] we had anatomic reduction in 9 cases, good reduction in 15 cases, fair reduction in 6 cases. Average IOWA scores were 78, with good outcome in majority of cases. In present study excellent functional outcome in about 30% of cases, good functional outcome in 50% of cases fair and poor outcome 10% of cases each based on KAIKKONEN ANKLE SCORE.

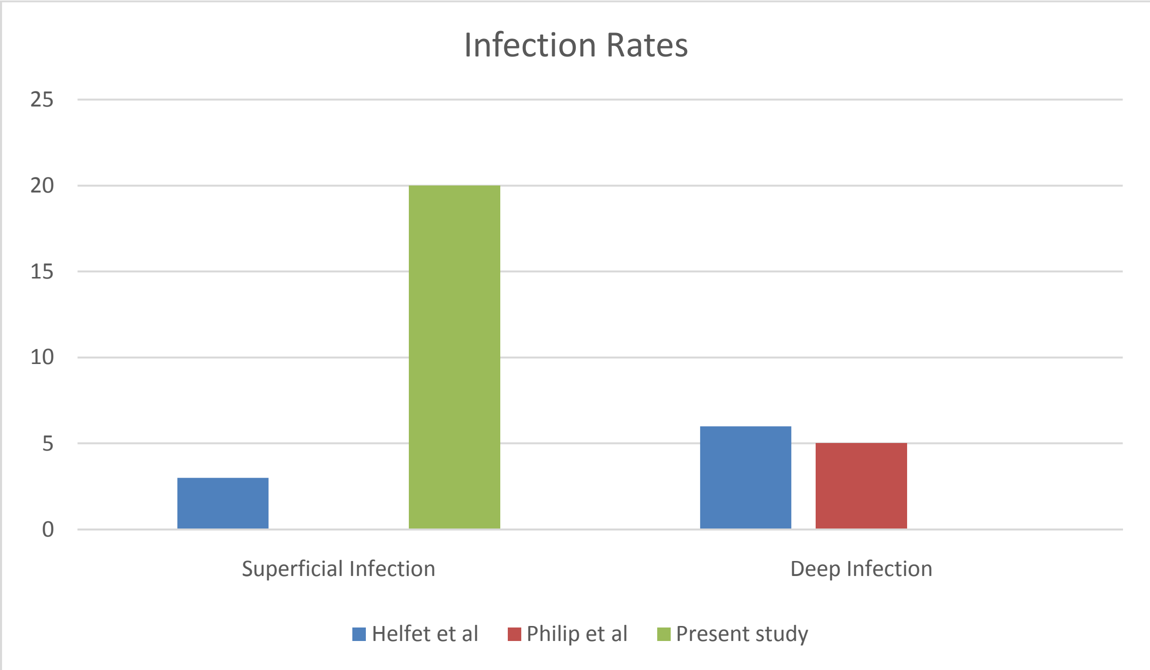
Mast et al[25] recommended primary internal fixation as a definitive procedure if the patient presented early within 8 to 12 hours following injury. They followed a protocol of delaying definitive procedure for about 7 to 10 days for soft tissue to heal, if the patient presented late. In our study the average duration of delay in the definitive treatment was about 21 to 28 days[27].

Patterson and Cole et al reported an 0% infection rate following fixation after an average of 24 days, however this study is limited by its relatively small sample size. In our study we had a delay of about 24days before going for definitive stabilization[34].

Helfet et al in their study had a superficial infection rate of 3% and deep infection of 6 % in their series of 32 fractures treated with locking compression plate. In our study we had 6 cases (20%) of superficial infection and no case (0%) of deep infection, which was comparable to the above study[17,18].

Philip et. aland Mark Jackson et al in their study of definitive open reduction and internal fixation of distal tibia fractures, had good functional result in 73.7% cases and 5% of deep infection rate in a follow up of 30.4

months. In our study we had 50% of cases with good functional outcome and 0 % deep infection rate, which was acceptable when compared to the above study[36].



Pierre Joveniaux et al and Xavier Ohi et al in their study of distal tibia fracture: management and complication, they had a functional score of 76 % in their series. Their result had 20 cases of excellent, 15 cases of good, 9 cases of fair and 6 cases of poor in their series of 50 cases. In our study we had nearly 9 cases of excellent outcome, 15 cases of good, 3 cases of fair and 3 cases of poor outcome among the 22 cases[35].

Mario Ronga MD et al and Nicola Maffulli MD et al in their study of minimally invasive locked plating of distal tibia fractures, they had the following outcomes – of the 21 cases they achieved union in 20 cases and one case went in for non-union. They had 3 cases of angular deformities all less than 7° and no patient had a leg-length discrepancy. Compared to their study, in our study we used MIPPO in about 6 cases, in which all cases went in for union in about 10 to 14 weeks with no case of malunion or nonunion[26].

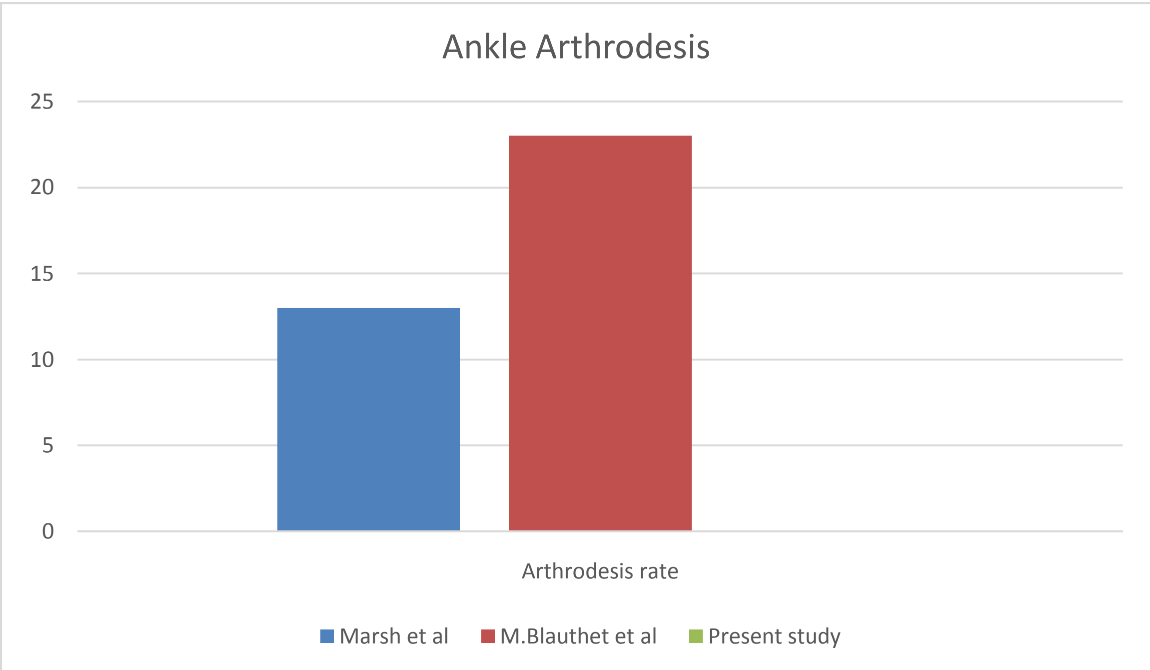
Rakesh Gupta et al and Rajesh Kumar Rohllla et al in their study of locking plate fixation in distal tibia fractures – series of 79 patients, had reported about 88% of healing without malunion, 2.5% of malunion and 3.7% of non-union. They used both MIPPO and ORIF for fixing these fractures. They found good and early union rate in the MIPPO group. In our study also we had good and early union in the MIPPO group and also we had three cases of non-union.

Pugh and colleague evaluated 60 patients, 25 of whom were treated with external fixators. They noted that they had more number of malunion in the external fixator group compared to that of internal fixation. They met most of their complication in the external fixator group. In our study also we had good functional outcome in internal fixation group[38].

The average follow up period our study was 9 months (range from 4 to 12 months). In type III fractures patients may develop late secondary arthrosis, but it requires a longer follow up. In our series, the results of the patients who had follow up period of upto 9 months had good clinical scores.

Arthrodesis was indicated when there was extensive communition and also in severe type III fractures. In our study, type III injuries accounted for 20% of the cases and arthrodesis was not done in any of our patients, compared to that of 23 % of cases in a study by **M.Blauthet et al.**

Marsh et al reported an arthrodesis rate of 13 % in their series of 40 ankle fractures after a minimum follow up of 5 years. Chen noted a 4.7% arthrodesis rate in plating tibial plafond fractures when followed for a period of 10 years. Since our study was a short term study, arthrodesis could not be commented which might require a long term follow up.



Hence the outcome of surgically treated distal tibia fractures depends on the severity of injury mechanism and assessing the grade of soft tissue injury, delaying definitive fixation till soft tissue heals and accuracy of the articular reduction and fibula plating during definitive procedure. A correlation exists between the severity of the fracture, overall outcome and the development of secondary degenerative arthritis.

CONCLUSION

CONCLUSION

- A short series of result of our study were analyzed and the overall results have encouraged us in preferring the surgical management of distal tibia fractures over conservative methods.

- Distal tibia fractures with high grade of soft tissue injury are to be internally fixed after a delay of 21 days for the edema to settle down and the wrinkle sign appears.

- Respect the soft tissues: do not operate too early or through compromised skin, instead wait till the soft tissues is amenable for surgery.

- On the other hand, low energy fractures with insignificant soft tissue injury can be addressed by definitive internal fixation immediately

- Restoration of the articular surface and reestablishing its relationship to the tibial shaft is the primary goal of treatment.

- Good functional result depends on reasonable anatomic reduction of the articular surface either by direct or indirect methods.

- Understand the fracture completely before planning any surgery (obtain adequate radiographs, CT scan and radiographs of the uninjured limb).

- Open reduction and internal fixation with anatomical restoration of the articular surface is to be done in all cases AO type C fractures otherwise it will lead to mal-alignment and secondary degenerative osteoarthosis.

- Anatomic realignment of fibula indirectly reduces the talus beneath the anatomic axis of tibia. Restoration of fibular length, alignment and rotation has the substantial impact on the indirect realignment of anterolateral and posterolateral tibial plafond from their attachment to the anterior and posterior tibiofibular syndesmotic ligaments. Hence fibula fixation is advocated wherever possible.

- Conservative management can be reserved in cases where fibula is intact and type I fractures and also in those with associated medical contraindication to surgery.

- Surgical reconstruction must be tailored to the personality of each fractures and operative approaches dictated by the quality of the soft tissues.

- From our study 3.5mm Anterolateral Distal tibia Locking Compression Plating for tibial pilon fractures were found to be safe and effective. For AO type A fractures, can be fixed either using MIPPO or ORIF technique. For AO type C fractures Open reduction of the articular fragment is mandatory and then stabilize with locking compression plate for added up stability. Also the incision between the tibial and fibula exposure must be atleast 7 cm.

- For highly comminuted injuries with unreconstructable articular surface, primary ankle fusion is an alternative to ORIF.

CASE ILLUSTRATIONS

CASE ILLUSTRATIONS

Name	:	Kannan
Ip No.	:	304
Age	:	63/M
Occupation	:	Household
Mode of injury	:	History of Fall
Diagnosis	:	Distal tibia fracture
Classification	:	AO Type 43.A.3
Procedure	:	ORIF with 3.5mm anterolateral distal tibia LCP
Approach	:	Anterolateral approach to ankle
Complication	:	None
Time of Union	:	12 weeks
Ankle Range of Motion	:	Pain free and fully functional
Kaikkonen ankle Score	:	90
Outcome	:	Excellent.

CASE 1:

PRE OP

IMMEDIATE POST-OP

NINE MONTHS FOLLOW UP

POST OP RANGE OF MOVEMENTS

Name	:	Sundar
Ip No.	:	2986
Age	:	52/M
Occupation	:	Salesman
Mode of injury	:	Road Traffic Accident
Diagnosis	:	Distal tibia fracture
Classification	:	AO Type A2
Procedure	:	ORIF with LCP
Approach	:	Anterolateral approach
Complication	:	Wound dehiscence, healed by secondary intention.
Time of Union	:	24 weeks.
Ankle Range of Motion	:	Pain free and restricted dorsiflexion
Kaikkonen ankle score	:	75
Outcome	:	Good.

CASE 2:

PRE OP

Immediate post op

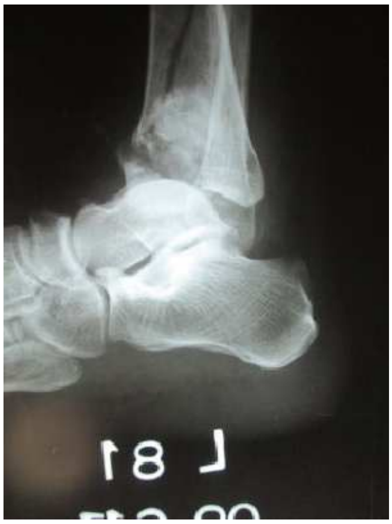
8 months follow up

POST OP WOUND STATUS AND RANGE OF MOVEMENTS

Name	:	Duraisamy
Ip No.	:	59053
Age	:	52/M
Occupation	:	Shop owner
Mode of injury	:	Self Fall
Diagnosis	:	Distal tibia fracture
Classification	:	AO Type C2
Procedure	:	ORIF with LCP
Approach	:	Anterolateral
Complication	:	None
Time of Union	:	12 weeks
Ankle Range of Motion	:	Full and Pain free
Kaikkonen ankle score	:	90
Outcome	:	Excellent.

CASE 3:

PRE OP



IMMEDIATE POST OP

6 MONTHS FOLLOW UP

POST OP WOUND STATUS AND RANGE OF MOVEMENTS

Name	:	Gunasekar
Ip No.	:	60314
Age	:	27/M
Occupation	:	Coolie
Mode of injury	:	Road Traffic Accident
Diagnosis	:	Distal tibia fracture
Classification	:	AO Type A3
Procedure	:	MIPPO with LCP and plating for fibula
Approach	:	Antero lateral
Complication	:	Superficial Infection
Time of Union	:	20 weeks
Ankle Range of Motion	:	Restriction of dorsiflexion but pain free
Kaikkonen ankle Score	:	80
Outcome	:	Good.

CASE 4:

PRE OP

IMMEDIATE POST OP

16 WEEKS FOLLOW UP

POST OP WOUND STATUS AND RANGE OF MOVEMENTS

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BIBILIOGRAPHY

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PROFORMA

PROFORMA

Case No: Unit:

Name: Age/Sex:

I.P No: Occupation:

Address: Phone:

Date of Injury:

Date of Admission:

Date of Surgery:

Date of Discharge:

Mechanism of Injury:

- Road Traffic Accident
- Accidental Fall
- Industrial Accident
- Others

Severity of Injury

- High Velocity
- Moderate Velocity
- Trivial

General Condition:

Hemodynamic Status:

Side Involved: (Right/Left)

X-Ray findings:

Type of Fracture:

- Type A: Extra-articular
- Type B: Partial-articular
- Type C: Intra-articular

Associated other long bone injuries: (Yes/No)

Associated Head injury: (Yes/No)

Treatment elsewhere if any:

Treatment in our Institution:

- Time interval between injury and definitive management
- Procedure done

- Additional Procedures
- Bone grafting:(Yes/No)

Blood transfusion:(Yes/No)

Post Operative Events:

Complication:

Follow Up:

- No. of Weeks since Surgery
- Radiological Picture
- Scar Status
- Complications
- Ankle Range of motion
- Ankle Score

Assistant Professor Signature:

ANNEXURE

S.no.	Name	Age	Sex	Mode	Velocity	GC	Side	Other#	Fibula	Skin	Comorbid	AO type	Initial Rx	Delay
1.	Sundar	52	Male	RTA	High	Stable	Left	Nil	Yes	Grade I	DM	43A2	POP	30
2.	Ramesh	40	Male	RTA	High	Stable	Right	Nil	Yes	GradeIII	DM	43B2	POP	30
3.	Kannan	63	Male	Fall	Low	Stable	Right	Nil	Yes	Grade 0	DM	43A2	POP	14
4.	DeCruz	50	Male	RTA	Moderate	Stable	Right	Nil	Yes	Grade 0	Nil	43A3	IL Nail	90
5.	Gunasekaran	27	Male	RTA	High	Stable	Right	MT #	Yes	Grade II	Nil	43A3	POP	12
6.	Duraisamy	52	Male	Fall	Low	Stable	Left	Nil	No	Grade I	Nil	43C2	POP	21
7.	Sivagami	80	Female	Fall	Low	Stable	Right	Nil	Yes	Grade 0	Nil	43A1	POP	21
8.	Malliga	48	Female	Fall	Low	Stable	Right	Nil	Yes	Grade 0	Nil	43A3	POP	30
9.	Balachander	39	Male	RTA	Low	Stable	Right	Nil	No	Grade 0	Nil	43A2	POP	30
10.	Raghu	50	Male	RTA	High	Stable	Left	Nil	Yes	Grade II	RTI	43C1	POP	14
11.	Selvam	40	Male	RTA	Low	Stable	Right	Nil	No	Grade 0	Nil	43A2	POP	30
12.	Bagyam	75	Female	Fall	Low	Stable	Right	Nil	Yes	Grade 0	Nil	43A1	POP	21
13.	Kumar	30	Male	RTA	High	Stable	Right	Nil	Yes	Grade II	Nil	43A3	POP	12
14.	Sadayan	65	Male	Fall	Low	Stable	Right	Nil	Yes	Grade 0	DM	43A2	POP	14
15.	Ramalingam	50	Male	RTA	High	Stable	Left	Nil	Yes	Grade I	DM	43A2	POP	30
16.	Raju	50	Male	RTA	High	Stable	Left	Nil	Yes	Grade I	LRI	43C1	POP	14
17.	Ethirajulu	39	Male	RTA	Low	Stable	Right	Nil	No	Grade 0	Nil	43A2	POP	30
18.	Rakkammal	48	Female	Fall	Low	Stable	Right	Nil	Yes	Grade I	Nil	43A3	POP	30
19.	Kanniyammal	80	Female	Fall	Low	Stable	Right	Nil	Yes	Grade 0	Nil	43A1	POP	21
20.	Gopi	52	Male	Fall	Low	Stable	Left	Nil	No	Grade I	Nil	43C2	POP	21
21.	Kovalan	23	Male	RTA	High	Stable	Right	Phalanx	Yes	Grade II	Nil	43A3	POP	12
22.	Durairaj	50	Male	RTA	Moderate	Stable	Right	Nil	Yes	Grade 0	Nil	43A3	POP	28
23.	Jayaraman	63	Male	Fall	Low	Stable	Right	Nil	Yes	Grade 0	DM	43A2	POP	14
24.	Boopathy	40	Male	RTA	High	Stable	Right	Nil	Yes	Grade II	Nil	43B2	POP	30
25.	Palani	52	Male	RTA	High	Stable	Left	Nil	Yes	Grade I	DM	43A2	POP	30
26.	Ramaiah	50	Male	RTA	High	Stable	Left	Nil	Yes	Grade I	URI	43C1	POP	14
27.	Gangammal	49	Female	Fall	Low	Stable	Right	Nil	Yes	Grade II	Nil	43A3	POP	30
28.	Saravannan	55	Male	Fall	Low	Stable	Left	Nil	No	Grade 0	Nil	43C2	POP	21
29.	Govindasamy	48	Male	RTA	Moderate	Stable	Right	Nil	Yes	Grade 0	Nil	43A3	POP	21
30.	Vijayan	42	Male	RTA	High	Stable	Right	Nil	Yes	Grade II	DM	43B2	POP	30

S.No.	Name	MIPPO/ Open	Distractor	Durn.	Fibula Fixed	Wound	Plastic	Length	Union	PF	DF	Teeny Wiss	Kaikko nen	
1.	Sundar	Open	No	100	Recon	Dehisc	No	5mm s	24	30	10	12	75	
2.	Ramesh	Open	No	90	1/3	Flap ne	Flap	Equal	28	25	10	16	65	
3.	Kannan	Open	No	95	1/3	Healed	No	Equal	16	35	20	9	90	
4.	DeCruz	Open	No	120	No	Healed	No	5mm s	Fail	40	20	11	40	
5.	Gunasekaran	MIPPO	Yes	100	1/3	Healed	No	Equal	20	35	20	12	80	
6.	Duraisamy	Open	Yes	90	NA	Healed	No	Equal	12	40	20	9	90	
7.	Sivagami	MIPPO	Yes	100	1/3	Healed	No	Equal	16	35	10	10	70	
8.	Malliga	Open	No	95	1/3	Healed	No	Equal	16	30	10	14	75	
9	Balachander	Open	No	75	NA	Healed	No	Equal	12	45	20	9	95	
10.	Raghu	Open	No	120	K wire	Dehisce	No	Equal	16	25	10	11	70	
11.	Selvam	Open	No	75	NA	Healed	No	Equal	12	45	20	9	95	
12.	Bagyam	MIPPO	Yes	100	1/3	Healed	No	Equal	16	35	15	10	70	
13.	Kumar	MIPPO	Yes	100	1/3	Healed	No	Equal	20	35	20	12	80	
14.	Sadayan	Open	No	95	1/3	Healed	No	Equal	16	35	20	9	90	
15.	Ramalingam	Open	No	100	1/3	Healed	No	5mm s	24	30	10	11	75	
16.	Raju	Open	No	120	K wire	Dehisce	Flap	Equal	16	25	10	11	70	
17.	Ethirajulu	Open	No	75	NA	Healed	No	Equal	12	45	20	9	95	
18.	Rakkammal	Open	No	95	1/3	Healed	No	Equal	16	30	10	14	75	
19.	Kanniyammal	MIPPO	Yes	100	1/3	Healed	No	Equal	16	25	15	10	70	
20.	Gopi	Open	Yes	100	NA	Healed	No	Equal	12	40	20	9	90	
21.	Kovalan	MIPPO	Yes	100	1/3	Healed	No	Equal	20	35	20	12	80	
22.	Durairaj	Open	No	120	NA	Healed	No	5mm s	NU	60	20	11	40	
23.	Jayaraman	Open	No	95	1/3	Healed	No	Equal	16	35	20	9	90	
24.	Boopathy	Open	No	90	1/3	Dehisce	No	Equal	26	25	10	16	65	
25.	Palani	Open	No	100	Recon	Healed	No	5mm s	24	30	10	12	75	
26.	Ramaiah	Open	No	120	K wire	Dehisce	No	Equal	16	25	10	11	70	
27.	Gangammal	Open	No	95	1/3	Healed	No	Equal	16	30	10	14	75	
28.	Saravannan	Open	Yes	90	NA	Healed	No	Equal	12	40	20	9	90	
29.	Govindasamy	Open	No	120	NA	Healed	No	5mm s	NU	35	20	11	40	
30.	Vijayan	Open	No	90	1/3	dehisc	No	Equal	24	25	10	12	65	

INFORMATION SHEET

Title: **"ANALYSIS OF FUNCTIONAL OUTCOME OF ANTEROLATERAL PLATING IN TIBIAL PILON FRACTURES"**

Principal Investigator:

Name of the Participant:

Site :

We are conducting a study on **"ANALYSIS OF FUNCTIONAL OUTCOME OF ANTEROLATERAL PLATING IN TIBIAL PILON FRACTURES"** among patients attending the Institute of Orthopaedics & Traumatology, Rajiv Gandhi Government General Hospital, Chennai and for that your specimen may be valuable to us.

The purpose of this study is to evaluate and "ANALYSIS OF FUNCTIONAL OUTCOME OF ANTEROLATERAL PLATING IN TIBIAL PILON FRACTURES"

We are selecting certain cases and if you are found eligible, we may be using your radiographs of the spine to evaluate the outcome of surgery which in any way do not affect your final report or management.

The privacy of the patients in the research will be maintained throughout the study. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

Taking part in this study is voluntary. You are free to decide whether to participate in this study or to withdraw at any time; your decision will not result in any loss of benefits to which you are otherwise entitled.

The results of the special study may be intimated to you at the end of the study period or during the study if anything is found abnormal which may aid in the management or treatment.

Signature of Investigator | Signature of Participant

Date :
Place :

PATIENT CONSENT FORM

Study Detail	:	**“ANALYSIS OF FUNCTIONAL OUTCOME OF ANTEROLATERAL PLATING IN TIBIAL PILON FRACTURES”**
Study Centre	:	Rajiv Gandhi Government General Hospital, Chennai.
Patient’s Name	:	
Patient’s Age	:	
Identification Number	:	

Patient may check (√) these boxes

a) I confirm that I have understood the purpose of procedure for the above study. I have the opportunity to ask question and all my questions and doubts have been answered to my complete satisfaction. ❑

b) I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving reason, without my legal rights being affected. ❑

c) I understand that sponsor of the clinical study, others working on the sponsor’s behalf, the ethical committee and the regulatory authorities will not need my permission to look at my health records, both in respect of current study and any further research that may be conducted in relation to it, even if I withdraw from the study I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published, unless as required under the law. I agree not to restrict the use of any data or results that arise from this study. ❑

d) I agree to take part in the above study and to comply with the instructions given during the study and faithfully cooperate with the study team and to immediately inform the study staff if I suffer from any deterioration in my health or well being or any unexpected or unusual symptoms. ❑

e) I understand that my identity will be kept confidential if my data are publicly presented ❑

f) I hereby give permission to undergo detailed clinical examination, Radiographs & blood investigations as required. ❑

g)) I have had my questions answered to my satisfaction. ❑

h)) I hereby consent to participate in this study. ❑

Signature/thumb impression	Signature of Investigator
Patient’s Name and Address:	Study Investigator’s Name: **Dr. THIRUMURUGAN.A**

Analysis of functional outcome of anterolateral plating in tibial pilon fractures

BY THIRUMURUGAN ARUMUGAM

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ANALYSIS OF FUNCTIONAL OUTCOME OF ANTEROLATERAL PLATING IN TIBIAL PILON FRACTURES.

Dissertation submitted for

M.S DEGREE EXAMINATION

BRANCH II-ORTHOPAEDIC SURGERY

INSTITUTE OF ORTHOPAEDICS AND TRAUMATOLOGY

MADRAS MEDICAL COLLEGE AND RAJIV GANDHI GOVERNMENT GENERAL HOSPITAL

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6 ANALYSIS OF FUNCTIONAL OUTCOME OF ANTEROLATERAL PLATING IN TIBIAL PILON FRACTURES. Dissertation submitted for M.S DEGREE EXAMINATION BRANCH II-ORTHOPAEDIC SURGERY INSTITUTE OF ORTHOPAEDICS AND TRAUMATOLOGY MADRAS MEDICAL COLLEGE AND RAJIV GANDHI GOVERNMENT GENERAL HOSPITAL CHENNAI-600003 THE TAMILNADU DR.M.G.R MEDICAL UNIVERSITY CHENNAI-600032 MARCH-2014 7 CERTIFICATE This is to certify that this dissertation in "ANALYSIS OF FUNCTIONAL OUTCOME OF ANTEROLATERAL PLATING IN TIBIAL PILON FRACTURES" is a bonafide work done by Dr.A.THIRUMURUGAN under my guidance during the period 2011–2014. This has been submitted in partial fulfilment of the award of M.S. Degree in Orthopedic Surgery...