"TO EVALUATE FUNCTIONAL AND RADIOLOGICAL OUTCOME OF DISTAL END TIBIA FRACTURES MANAGED BY MINIMALLY INVASIVE PLATE OSTEOSYNTHESIS"

By

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DISSERTATION SUBMITTED TO SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, KOLAR, KARNATAKA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE

DEGREE OF

MASTER OF SURGERY

IN

ORTHOPAEDICS

Under the Guidance of

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ABBREVIATIONS

Glossary	Abbreviations
ACL	Anterior cruciate ligament
AO	Arbeitsgemeinschaft für Osteosynthesefragen
BMPs	Bone morphogenetic proteins
DVT	Deep venous thrombosis
EF	External fixation
IMIL	Intra medullary Interlocking nail
IMTN	Intramedullary tibial nailing
LC-DCP	Limited contact dynamic compression plates
LCP	Locking compression plate
Le	working length
LISS	Less intrusive stabilization system
MIPO	Minimally invasive plate osteosynthesis
ORIF	Open reduction and internal fixation
OTA	Orthopaedic Trauma Association

PCL	posterior cruciate ligament
TARPO	Transarticular retrograde plate osteosynthesis
TNF	Tumor necrosis factor-Alpha
VEGF	Vascular endothelial growth factor

Abstract

Background:

Surgical treatment for distal end tibia fractures is frequently prone to develop complications like wounds, infections, malunions, and non-unions because the bone is subcutaneous and has a minimal muscle cover. The risk of soft tissue complications seen with extensive anterolateral plate osteosynthesis has been reduced with the minimally invasive plate osteosynthesis (MIPO) technique for distal tibia fractures. The current study assesses the functional and radiological outcome of distal end tibia fractures treated by MIPO.

Materials and methods:

This is a prospective study conducted on patients above 18 years diagnosed with closed and open type one fracture of distal end tibia admitted at R. L. Jalappa Hospital and Research center from December 2020 to July 2022. With Institutional human ethics committee approval, patients are recruited until sample size is reached. Surgical fixation of the distal third tibia is done by MIPO and patients are followed up at 3rd and 6th month and assessed with Teeny-Wiss radiological scoring system and IOWA ankle functional evaluation score.

Results:

The study included 32 subjects with a mean age of 47.81±9.72 years, predominantly male population with 87.50% males and 12.50% females. 84.38% had RTA mode of injury. Among those who had fair IOWA score at 3rd month, 52.95% graduated to an excellent score by 6th month and those with good IOWA scores at 3rd-month scoring did well by the 6th month follow up scoring excellent on IOWA scale.

Conclusion:

In summary, MIPO is an effective modality for the treatment of distal third tibia fractures, with several advantages over traditional open techniques. The minimal surgical trauma, improved cosmesis and faster rehabilitation make it a superior option. Studies have shown that MIPO leads to similar or better outcomes in terms of fracture healing, functional recovery, and patient satisfaction. Thus, MIPO should be considered as a viable option for the treatment of distal end tibia fractures.

Key words: Distal end tibia fracture, Minimally invasive plate osteosynthesis (MIPO), RTA, IOWA scale, Teeny-Wiss score,

INTRODUCTION

Fractures involving the distal tibia may be intimidating to treat because of the lack of surrounding soft tissue coverage over bone, the fragile vascularity, and the proximity to the ankle joint.[1,2] There has been progress in non-operative and surgical treatment, but the debate continues. In the case of distal tibia fractures, the metaphyseal flare might be problematic because it decreases implant contact and, in turn, promotes instability and malalignment. A malaligned ankle causes a change in the gross mechanics of the ankle, which in turn increases discomfort and hampers its ability to operate.[3] Axial loading from the talus's forceful impact with the lower end of the tibia is the cause of the injury.[4] The articular surface injury, metaphyseal comminution, joint impaction, and related soft tissue injuries are all influenced by the axial loading on the distal tibia. Although the injury mechanism may be complicated, vertical compression is the main force. The position of the foot at the time of impact determines where the articular portion of the fracture is located.[5,6] High-energy trauma is frequently responsible for distal tibia fractures, which are frequently linked to grave injuries. “Advanced Trauma Life Support” guidelines should be followed while managing these fractures.[7]

Because of its anatomical location, the distal tibia has 2nd highest incidence of fracture.[8] In the documented cases of tibia fracture, distal tibia fractures account for 3% to 10% and 1% of the total lower limb fractures. “70% to 85% of cases are accompanied by fracture of the fibula.[9] Distal tibia fractures have different classification schemes developed for them. The “Gustilo-Anderson”[10] for open fractures and “Tscherne-Gotzen”[11] classification systems for closed fractures can be used to assess soft tissue injury. Müller recommended that the categorization of fracture should take prognosis and potential treatment modalities into account.[12] The Rüedi and Allgöwer classification and AO/OTA fracture classification are the most frequently used classification systems in articles that discuss intra-articular distal tibial fractures.[13] Extra-articular (type A), partial-articular (type B), and fully articular (type C) fractures are identified by the AO/OTA classification system.

For stable, displaced closed fractures, non-surgical treatment is an option. But after treating these fractures, especially pilon fractures, malunion, shortening of the affected leg, movement restrictions, and early osteoarthritis of the ankle joint have been reported.[14, 2, 15] Careful preoperative planning is essential for surgical management of the distal tibia fractures as the choice of fixing method is highly dependent on the kind of fracture, the degree of soft tissue damage, the bone quality, and the articular involvement. Conservative methods, as well as hybrid external fixation and intramedullary nailing and plating methods, have evolved.[3] Inaccurate reduction, malunion/nonunion, and pin tract infection are all possible complications of external fixation.[16] Although intramedullary nailing is the gold standard for medically treating tibial diaphyseal fractures, complications might arise in the distal tibia due to fracture displacement during nail insertion, nail and locking screw breakage, and final tibial alignment.[17,18] Minimally invasive submuscular and subcutaneous plate fixation (MIPO) is a less invasive alternative to intramedullary nailing that offers all the physiologic advantages of closed reduction and fixation without the risks.[19, 20]

The focus of MIPO has shifted from absolute fracture stability to the preservation of circulation of the fractured zone with the use of biologic plate osteosynthesis. Known as minimally invasive plate osteosynthesis, or MIPO, this fracture repair technique is gaining favor due to its ability to minimize surgical stress without requiring excessive exposure of the fractured zone. Soft tissue dissection is minimized, wound problems are lessened, the hematoma from an osteogenic fracture is not lost, and union rates are boosted, according to the proponents of MIPO.[21,22,23] When compared to a traditional plate, which often experiences fracture displacement due to inaccurate contouring, the "Locking compression plate" (LCP), which consists of the plate and screw systems in which screws are locked at a fixed angle in the plate, effectively prevents the fracture from being displaced. It is advantageous for bone healing since the plate does not compress too hard on the bone, which would compromise the periosteal vascular supply.[24] The LCP with MIPO approach will get back the patients on their feet faster and with fewer difficulties. The radiological evaluation of patients treated with MIPO for tibia with or without fibula fixation was evaluated using the modified Teeny and Wiss Score and the IOWA scoring system for functional analysis; the results showed that 84% of patients achieved good anatomic reduction, 12% had a good score, and 4% fair.[3] Radiologic union and complete weight bearing were accomplished in 13-16 weeks in 75% of instances when patients with distal tibial fractures were handled with the MIPO approach, whereas in 25% of patients, this occurred in 17-20 weeks. Overall, 85 percent of patients had an excellent or good result, while three instances with problems had a fair outcome in two cases and a bad outcome in one as per Teeny Wiss criteria.[25]

Need for the study

A rising number of young people are suffering from distal tibia fractures, making the need for the evolution of fracture fixation techniques with better outcomes. High-speed vehicle usage may lead to a rise in fracture rates in the future. The incidence increases in the '40s, and most distal tibia fractures are accompanied by extensive soft tissue damage, making treatment difficult for orthopaedic surgeons. Recent advances in minimally invasive percutaneous plate osteosynthesis have made this technique a safe and dependable way to repair these fractures, especially when care is taken to handle and preserve the soft-tissue envelope. Indirect reduction and persistent fixation with a small biological footprint are made possible by the MIPO approach, which has recently gained popularity as an alternative method. Owing to the proximity of our hospital to the highway in a largely rural setting, this study can prove and provide the benefits of MIPO technique. This technique will also help in providing the much-required literature on the use of MIPO technique for distal third tibia fractures, as there is lacunae of literature for this technique.

REVIEW OF LITERATURE

Fractures of Tibia

Tibia fractures may inflict upon people of all ages, and the severity of the resulting injuries can vary from those easily treated with a cast or brace to those requiring extensive osteosynthesis in conjunction with cosmetic surgery or even amputation due to significant soft-tissue damage.[26] Fractures of the tibia are categorized as either proximal, diaphyseal, or distal based on location. Epiphyseal, metaphyseal, and physeal types of tibial fractures may occur at both the proximal third and distal end of the bone

Anatomy of tibia

The tibia is the bigger and stronger of the two leg bones, tibia and fibula because it bears the brunt of the body weight during walking. The tibia articulates with the femur to create the knee joint, and the fibula and talus form the ankle joint. The tibia sits medially to the fibula and is joined by the interosseous membrane.[27] Medial and lateral condyle on the proximal end of the tibia come together to create the knee's inferior compartment. The attachments of "the anterior collateral ligament, the posterior collateral ligament, and the menisci" may all be found in the intercondylar space between the two condyles. As a cross-section, the tibial shaft is triangular, having three edges and three faces.[28] The three sides are labeled as lateral, medial (anterior), and posterior, while the three boundaries are referred to as anterior, medial, and interosseous. Specifically, the anterior border separates the medial and lateral surfaces, the medial border separates the medial and posterior surfaces, and the interosseous border separates the lateral and posterior surfaces. The medial surface is primarily subcutaneous, the lateral surface is next to the anterior compartment of leg, and the posterior surface is adjacent to the posterior compartment of leg. The medial malleolus is located on the distal end of the tibia and has a boxy form.[29] The distal tibia is comprised of five different surfaces:

- The talus may articulate easily with the lower surface.
- Ankle joint capsule attaches to the front surface, which is covered by the extensor tendons.
- A depression is located on the back of the tibia to accommodate the tibialis posterior muscle.

- An attachment for the interosseous membrane, or synovium, may be found in a fibular notch on the lateral side.
- The medial malleolus is a prominent bony protrusion located on the distal and medial aspect of tibia

The tibia is the biggest bone in the lower leg and serves primarily as a weight-bearing structure, particularly along its medial surface.[30] Eleven muscles attach to or originate from here, providing flexion and extension at the knee as well as plantarflexion with dorsiflexion at the ankle.

Tibial Osteology[28]

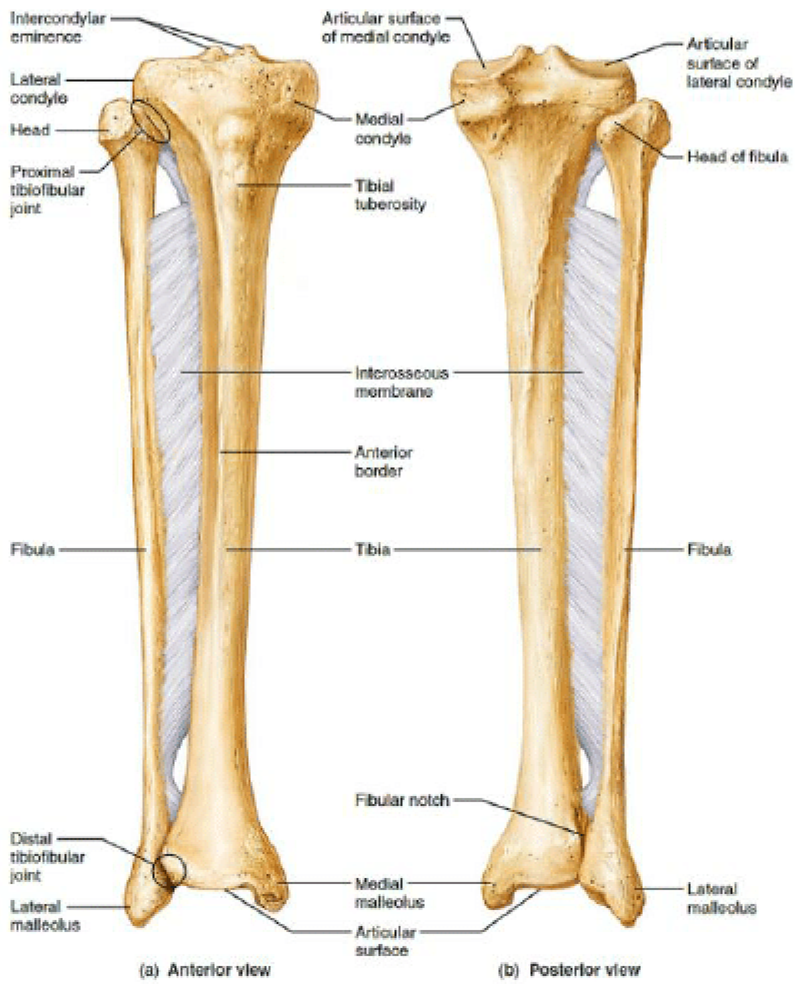
The Proximal Tibia: “Lateral condyle” is the upper and lateral portion of the tibia where it joins with the femur. “Medial condyle” is the proximal-most medial part of the tibia that connects to the femur. The superior articular surface of the lateral condyle of the tibia is known as the lateral tibial plateau. "Medial tibial plateau" is the upper articular surface of the medial condyle. [28]

Anterior intercondylar area lies between the medial and lateral condyle where the anterior cruciate ligament connects to the thighbone. The posterior intercondylar area lies between the medial and lateral condyle, precisely where the posterior cruciate ligament (PCL) attaches. The intercondyloid eminence (tibial spine) is a pair of tubercles, one medial and one lateral, that sits between the articular facets. Anterior cruciate ligament (ACL) and meniscal attachments are located in a dip behind the intercondyloid eminence. [28]

The tibial shaft is prism-shaped, with three surfaces (lateral, medial/anterior, and posterior) and a boundary on each side (anterior, medial, and interosseous). In other words, the anterior boundary separates the middle and the outside layers. The medial boundary separates the middle and back of the body. The interosteal margin separates the body's lateral and posterior faces. Medial and anterior surface: detectable all the way down the lower leg, or shin. The tibial tuberosity is located there.

The patellar ligament attaches to a bony bump on the front of the tibia called the tibial tuberosity. The lateral aspect of the tibia and fibula is where the interosseous membrane attaches and forms a boundary. On the posterior aspect of the tibia, lies the soleal line, an oblique crease that marks the genesis of the soleus, flexor digitorum longus, and tibialis posterior muscles. Several muscles, such as the tibialis anterior, soleus, extensor digitorum longus, sartorius, gracilis, quadriceps femoris, semimembranosus, semitendinosus, and popliteus, originate or insert at this bone.[28]

Figure 1: The right tibia and fibula[31]



Muscles Inserting on the Tibia [32]

The "Gerdy tubercle" (lateral tubercle of the tibia) is where the tensor fasciae latae muscle attaches. Anterior to the tibial tuberosity is where the quadriceps femoris muscle attaches. The sartorius, gracilis, and semitendinosus muscles all have an anteromedial insertion on the pes anserinus. Horizontal head of semimembranosus muscle inserts on the medial condyle. The soleal line of the posterior tibia is where popliteus makes its insertion.

Muscles Originating at the Tibia[32]

Tibialis anterior is a muscle that attaches to the front of the lower leg. Its origin is in the top two-thirds of the lateral tibia. The tibial lateral condyle serves as the insertion point for the extensor digitorum longus. Soleus and flexor digitorum longus originate in the posterior side of the tibia on the soleal line.

Figure 2: Anterior view of the right distal femur, tibia, and fibula[33]

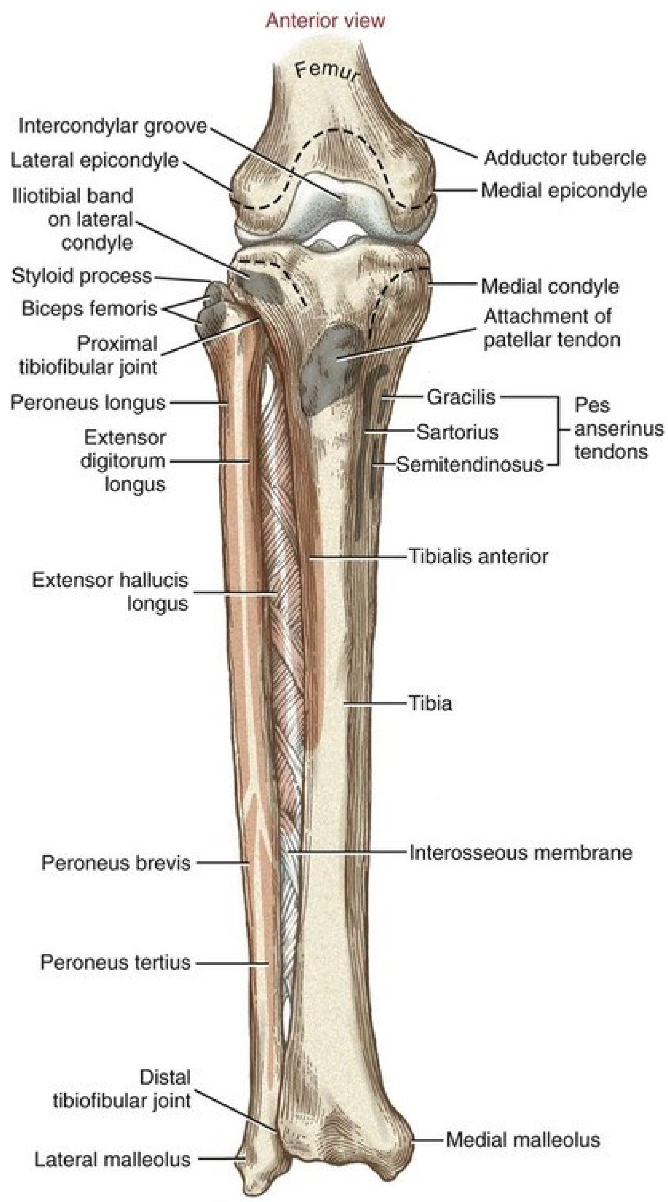
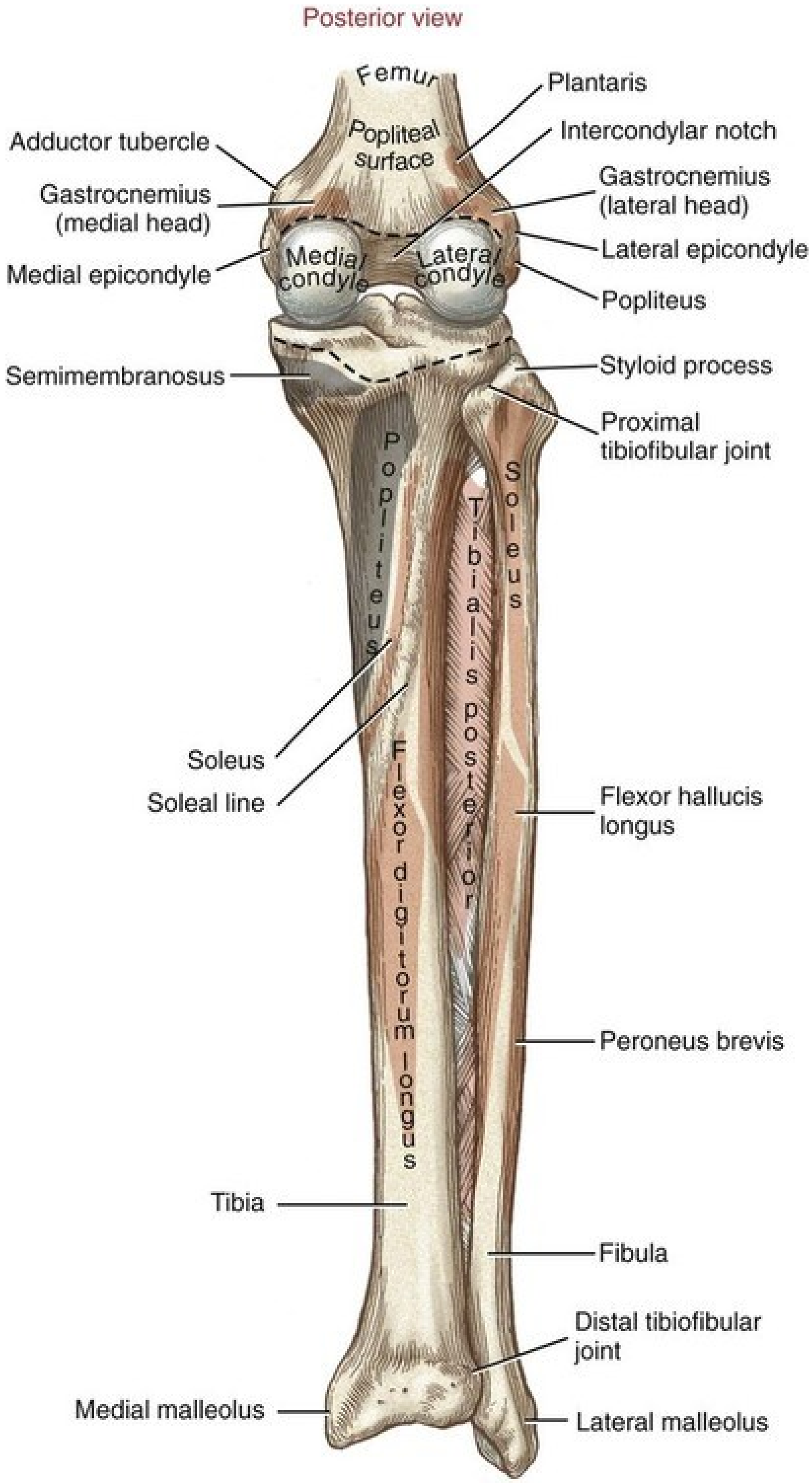


Figure 3: Posterior view of the right distal femur, tibia, and fibula.[33]



There is a lot of variety in the vascular architecture, which changes depending on which group of muscles a given vessel serves knowing which compartments are supplied by which nerves is essential. The tibial nerve travels under the soleus muscle and exits at the back of the medial malleolus. Back muscles (both superficial and deep) are innervated by this nerve's muscular branches. The common peroneal nerve separates into the superficial and deep peroneal nerves. The peroneus longus and brevis are supplied by the superficial peroneal nerve, which may be found along the boundary between the lateral and anterior compartments. On the other hand, the first web space may feel sensations from the deep peroneal nerve, which feeds the anterior compartment's muscles. The medial aspect of the foot and the leg are supplied by the saphenous nerve. Popliteus, tibialis posterior, flexor digitorum longus, and flexor hallucis longus are the muscles that make up the deep compartment. The gastrocnemius, soleus, and plantaris are the muscles that make up the superficial posterior compartment. The peroneus longus and brevis make up the lateral compartment of the human body. The tibialis anterior, extensor digitorum longus, extensor hallucis longus, and peroneus tertius make up the muscles of “anterior compartment”.[34]

The articular surface at the distal end of the tibia, also called the tibial plafond, is a quadrilateral and is broader towards the front. This area is somewhat convex when seen from the transverse plane and concave when viewed from the sagittal plane. During the movement of the ankle joint, the medial malleolus, an inferomedial projection of the distal tibia, articulates with the medial articular surface of the talus. The anterior colliculus and the posterior colliculus are two rounded projections on the distal side of the medial malleolus. Greater distal projection is seen in the anterior colliculus. The fibula attaches to the distal lateral tibia in a notch called the incisura fibularis, and this area is encircled by the strong ligaments that make up the ankle syndesmosis (more on that in a bit). The lateral malleolus is the point where the distal end of the fibula protrudes beyond the top of the tibia. The lateral malleolus' medial side articulates with the talus' lateral surface. The ankle mortise is comprised of the “tibial plafond” “medial malleolus”, and “lateral malleolus.” When the syndesmosis between the talus and the ankle is complete, the talus cannot move laterally or medially inside the mortise. In the sagittal plane, the concavity of the tibial plafond produces a posterior, distal projection called the posterior malleolus. In contrast to the medial and lateral malleoli, this structure does not have a bony wall running vertically to stop talar translation. [35]

DISTAL END TIBIA FRACTURES

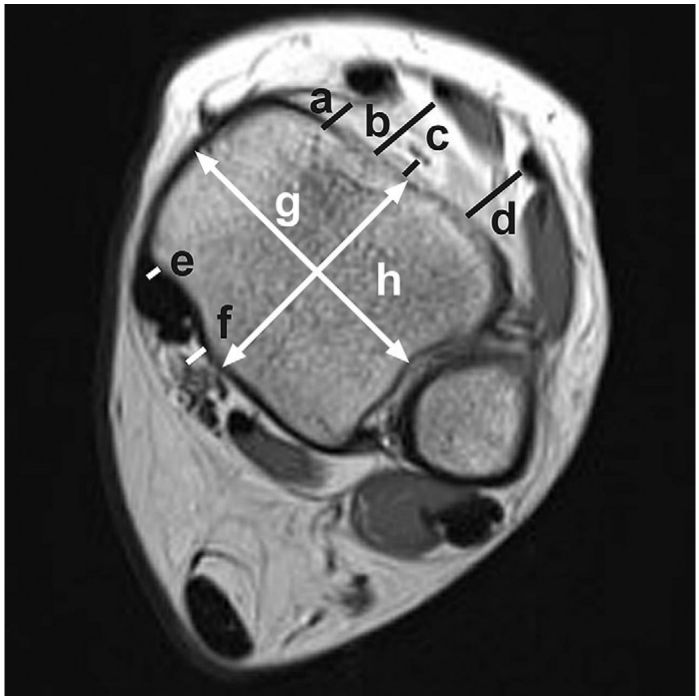
A distal tibia fracture is a break that starts in the metaphyseal region and may extend all the way to the articular surface where you put your weight. If the articular surface is affected, the fracture is referred to as a tibial Pilon fracture or tibial plafond fracture. In 1991, Etienne Destot coined the name tibial Pilon to describe the 5 cm of distal tibia metaphysis that extends upward from the ankle joint, much like the form of a pharmacist's pestle.[36] The distal tibia's flat articular surface, or plafond, is named after the French word for ceiling.[36] Due to the enormous energy involved in these types of fractures (such as those sustained in a fall from a great height or a car accident), they generally include substantial soft tissue damage and are presented as open fractures. These correlations increase the likelihood of infection, malunion, and non-union, all of which contribute to a poor clinical result. Tibial soft tissue injury is common due to its subcutaneous nature and inadequate musculature; many treatments have been documented. Soft tissue preservation and reconstruction, early mobilisation, and functional use of the affected extremity while preserving adequate length and alignment of the fracture are the keys to effectively treating these challenging fractures. Displacement, comminution, intra-articular extension, and soft-tissue envelope damage all play a role in determining the most appropriate treatment. [37]

Relevant surgical anatomy

Fractures of the distal tibia may be induced by rotational stresses and/or axial loads. Spiral fractures, either intra- or extra-articular, are common results of rotational forces (torsional trauma). Due to the low energy involved, they tend to heal closed, and the accompanying injuries are typically rarely life-threatening. In a trauma, the convexity of the talar dome collides with the concavity of the plafond at a high velocity, fractures involving the intra articular surface of distal tibia may occur. Articular damage is more or less severe according on the force of the impact and the foot's orientation. Plantar flexion of the foot causes a disproportionately large posterior fragment to develop because most stresses act on the posterior aspect region of the articulating surface. On the other hand, when the ankle is flexed the dome of the talus strikes the anterior aspect of the articulating surface of the tibia. When the ankle joint is in its neutral position, a Y-shaped gap between the anterior and posterior pieces is typical, and central joint impaction is common.[38]

A view through the axially oriented cross section of the tibia, the contour changes from that of triangle with the apex pointing towards the anterior aspect to a more oval shape as one moves distally from the diaphysis to the metaphysis. Metaphyseal cortical bone is thinner than diaphyseal cortical bone, the secondary spongiosa and the and the cancellous bones takes up the space that has been previously occupied by the central cortex and cancellous bone, both of which make screw fixation more difficult. The diaphyseal portion of the tibial medullary canal is narrower than the metaphyseal portion, creating an hourglass form. A tight fit in the medullary canal with an intra medullary nail is only established in the mid part of the diaphysis, making intramedullary (IM) fixation difficult in cases where the metaphyseal area has flared out. The lateral “syndesmotic ligaments” and the distal “interosseous membrane” make up the distal tibiofibular articulation which is the main cause of ipsilateral fibula injury in higher-energy fracture patterns. Conversely an intact or healed fibula may aid in preserving the tibial alignment during fracture recovery.[7]

Figure 4: The distal tibia as seen on a T1-weighted axial MRI scan.



a) distance from anterior cortex to the tendon of the "tibialis anterior" muscle; b) distance from anterior cortex to the tendon of the extensor hallucis longus muscle; c) distance from anterior tibial cortex to the anterior neurovascular bundle; d) distance from anterior cortex to the tendon of the "extensor digitorum longus" muscle; e) distance from posterior cortex to the tendon of the "tibialis posterior" muscle; f, distance.

There are two main veins that provide blood to the distal tibia. A collateral circulation of periosteal vessels over the medial surface, which arises from the "anterior and posterior tibial arteries", provide extraosseous perfusion to the outer one-tenth to one-third of the tibial cortex. Branching off of the posterior tibial artery, intraosseous nutritional arteries nourish the distal two-thirds of the tibia. This intraosseous supply may be compromised after a segmental fracture, leaving only the extraosseous supply. Bone healing may be complicated if the periosteum is severely stripped away during fixation, since this might cut off the bone's residual blood supply and lead to avascular necrosis. "The great saphenous vein and the saphenous nerve" are vulnerable to damage during medial fixation of the distal tibia. Approximately 10 centimetres from the medial malleolus's tip, this vein and the prominent branch of the saphenous nerve meet at the posterior aspect of distal tibia and then travel anteriorly to pass the cortex about 3 centimetres from the malleolus's tip

Blood supply of distal tibia[39]

Figure 5: Anterior tibial artery; 2. Peroneal artery; 3 Branch from anterior to the distal aspect of fibula; 4 and 5. Peri-malleolar arterial circulus.[39]

Epidemiology

Distal tibial fractures are responsible for 3- 10% of all tibial the fractures and 1% of all lower extremity fractures, respectively. Complex injuries, such as those sustained by athletes, result in a fibular fracture in 70%-85% of instances. [9] Males account for 57%-66% of all cases of Pilon fractures, whereas females account for just 33%-35%. Distal tibia Pilon fractures have a bimodal age distribution, with peaks at 25 and 50 years old.[40] In ~75–90 percent of all instances the fibula is also broken.[41] There is a correlation between AO Type B tibial Pilon fractures and an unbroken fibula. As an added bonus, current research suggests that when the fibula is unbroken, tibial Pilon fractures are less likely to be comminuted and less severe. [42]

Soft tissue injuries associated with distal tibia fractures

In closed tibial fractures, the most commonly used soft tissue classification is "Tscherne and Gotzen's" (1984) system, which describes four different soft tissue injury patterns with a higher number indicating worsening severity, from absence of any soft tissue injury to superficial abrasion or contusion to deep abrasion that could pre dispose the affected limb to compartment syndrome to severe crushing muscle damage.[11] Classifying the bone fracture pattern along with the soft tissue damage is essential because both affect the management and healing in different ways.

Table 1: "Tscherne and Gotzen's" classificatioon of Soft Tissue Injuries. [11]

Classification	Description
C0	Soft tissue damage is non-existent or minimal.
C1	Minor scrapes and bruises on the skin
C2	The danger of compartment syndrome is high, with deep wound, contaminated.
C3	Extreme contusions or crushing of the skin; possible serious muscular injury.

Distinct criteria are used to evaluate the severity of open tibial fractures. The most common grading system used for open fractures of the tibia was created by "Gustillo and Anderson," and it separates open fractures into three primary classes.[43]

Table 2: Gustillo and Anderson classification system used in open fractures [43]

Classification (Grade)	Wound Size	Description
I	< 1 cm	"In/out" injury
II	1 – 10 cm	Potential for microbial infection and tissue injury
III	>10 cm	Severe contamination and tissue damage
IIIA		Bones should be well covered by soft tissue.
IIIB		Extensive tissue damage, periosteal stripping
IIIC		Complications involving the circulatory system and probable limb loss

Etiology

Trauma due to Both low- velocity and high-velocity impacts contribute to these fractures' bimodal distribution. Low-energy injuries include those which are caused by a torsional force on the leg, indirect trauma leading to spiral fractures, with or without a fibular fracture at varying levels with little soft-tissue damage.[44,30] Injuries caused by high-energy mechanisms include soft-tissue damage, compartment syndrome, bone loss, and ipsilateral skeletal injury, and are often the consequence of trauma that can cause wedging of the fracture or oblique fractures with substantial comminution.

Tibia fractures are a common injury sustained in the line of work. Because of the force of the impact, the tibia may be fractured, and there is usually significant injury to the soft tissues as well. High-energy injuries to the tibia include fractures caused by gunshots or other penetrating trauma. Tibial insufficiency fractures are one example of an uncommon mechanism of injury. Normal loads (walking, using stairs, bending, sitting) applied to defective bone (osteopenic or underlying illness) may cause pathologic fractures known as "insufficiency fractures."[45]

A Pilon fracture is a more severe kind of ankle fracture that occurs when the tibial plafond breaks through the talus due to high-energy trauma with considerable axial strain. [46] Pilon fractures may also be caused by low-energy rotating stresses, such as those seen in skiing accidents, although the comminution observed in these fractures is often milder. [41] High-energy traumas often result from high-velocity impacts, such as those sustained in car accidents or from falls or leaps from considerable heights. Six percent of all patients with tibial pilon fractures have multiple injuries and need critical care units due to the tremendous energy surrounding the events and the resulting significant damage to the surrounding soft tissue.[46 47]

Classification

Classification of fracture of the distal tibia are done based on the mode of injury, the position of the foot In relation to the mode of injury and pattern of the fracture fragment caused by the injury Common methods of categorising fractures include the Lauge-Hansen and Denis-Weber systems. Some distal tibial fractures are so common that they have their own names. Both the anterolateral distal tibial epiphysis and the articular surface of the ankle joint are broken in a Tillaux fracture, whereas the distal tibia is fractured in a Pilon fracture. Open reduction with internal fixation is the gold standard for treating distal tibial fractures.[48,49]

“Lauge-Hansen Classification

- Supination-adduction
- Supination-external rotation
- Pronation-abduction
- Pronation-external rotation”

Danis-Weber classification

- Type A: fracture of lateral malleolus distal to the syndesmosis
- Type B: fracture of the fibula at the level of syndesmosis
- Type C: fracture of the fibula proximal to syndesmosis

“Mast, Speigl, and Pappas's classification, the Bohler’s classification, the Weber,s classification, Ruedi’s and Allgower's classification, and the AO/OTA classification” are just a few of the early classifications that have been used and refined throughout time. When it comes to long-bone fractures, however, the Ruedi’s and Allgower's classification and the “Arbeitsgemeinschaft fu¨r osteosynthesefragen” or the “Orthopaedic Trauma Association (AO/OTA)” classification are still the two most often used systems.

In accordance with to the AO/OTA classification[12], the term "distal tibial fracture" encompasses a diverse range of fractures affecting the distal tibia and fibula. Etienne Destot coined the term "pilon fracture" to describe a fracture on the articulating surface of the “ankle joint” joint caused by an axial stress.[50] Distinguishing between extra-articular (type A), partial-articular (type B), and complete-articular (type C) fractures is the focus of the AO/OTA fracture classification system.

Figure 6: "AO/OTA classification of distal tibia fractures[9]

Type 43A. Simple 43-A1, Wedge 43-A2, and Complex 43-A3 Partial articular fracture, grade 43B. Defined as a 43-B1 pure split, a 43-B2 split depression, or a 43-B3 multi-fragmentary depression. Fracture of the articular surface, grade 43 C. The articular surface of 43-C1 is simple, and the metaphyseal surface is also simple; 43-C2 is simple on the articular surface but multi-fragmentary on the metaphyseal surface; and 43-C3 is multi-fragmentary on the articular surface." [9]

Pappas, Mast, and Speigl Classification: Supination-external rotation fractures sustained under vertical force are classified as Type-1 fractures. Spiral extension fractures are the second kind. Fracture of the third kind is one that occurs due to vertical compression**.** [51]

Rüedi and Allgöwer classification[52]

Trauma surgeons "Rüedi and Allgöwer" did some of the first work on pilon fractures. Cleavage fractures of the distal tibia without displacement characterize Type I Ruedi-Allgower fractures. With no comminution, type II fractures include a mild articular surface fracture-dislocation. Because of the difficulties in obtaining articular reduction and treating the soft tissue damage, type III fractures, which are characterised by a significant degree of comminution of the articular surface with impaction of the metaphysis, provide the greatest treatment challenges.[52]

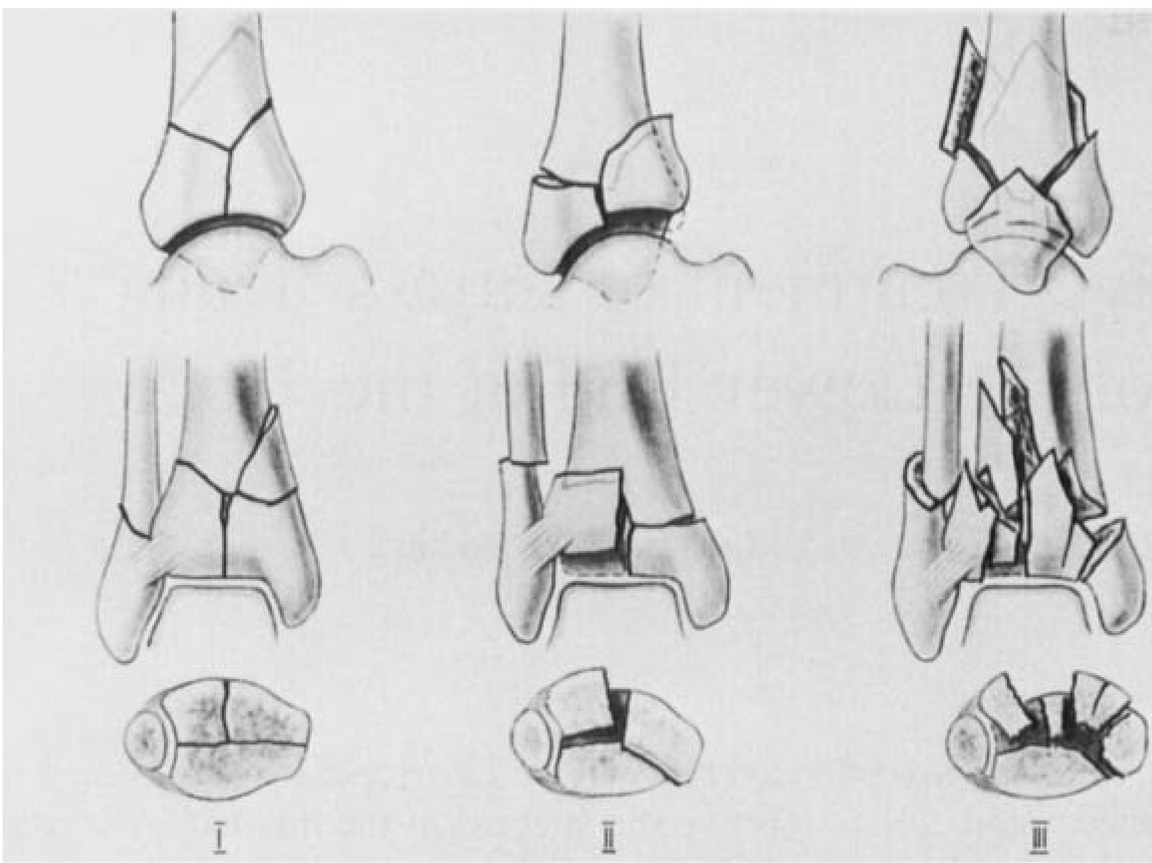


Figure 7: Rüedi and Allgöwer classification. [52]

Cleavage fracture of the distal tibia without significant articular surface displacement constitutes a type I injury. Joint surface dislocation with substantial fracture (type 11) but no comminution. Distal tibial impaction and comminution (type 111).[52]

The Ruedi-Allgower classification is the simplest approach for characterising tibial pilon fractures, with just three distinct forms of fractures. To begin, in the first series by Rudi and Allgower, most fractures were caused by skiing accidents, and the majority of them were low-energy rotational deformities of the distal tibia.[53] Metaphyseal displacement is a common effect of this mode of damage but is not specifically addressed by this categorization, prompting Ovadia and Beals to suggest revisions.[54]

Categorization by Ovadia and Beals[54]

"Type I undisplaced articular fractures

Type II which involve very little displacement.

Type III. Multiple large fragments of a displaced articular fracture are of

Type IV Articular dislocation with multiple fragments and a significant metaphyseal defect,

Type V Displaced articular fracture with extensive comminution" [55]

Management of distal tibial fractures relies heavily on health of the surrounding soft tissues. If the skin and subcutaneous soft tissues are in good shape, a straight forward approach and open repair of the articulating surface may be performed soon after the injury. The "Gustilo and Anderson" classification is the gold standard for open fractures.[10] Tscherne and Oestern's classification system may be used to categorise closed soft-tissue injuries.[11,53]

Clinical presentation

Swelling, contusion, presence of blebs over a tense leg compartment and open wounds are all symptoms of soft tissue injury; distal metaphyseal fractures often cause more damage to soft tissues than diaphyseal fractures. The antero medial aspect of the tibia, which is protected with nothing but a thin subcutaneous layer of tissue, is the most prevalent location for an open tibial which occur with an estimated frequency of 20%.[7]

Diagnosis

In light of the fact that a sizable proportion of patients with distal tibial fractures will also have other injuries, it is imperative that they undergo a thorough clinical assessment in accordance with the Advanced Trauma Life Support protocol.[55] In the case of extra-articular fractures, simple radiographs offer enough data for surgical preparation. CT scans are essential for diagnosing intra-articular fractures. In the vast majority of the instances, CT scans revealed new information on the fracture patten leading to a change in surgical strategy in 64%.[56]

“Based on CT examinations of 22 distal tibial fractures, Tornetta and Gorup discovered six common fracture fragments: the anterior fragment (seen in 76%), the medial malleolar fragment (84%), which may still be connected to the anterior or posterior fragment and may include up to 40% of the tibial articular surface, the posterolateral fragment (26%), and the anterolateral fragment (58%), which is attached to the fibula via anterior tibiofibular ligament. Up to 20% of the articular surface may be made up of a central component (50%), which is not related to the other fragments by ligaments”. [56]

Fracture healing

When the cortical bone layer of a bone is broken, it causes damage to the soft tissue surround the fracture site. Secondary healing starts after the fracture which includes four stages:

A hematoma forms when blood arteries feeding the bone and periosteum are disrupted during the fracture (days 1–5). Pro-inflammatory cytokines are released in response to tissue damage; they include tumour necrosis factor alpha (TNF-), bone morphogenetic proteins (BMPs), and interleukins (IL-1, IL-6, IL-11, and IL-23), all of which recruit and activate vital cellular biology at the injured location. Together, these cells may clear away dead or dying tissue and release healing cytokines like vascular endothelial growth factor (VEGF).

During the callus-forming phase (days 5–11), fibrin-rich granulation tissue and new blood vessels form thanks to VEGF. Chondrogenesis results from mesenchymal stem cells differentiating into fibroblasts, chondroblasts, and osteoblasts.

Building a skeletal callus (days 11-28): Endochondral ossification occurs when a cartilaginous callus arises, RANK-L is produced to promote the differentiation of cells such as “osteoclasts, chondroclasts osteoblasts, chondroblasts” and calcification of the callus results. In order for mesenchymal stem cells to continue spreading, the newly created blood arteries must continue to multiply.

The reshaping of bones (beginning on day 18 and continuing for up to a year): Osteoclast resorption and osteoblast bone production are in a state of dynamic equilibrium during combined remodelling of the hard callus. Together with these changes is a substantial reworking of the vasculature. Bone remodelling is a lengthy process that takes months but eventually leads to the recovery of normal bone structure.[57,58,59,60]

Evolution of MIPO

The principles of 'Technique of internal fixation of fractures,' first published in 1956, centre on these goals of vascularity preservation, anatomic reduction, and rigid fracture fixation.[61] It was formerly thought that the best way for a fracture to heal was without the creation of a callus, and that the presence of a callus was an indicator of poor fixation. Since this was the case, a narrowing of focus on the body's anatomy became obligatory. However, vascularity preservation and soft tissue preservation were not always prioritized.[62] In time, however, it became clear that strict internal healing of fractures did not always provide the desired effect. Common complications were sepsis, sequestrum formation, delayed or absent union, and refractures. Interfragmentary compression, plate fixation with articulating tension mechanisms, and ultimately dynamic compression plates were developed later on. [63]

When researchers dug further into the source of these failures, they found that the interruption of the periosteal blood flow led to temporary osteoporosis in the region where the plate met the bone. To prevent injury to the periosteal blood vessels, plates with undercuts and grooves were designed. Because of this, limited contact dynamic compression plates were developed (LC-DCP). [63]

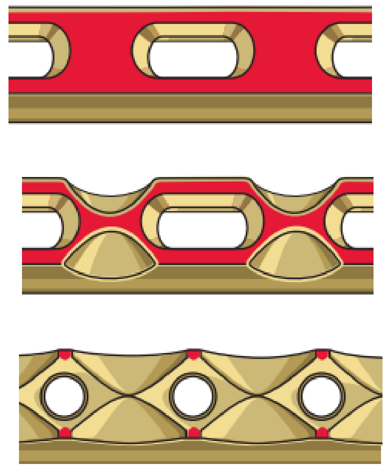


Figure 8: The evolution of plates to reduce the contact surface area, preserving the periosteal blood supply. [63]

Since the total displacement is spread out over multiple fracture gaps, multi-fragmentary fractures are able to endure a larger degree of instability, according to the concept of interfragmentary strain. In contrast, single-gap fractures cannot tolerate even little movement because the repair tissues must flex to accommodate the break.[64] As these ideas developed, attention switched to ensuring that fracture pieces continue to rotate in the same axial direction. Because of these ideas, a more biological procedure was developed and is currently known as "Minimally Invasive Plate Osteosynthesis. (MIPO)"

The basic requirements of MIPO included

- The use of a tiny window in the soft tissue to insert devices and implants at a great distance from the site of a fracture.
- Indirect reduction is preferred because it causes less trauma to the soft tissue and fracture fragments.
- To avoid further soft-tissue injury, specialised devices are used. [63]

Internal fixators like PC- fix were created when the MIPO approach became widely used. PC-Fix devices safeguard the periosteum's blood supply by preserving point contact. Since the screws in these fixators are only inserted in one cortical layer, they are less effective. The screw provides the required angular stability and its tapered head ensures a snug fit in the plate hole. [65]

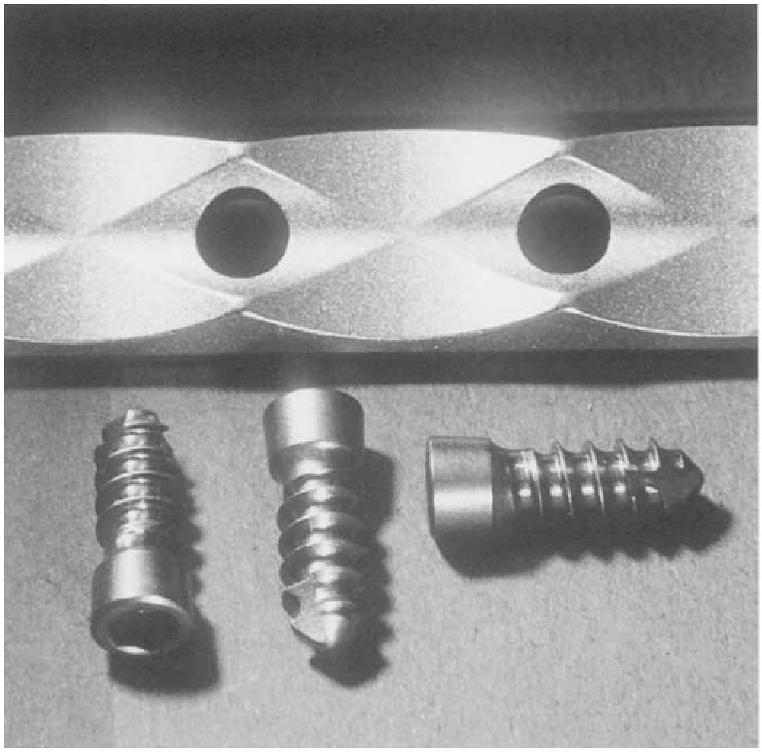


Figure 9: pc fix plate[65]

Building off of PC-FIX, a less intrusive stabilisation system (LISS) was created. The LISS may have been the first plate designed and instrumented specifically for minimally invasive submuscular implantation. An innovative insertion handle facilitates submuscular implantation and acts as a drill guide for screw placement via a second, smaller incision. [66]

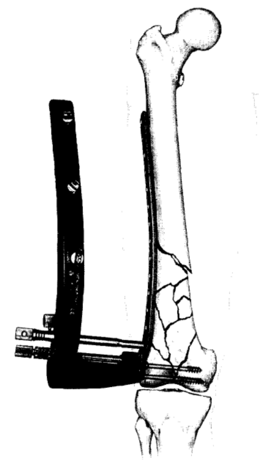


Figure 10: LISS fixator [66]

By analysing the biomechanical features of the PC fix and the LISS fixator, a new cornerstone of the MIPO approach was developed: locking compression plates (LCP). The mechanical benefit of locking and cortical screws is realised by the combination hole arrangement. The compliance of the plates was enhanced by the introduction of anatomically shaped plates for location-specific fractures. Surgical modalities like MIPO are constantly improving, and new tools are always being developed to make MIPO plating simpler. Data from multi-center studies and research are continually contributing to this method's advancement. MIPO may emerge as the primary therapeutic target in the next years.

Biomechanics of MIPO

In the first phases of the evolution of these ideas, the primary goal of surgical therapy was to provide a static setting for the fracture. It is the balance between the stability and stiffness of fracture fixation that creates immobility.

An implant's stiffness indicates how well it will withstand being distorted. Because of this, even if the fixation mechanisms used in an internal fixation are robust, the fragments themselves may be unstable. Fragment impaction, rather than the implant's rigidity, produced stability. Fragment contact and compression re-established structural continuity and stability by transferring loads directly from one fragment to another without involving the implant.[67]

When a fracture is entirely stabilised, with no gap mobility across the fracture site and limited or no callus growth, primary bone healing occurs. There was a time when the primary function of internal fixation devices was to serve as compressive stress protectors to halt fracture displacement. Callus formation after a fracture was considered a red flag for instability. However, relative stability takes use of callus formation, often known as indirect healing.[63]

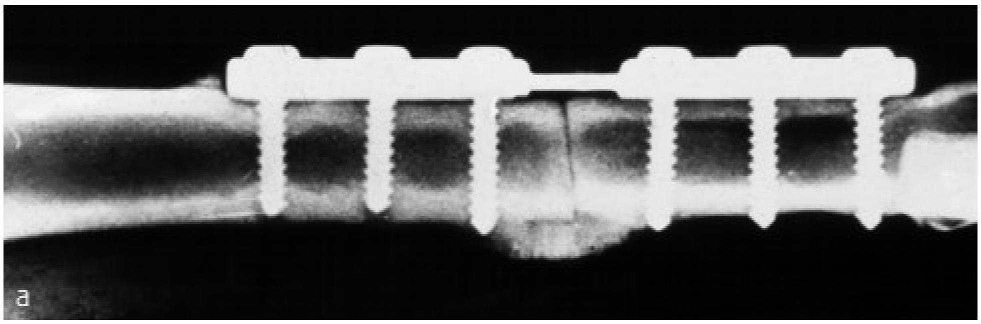


Figure 11: Shows the formation of callus on flexible fixation[63]

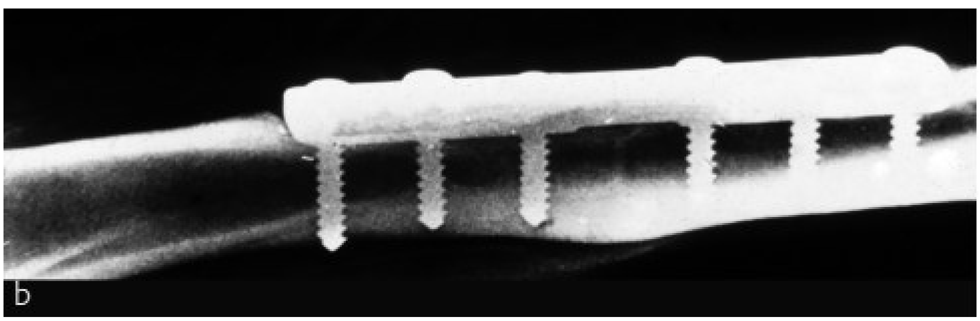


Figure 12: shows rigid fixation with dense bone formation[63]

Many research over the last few decades have revealed that mechanical stimulation accelerates the healing process; hence, relative stability is an essential part of modern osteosynthesis. [68] Traditional secure internal fixation with accurate reduction often requires a comprehensive surgical approach to the bone. Increased necrosis from the injury increases the risk of a sluggish recovery, an infection, and even a refracture. [69] Accurate fracture reduction and fixation with absolute stability was given full attention, with an overemphasis on mechanical stability at the cost of biology. However, once it was realised that biology and mechanics are equally important, advancements in fracture therapy have occurred. On the other hand, there are situations when a precise reduction and absolute secure fixation are not required and, in fact, might be detrimental to the biology of the fracture. A satisfactory functional result and early rehabilitation are possible because of the concept of relative stability, which states that the surgeon may regulate the fracture mobility to some degree to encourage healing while preserving fracture reduction. [70]

Minimally invasive surgery aims to retain the natural biological sate of the soft tissue and bone of the patient. The stabilisation via internal fracture fixation can be justified due to the need to restore the bone's anatomy and mechanical function. Optimized bone healing is achieved by the integration of mechanics and biology, both of which are facilitated by modern concepts of osteosynthesis.[70]

Splinting plate osteosynthesis consists of a splint (i.e., plate) and fixing devices (i.e., screws or cerclages) to hold the plate in place. It is important to place these fixing pieces in a way that makes sense for the fracture. Screws placed in proximity to the fractured bone fragments decrease the mobility at the fracture site even if they are subjected to substantial exposure to physiological pressures. Screws positioned too far from the proximal and distal end of the fracture may not be able to satisfactorily support the displaced bone fragments. It is possible to employ them to protect screws near the gap from large moments and forces even if they are mechanically inferior. Minimally invasive plate osteosynthesis (MIPO) shares the objective of all fixation techniques: to produce the best result with the help of minimal components as possible. A wide-spanning fixation with lesser number of screws is preferred over narrow-span fixation with more screws. [63]

For a satisfactory layout, aim for a plate-screw density of 0.4 to 0.5, defined as the percentage of available screw holes that are actually being used.[71]

As such, no more than half of a plate's screw holes should be utilised for fixation. Most of the time, inconsistent plate stiffness may be avoided by using screws fixed with even spacing. However, owing to individual anatomical constraints, this goal is often compromised.

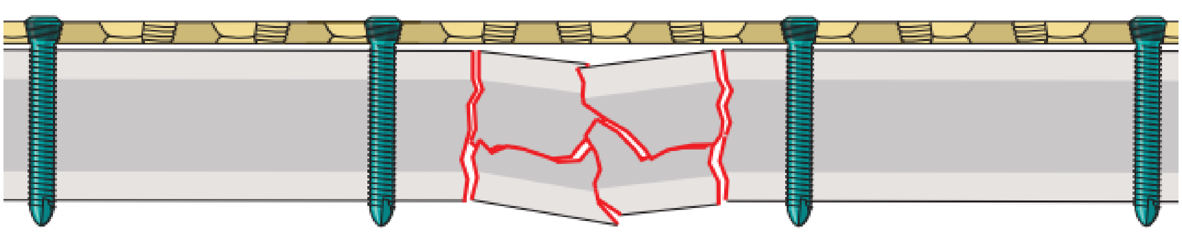


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Figure 13: The placement of screws in close proximity to the opening helps to stabilise the fracture and reduce its movement. in a lengthy plate the widely spaced screws reduce the physiological strain and protects the more closely approximated screws. [63]

The "working length (Le)" is the sum of the lengths of all the fixation components. The spacing between the proximal most screws on each side of the fracture is known as the "working length (Lw)" of the plate. When a plate is fixed in place, the stability of the fixation is not improved by any plate material that extends beyond the last filled screw hole. In other words, the longer the "working length "the greater is the fracture mobility because of the decreasing stiffness of the construct.[63]

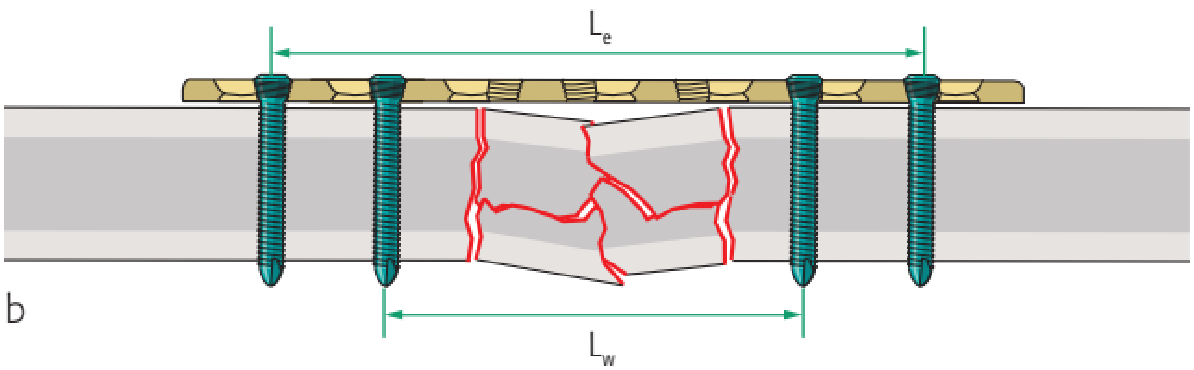


Figure 14: The screws will be under greater strain and more susceptible to backing out if the "effective plate length (Le)" is low, as in the case of a short plate.[63]

Fracture mobility increases with increased working length due to the decreased stiffness of the construct. The chance of fatigue failure is increased by a short "working length (Le)" because of the decreased mobility in the fracture gap and the therefore increased stress on the plate. As the space between the fracture fragments heals, the strain is transferred from the implant to the bone which bears a greater portion of the weight.[72]

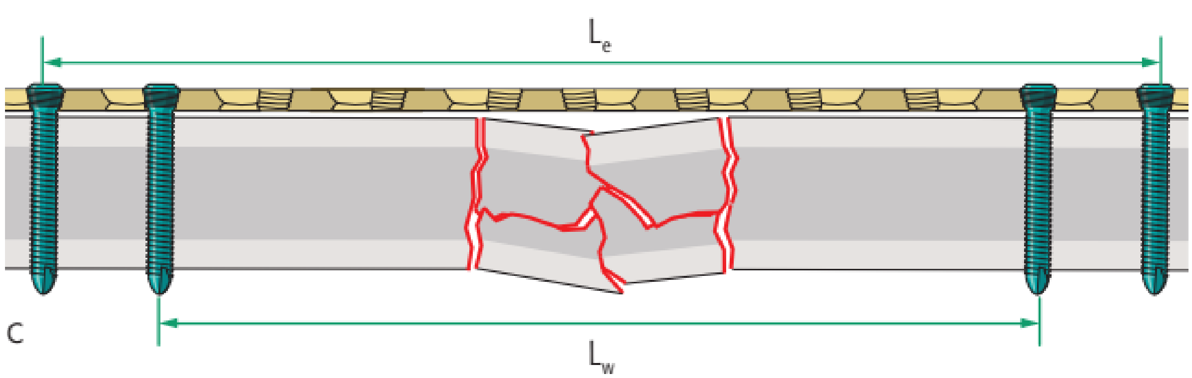


Figure 15: as the "working length (Lw) "of the plate, increases so does the gap motion and therefore the fracture mobility.[63]

CONCEPTS OF PLATE FIXATION

In traditional plating, the plate and bone cortex are compressed together. By tightening the screw, you increase the friction between the plate and the bone, which helps it withstand the normal stress placed on it by the body. The concept that "bone-to-metal contact" could be maintained without the adverse effects like resorption of the bone and that additional "preloading" prevented occasional separation of the fracture surfaces paved way for the development of the "Dynamic Compression Plate (DCP)". By tightening screws eccentrically inserted into oval screw holes, the fracture pieces are pushed back together. One possible drawback of this technique for fixing fractures is that it may disrupt blood flow in the periosteum. Compression plates often have undercuts to allow blood to continue flowing underneath them.[73]

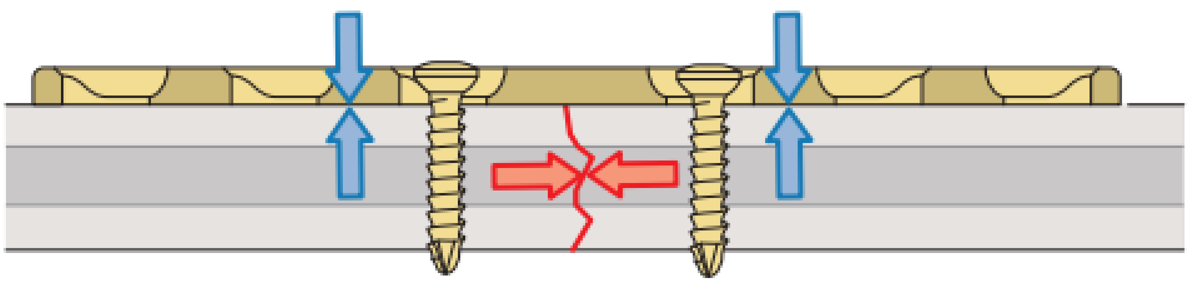


Figure 16: shows "implant-to-bone compression" (blue arrows) and "bone-to- bone compression" (red arrows) the screw in the "compression plate hole" must be tightened to achieve this.

As the screw is tightened, bone fragments and screw heads slide axially as a result of the design of the hole and screw head. [63]

Another common plating idea in MIPO is a method that allows for angular stable locking of the screw into the plate. The screw's conical thread allows it to be securely fastened into a" threaded plate hole". This allows the plate to be raised above the periosteum of the bone while the screw transfers the load from the bone to the plate. Thus, contact damage to the periosteal blood flow is avoided, and plate-bone compression is not required for the fixation. By securely fastening a pre-shaped metal plate to the patient's bone using a locking plate, surgeons can keep their patients' fractures from moving out of place. Locked plates prevent the anatomical position of the parts from shifting due to the plate's form while screws are being inserted. The traction of the screw approximates the bone toward the implant when the screws are tightened, standard plates may relocate a fracture if they aren't a perfect match. An important benefit of MIPO is the use of angular stable locking plates, which allow for precise implant shaping even when the bone surface is obscured. [74]

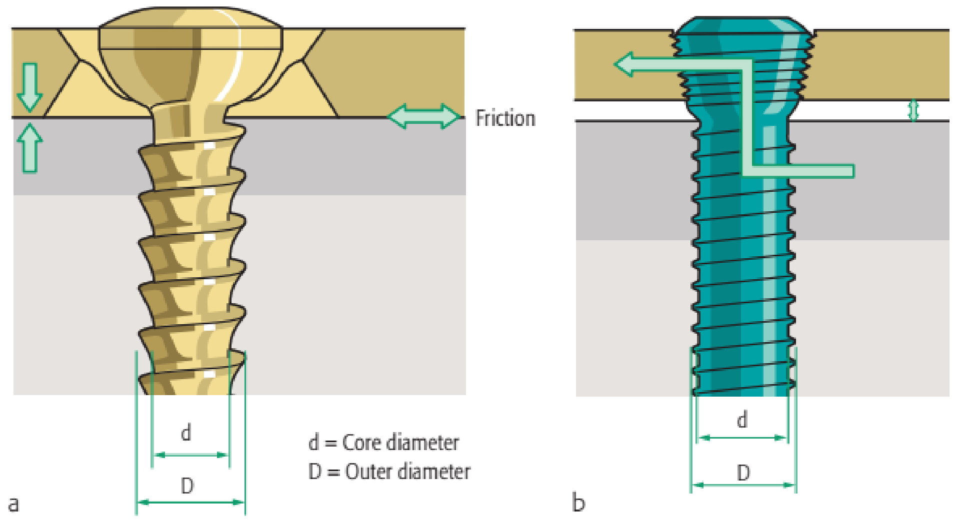


Figure 17: (a) In traditional plate attachment, the axial tension in the screw presses the plate against the bone, resulting in friction that transfers the weight to the bone fragment.

(b) The vascularity of the periosteum is protected by the locking screw, which may also maintain a relatively small space between the bones. Force transmission is based on the screw's bending and shear resistance.[63]

Flexible fixation may be achieved with the help of angular stable locking plates. The modern locking compression plate (LCP) opens up the potential prospect for the operating surgeon to achieve fixation with either compressing or splinting. With an LCP, you can have both absolute and relative stability from a single osteosynthesis thanks to the combination holes that can take either a standard or a locking screw. [65]

Figure 18: A keyhole shaped combo hole where first, a hole (1) may be inserted for an angular stable locking screw, and then, second, a cortical screw can be placed into the same hole (2) to compress the bone fragments. [65]

The cortical screws that is used to lower the plate should be fixed first before the locking screws that lift the plate off the bone is inserted as these can parasitically load the cortical screws if the plate is elevated

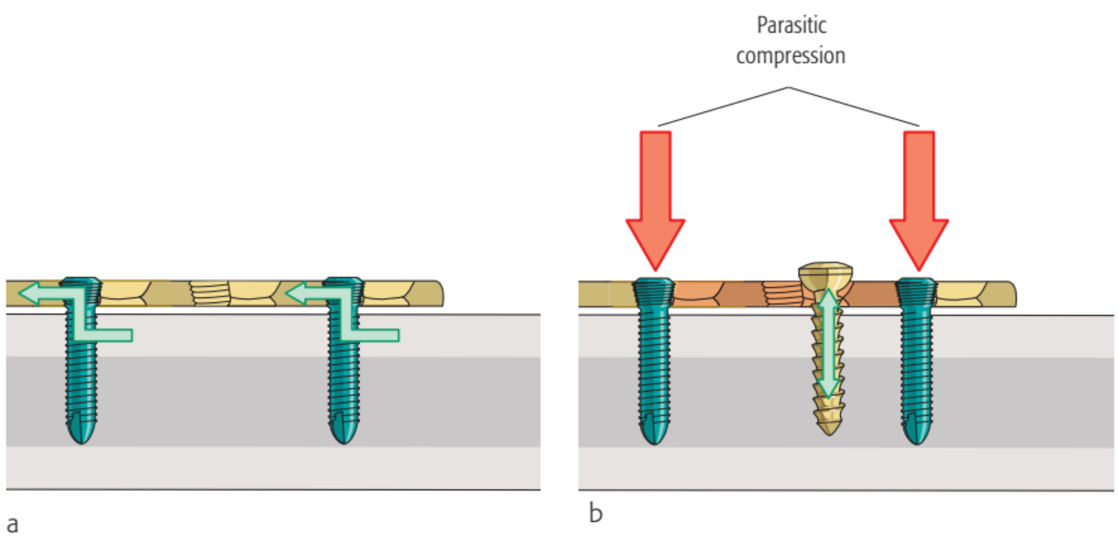


Figure 19: A perfectly angularly stable framework with ideal load transfer.

The screws are not under any static stress, and the plate is sitting comfortably above the bone. (b) "Parasitic compression "of the locking screws is what weakens the structures when cortical screws are added to the elevated plate fix. [63]

In a nutshell, the best fracture healing results from a balance between the biological and mechanical environments. Mechanical fracture stabilisation is essential, but it must be done in a way that does not compromise the local biology. Minimally invasive surgery won't go well until you completely grasp this concept. By taking use of surgeon's role in control over fracture healing, advances in contemporary fracture treatment have been made by meticulously planning the “osteosynthesis with regard to the degree of flexibility required for early beginning of repair”. [69] When repairing a fracture using the MIPO approach, the most important mechanical considerations are the implant used, the arrangement of the fixation parts, the size of the interfragmentary gaps, and the “functional load”.[63]

Management

Traditional conservative treatment for distal tibia fractures included traction followed by early range of motion. In ligamentotaxis, soft tissue attachment to the bone is thought to decrease fracture severity; however, it was later realised that in the case of a highly comminuted fracture, there was no soft tissue connection to the bone and hence no decrease in fracture severity. [75] In the early stages, closed reduction with immobilisation in a well-padded cast is adequate treatment for tibial pilon fractures caused by low energy trauma without considerable comminution and less severe soft tissue injury. However, because to the high energy trauma mechanism, most tibial pilon fractures are highly comminuted, necessitating an ankle-spanning external fixation (EF) as a damage control procedure, followed by a delayed intervention with open reduction and internal fixation (ORIF). As soon as feasible, realignment and restoration of length and anatomical reduction should be accomplished by the use of temporary fixation. The pins must be positioned far from the site of the fracture so that they do not compromise definitive fixation or prevent access to the area during subsequent operations.[76] In most cases, the "A" shape of the various external fixator systems is placed above the ankle. To avoid equinus contracture, it is recommended to extend the external fixator over the forefoot, often the first metatarsal. [77]

Fractures with less than “5 degrees of varus-valgus angulation", less than “10 degrees of anterior-posterior angulation” “greater than 50% cortical apposition,” “less than 1 cm of shortening” with less than “10 to 20 degrees of flexion, and less than 10 degrees of rotational malalignment “after reduction are suitable for closed reduction and non-operative treatment in a long leg cast.[34]

Tibial pilon fractures that are extensively comminuted and displaced may not benefit much from a CT scan before final reduction or temporal external fixation. Even after analysing the CT image, the operating strategy altered in 64% of the patients, as determined by Tornetta et al.[56] It has been advised that open reduction and internal fixation (ORIF) be delayed in fractures with severe soft tissue injury and subsequent production of fracture blisters until reepithelization of the area is completed. Even more so, the blisters' strategic placement may restrict surgical options. In the case of open fractures of distal tibia, VAC therapy may need numerous soft-tissue operations. Although external fixation should be considered, if open reduction and internal fixation (ORIF) is to be pursued, the wound must be in a sterile state before ORIF can begin. [78]

After studies by the AO group and writings by Ruedi and Allgower, open reduction and internal fixation gained traction. After publishing their findings, 70% of the patients treated by Ruedi and Allgower for intra-articular distal tibia fracture had satisfactory or outstanding late outcomes, demonstrating the success of their standardised approach and operating principles. [53,79]

In 1969, Rüedi and Allgöwer 54 proposed the classical approach to open reduction with internal fixation (ORIF) of fractures of distal third of tibia, which entails the following a four staged surgical management: "reduction and fixation" of the fibula; "reconstruction of the articular surface of the tibia"; "bone grafting of depressed articular and metaphyseal defects"; fixation of the diaphysis with a metaphysis with a medial plate. [53]

Several writers towards the decade's end recommended a staged procedure for treating distal tibial fractures.[80] [4] In the initial step, the fibula was secured using an external fixator via the medial aspect of the leg. In most cases, soft-tissue oedema had to subside for seven to fourteen days before definitive distal tibial fixation could be undertaken. Before the soft tissue state is suitable for surgical management, a temporary fracture stabilizing external fixator is suggested to align and stabilise the fracture and to provide soft-tissue stabilisation. The formation of wrinkles and the disappearance of any fracture blisters are suggestive of a healing soft tissue.[78]

If there is a varus or valgus component to the accompanying tibia deformity, the surgical technique and/or surgical construct to stabilise the tibia plafond must be adjusted accordingly. In the case of a tibial varus failure, for instance, a medial buttress plate is the ideal treatment once the articular segment has been stabilised.[81] An anterior-lateral plate is preferable for treating tibial valgus failure, however. These fundamentals of fixation will help in mitigating hardware failure, malunion, and/or nonunion by counteracting the primary deforming stresses at the metaphyseal-diaphyseal junction. Thorough analysis of the CT scans is required prior to surgery in order to establish the necessary strategies for addressing the primary pieces. Assessing the "anterolateral" (Chaput), "posterolateral" (Volkmann), and medial columns in that order is recommended. Soft tissue should be maintained as much as feasible, and the selected techniques should provide direct sight of the primary fracture zone and the joint block.[47]

Intra medullary Interlocking Nailing (IMN): Distal tibial fractures are treated by either closed reduction or open reduction followed by intra medullary inter locking nailing. With the goal of minimising soft-tissue disturbance from plate administration on the surface of the tibia and preventing plate prominence in patients with a poor soft-tissue envelope, IMN is often utilised for the treatment of extra-articular distal tibial fractures.[82] The main drawback of this treatment is that axial and rotational malalignment might develop because to the broad distal medullary canal, which results in malunion and delayed union.

For distal tibia intra articular fractures and complicated injuries, a hybrid external fixator for Tibia with plate osteosynthesis for fibula is often employed. Malalignment, pin loosening, pin tract infection, and the requirement for subsequent treatments like bone grating were the most common drawbacks. The Ilizarov external fixation technique has opened up new avenues of investigation. The use of tensioned transfixing wires makes it possible to fix tiny bone segments, creating a tight bone construct, while yet permitting axial micromovement, which has been shown to aid bone healing. [54]

The treatment of pilon fractures is a complex topic with many different methods documented. Preoperative CT scans and radiographs should be carefully examined to determine the best course of action. Furthermore, CT scans are useful for assessing any soft tissue structures, such as the posterior tibial neurovascular bundle, that may have been trapped inside the fracture. [83] [84] There are several other ways to enter a body, such as the anterolateral, anteromedial, direct anterior, direct lateral, direct medial, posterolateral, and posteromedial. [85]

As a result of the compromised soft-tissue envelope, methods that aim to minimise damage to this critical area have been developed. The medial plate osteosynthesis (MIPO) approach and intramedullary tibial nailing (IMTN) have both been reported for use in treating extra-articular and simple intra-articular tibial fractures, respectively. It is hoped that these techniques will reduce the need for soft tissue stripping and, with the benefit of fewer incisions, will be applicable to patients with soft tissue impairment. In either case, it is essential to first decrease, compress, and stabilise the articular surface.[78]

Indications

When the soft tissue envelope around the fractured distal tibia is less than ideal and extensive dissection carries a high risk for wound complications, MIPO is the treatment of choice. When the plafond is not severely comminuted, MIPO may be used to treat distal tibia fractures. MIPO may not be able to fully reconstruct the articular surface in situations where there has been severe disruption and comminution of the tibial plafond. Anterolateral open reduction and internal fixation (ORIF), other incisional methods that provide direct exposure of the articular surface, or primary fusion may be the best treatment option for these fractures. The choice of plating method also takes into account the fracture pattern and any deformity. Treatment of distal tibia fractures with varus deformity benefits from medial buttress plating. To reduce the effects of the deforming stresses and make the structure more robust, a buttress plate may be placed along the middle. [86]

Management of distal end tibia fractures managed by MIPO

Tibial fractures may be treated with plate osteosynthesis with a less invasive incision, which has the potential to reduce postoperative complications such soft tissue damage and amputation. When an accompanying fibular fracture is present, this method entails traditional open reduction and internal fixation of the fibula followed by temporary external fixation of the tibia until the swelling subsides. MIPO of the tibia employing pre-contoured plates and percutaneously implanted 4.5 mm cortical screws is then done after limited but open reduction and internal fixation of misplaced articular fragments. [87,88]

Some of the tools employed by the ancient Greeks and Romans are very comparable to those used in contemporary osteosynthesis. Lambotte et al. used the term "osteosynthesis" in 1907 to describe permanent bone fusion. [89] The first plate that allowed for stiff fracture fixation and subsequent primary bone healing was developed by Robbert Danis. Modern osteosynthesis often attributes him as its progenitor. [90] These plates were later refined into modern "dynamic compression plates" (DCP) by the "Arbeitsgemeinschaft für Osteosynthesefragen" (AO) in 1969. [91] Although axial compression in the fracture zone was possible with this plate, it necessitated an open procedure. In addition to increasing the risk of infection, the extensive bone removal necessary for anatomic reduction might delay or prevent healing of the fracture. Indirect reduction procedures and most of the surrounding soft tissue were originally reported by Mast et al. in 1989, and they were employed for fracture reduction. [92] Furthermore, Wenda et al. (1995) and Krettek et al. (1997a, 1997b) emphasised the importance of obtaining relative, rather than absolute, stability of the fracture, and emphasised the use of less intrusive techniques on the shaft level. [93,50] The authors also proposed sliding a plate into the submuscular plane on the lateral side of the femur to achieve minimum interference with the fracture zone. Thus, initially the term minimally invasive percutaneous plate osteosynthesis (MIPO) was utilised, which was eventually abbreviated to minimally invasive plate osteosynthesis (MIPO). The popularity of MIPO has been rising since 1995. As new plate technologies emerged, enabling fracture fixation with internal fixators, MIPO was able to progress (PC fix, LCP, LISS DF, LISS PT, Philos). These internal fixators allowed for indirect fracture fixing to be performed without the need of precise plate adaptation to the bone. Submuscular plates made feasible the notion of indirect reduction and bridging fixation, previously only achievable with intramedullary nails, to preserve the biology at the fracture site. It allowed MIPO to be used in parts of the body where nailing was previously impossible, such as with comminuted fractures or limited medullary canals, as seen in several Asian and indigenous cultures. The early and systematic teaching of MIPO to execute it in a safe and uniform fashion with dedicated MIPO courses beginning in 2004 may also have contributed to the quick and widespread expansion in the clinical use of MIPO. [94] "Transarticular retrograde plate osteosynthesis" (TARPO) was pioneered by Krettek, who also showed that a 12-week average time to union could be achieved with older implant designs (condylar buttress plate and dynamic condylar screw). [50]

Patient positioning

The patient is laid supine over the fracture table through asepsis with betadine scrub, savlon and surgical spirit is done till the mid-thigh region. Sterile drapes are used to cover till the knee joint, and the foot is wrapped in a sterile drape and secured with a cling film. The arms are rested on the arm board, and a sterile bolster is used to elevate the operating limb so that overlap of the C-arm image is avoided. A sandbag is placed over the buttock region of the same side to prevent the external rotation of the leg. The C arm comes from the opposite side of the leg being operated. A tourniquet can be applied as per the operating surgeon's preference [95]

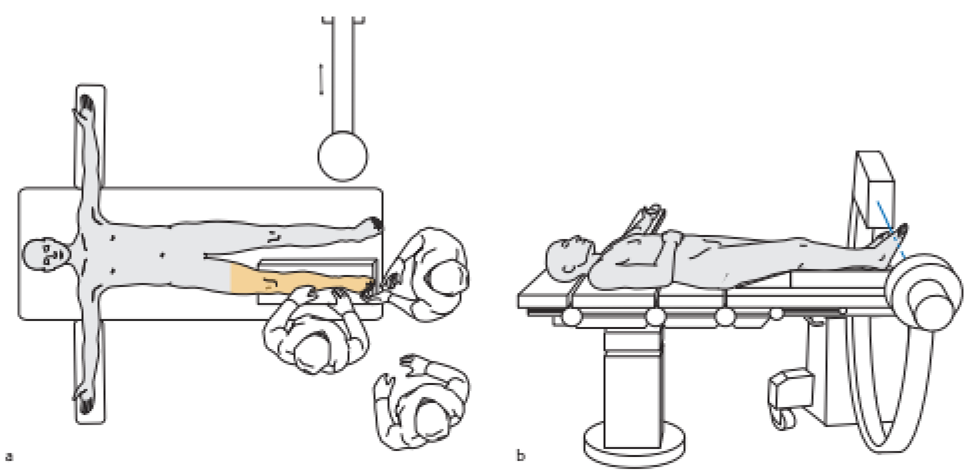


Figure 20: C arm positioning of the patient

The key principle of MIPO plating is the concept of preservation of blood supply. The plate is pushed from distal to proximal manner in the submuscular plane through a tunnel that is formed by the periosteum and the overlying soft tissue. The medial approach is the most commonly used for MIPO plating. A 3-5 cm incision is taken over the medial aspect of the distal tibia in a curved or straight manner. The tip of the medial malleolus marks the end of the incision. The incision is deepened and reached till the periosteal layer a tunnel is created toward the proximal aspect with the blunt tip of the plate . Under C arm guidance, separate stab incisions are made for the proximal screw sites . Care should be taken to retract the saphenous vein and saphenous nerve anteriorly to avoid damage

Procedure

The first closed reduction of a MIPO fracture may be accomplished directly with percutaneous reduction forceps or indirectly using manual traction, a femoral distractor, or a spanning external fixator.

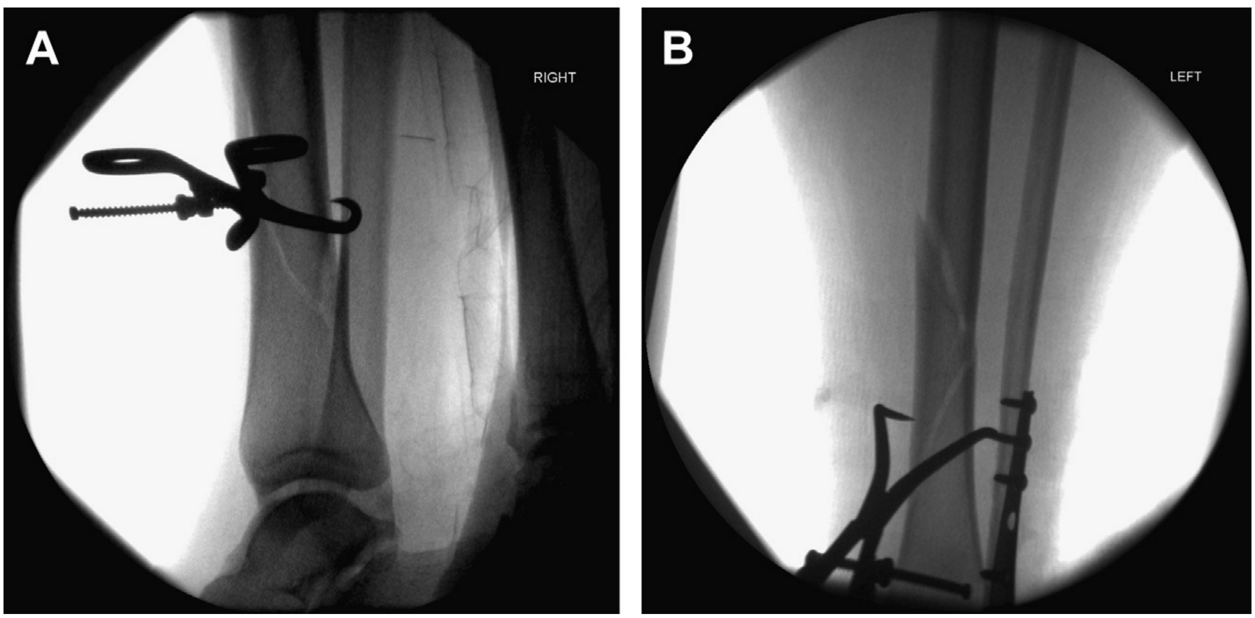


Figure 21: Percutaneous insertion of pointed reduction clamps.

as shown in AP (A) and lateral (B) fluoroscopic pictures. Due to the close anatomical alignment, ball-tipped wire transit and initial reaming are made easier.[7]

Fibular fixation at the same time, as was previously mentioned, may also be useful in the first stages of reduction. Due to the risk of sagittal plane malreduction, reduction should be undertaken gently. [96] It is common practice to create a subcutaneous plane by making a 3 cm curved incision above the medial malleolus, taking care to avoid the great saphenous vein and saphenous nerve. Intra-articular extension should be addressed with lag screws before permanent fixation. Plates may be adjusted anatomically to rectify varus/valgus or rotational deformities and eliminate supramalleolar prominence. [37] After that, it is placed distally to proximally via the subcutaneous tube along the tibia's medial edge. This retrograde insertion may be facilitated by using a suture that is threaded through a proximal hole in the plate. While the plate location is validated on orthogonal views, K wires are employed to provide temporary stabilisation of the construct using fluoroscopy. Afterwards, the construct may be secured with screws via the stab wounds, taking care that the distal screws that are inserted do not damage the" inferior tibiofibular joint." Care must be given to prevent the fixation of plate with distraction of fracture fragments, and it is widely accepted that fixation with at least 3 screws at the proximal and distal fragments with the engagement of the screw thread in 4 to 6 cortices of fixation on both side of the fracture fragments is acceptable. [97] Normal closure techniques are used, and patients are instructed to avoid putting too much weight on the operated foot until the formation of a callus has been confirmed. Open plating is required when alignment or congruency with MIPO cannot be achieved, and overlocked structures with an incomplete reduction are likely to result in nonunion and ultimately plate fracture, as was previously mentioned.

Postoperative care

Postoperative edema is almost an inevitable part of the surgery. Patients are managed with limb elevation, ice packs, and anti-edematic medications. A below-knee slab is applied for immobilization of the leg. Patients are mobilized with walker assistance. Sutures are removed on postoperative day 14, following which ankle ROM exercises are started. Weight-bearing is started as tolerated when there is radiological signs of callus formation in the Xray. Patients are reviewed in the OPD once every month [95]

Complications

Infection, non-union, or damaged hardware, with loss of alignment, are all possible risks, in addition to compartment syndrome and under or over sedation. Patients with an open tibia fracture, which may or may not include soft tissue damage, should be monitored for infective changes [98] Pin loosening and pin tract infections are the most common complications of using an external fixator.[99] The surgeon has to check for nonunion, malalignment, or damaged hardware at follow-up sessions. Tibial fracture patients are candidates for readmission and eventual surgical repair. When an infection spreads to the bone, treatment often entails long-term intravenous antibiotics, irrigation, and debridement for the patient (osteomyelitis). Healing might be affected by the patient's willingness to follow recommendations about weight-bearing status and smoking cessation. For optimal wound and bone healing, patients should be asked whether they smoke or chew tobacco and actively urged to quit. [100] The diagnosis and prevention of “deep venous thrombosis” (DVT) and “pulmonary embolism” (PE) are crucial consequences. [101]

Medial ankle wound problems, uncomfortable conspicuous hardware, and iatrogenic injury to the larger saphenous vein and saphenous nerve are all potential consequences of the MIPO procedure for distal tibia fracture. The risk of damage to the saphenous nerve and the larger saphenous vein while using the MIPO approach for distal tibia fractures was evaluated in cadaver research published by Ozsoy and coworkers. The authors noted a significant risk of harm to the saphenous nerve and the larger saphenous vein after percutaneous screw implantation with distal tibia locking compression plates. They advise taking great care to carve out the area and shield any delicate soft tissue prior to inserting the screws percutaneously. [102]

Another often mentioned issue is that the hardware is too noticeable, causing skin discomfort or impingement. Fifty two percent of MIPO patients had skin impingement, according to research by Lau and colleagues. The implants in question were taken out of those individuals at some point. Improvements in fracture fixation have led to the development of flatter plates. The risk of skin impingement and hardware protrusion may be reduced if this is done. [22]

Contraindications

Soft tissue defects or compromise of the medial ankle or distal leg, fractures with extensive comminution of the distal tibia and plafond, and vascular compromise or damage to the surrounding region are all circumstances in which MIPO would not be appropriate. [86]

MIPO is not indicated when there is persistence of cutaneous lesions like in all internal osteosynthesis; and substantial central subsidence for which a conventional approach is necessary.[103]

Outcome

Different clinical, radiological, and patient-reported criteria have been used to analyse recovery and functionality after tibial fracture. Among the functional outcome scores, we used Iowa ankle score and for radiological assessment, Teeny and Wiss scoring.

Functional outcome in distal end tibia fractures treated by MIPO by Iowa ankle assessment score

"IOWA ANKLE EVALUATION SCORE"[104]

Function: (40)

• "Does housework or job without difficulty" (8)

• "Climbs stairs" (10)

• "Carries heavy objects, such as a suitcase" (4) ___/40

• "Is able to run, or work at heavy labour" (4)

• "Walks enough to be independent" (8)

• "Does yard work, gardening, lawn mowing" (4)

• "Has no difficulty getting in or out of an automobile" (6)

Freedom from pain: (40)

• "No pain" (40)

• "Pain only with fatigue or prolonged use" (30) ___/40

• "Pain with weight-bearing" (20)

• "Pain with motion" (10)

• “Pain with rest or continuous pain” (0)

Gait:(10)

• “No limp” (10)

• “Antalgic limp” (8) ___/10

• “Uses cane or one crutch” (2)

• “Uses wheelchair or can’t walk” (0)

Range of motion (10)

• “Dorsiflexion and plantar flexion” ___/10

• “(2 Points for every 20 degrees)”

TOTAL SCORE: ___/100

Excellent: 100 - 90

• Good :89 - 80

• Fair :79 - 70

In research on distal tibial metaphyseal fractures treated with the MIPO approach, 37.7% of patients had outstanding outcomes, 54.1% had good outcomes, and 8.2% had fair outcomes, overall, 91.8% achieving excellent/good outcome according to the IOWA-ankle grading scale. [105] In the research by Ganesan et al., the average functional ankle score was 89.84, with a range of 76 to 96. [3] According to the research conducted by Dhanasekaran et al., the average functional ankle score was 80.5, with a range of 74 to 94.[106] Based on the IOWA Ankle Score, prospective research found that among 18 patients treated with MIPO, 15 had great outcomes, 2 had acceptable outcomes, and 1 had a fair outcome. Twelve patients had ORIF, and eight of them had a successful outcome. The research demonstrated no statistically significant correlation between treatment method and Iowa ankle score ($p > 0.05$).[107]

The average AOFAS score for distal tibia fractures treated with LCP plating was 85.6 at a mean follow-up of 16.4 months in a retrospective study. [108] In a cross-sectional research, patients with distal tibia fractures who had surgery with LCP using the MIPO approach had a mean AOFAS score of 88.83 after regular function testing based on the AOFAS scoring system. [109] The functional result of the Mipo Technique was evaluated using the AOFAS score in research by Singh et al. At 6 months, the final average AOFAS score for patients treated with distal tibial locking plates was 85.11. [110] Of the patients with tibial fractures treated with MIPO in Vishnusankar's trial, 64% had outstanding outcomes, 32% had good outcomes, and 4% had fair outcomes, as measured by the IOWA score. [111]

Radiological outcome in distal end tibia fractures treated by MIPO by Teeny-Wiss score

Postoperative roentgenograms were evaluated using criteria provided by Teeny-Wiss based on Ovadia and Beak[54]and others to assess the success of the surgical reduction.[112]

Table 3: "Scoring Criteria for Quality of Reduction Evaluation according to Teeny and Wiss"[113]

Measurement (mm)	Score		
	1	2	3
Lateral malleolus	1	2-5	5
Medial malleolus	1	2-5	5
Posterior malleolus	0.5	0.5-2	2
Mortise widening	0.5	0.5-2	2
Fibular widening	0.5	0.5-2	2
Talar tilt	0.5	0.5-2	2
Talar shift	0.5	0.5-2	2
Articular gap	2	2-4	4

Using the Teeny and Wiss Criteria, Kumar et al. identified a statistically significant difference in the functional outcomes of the IMIL (84.84 ± 9.66) and MIPO (84.26 ± 11.79) groups; nevertheless, the difference between the two groups was not statistically significant (p = 0.75656). Although the differences in functional outcomes are not statistically significant, they are clinically meaningful. [114] Radiological examination by Ganesan et al.

found that 84% of patients had excellent anatomic reduction, 12% had a good rating, and 4% exhibited fair rating. [3] Dhanasekaran et al. found that after MIPO therapy, 72% of patients had an excellent anatomic rating, 18% had a good rating, 8% had a fair rating, and 2% had a bad rating using the Teeny Wiss Score. [106]

Five patients were categorized as healed at 3 months, eleven at 4 months, twenty-four at 5 months, twenty-nine at 6 months, and thirty by 7 months postoperatively in a retrospective examination of distal tibia fractures handled with LCP plating based on the radiological definition of fracture healing. Absolutely no one was missing after being followed up on. Neither group saw a longer or shorter period of recovery. By the end of the 9-month follow-up period, all patients had regained their full range of motion. [108] Patients with distal tibia fractures treated by LCP using the MIPO approach had a favorable radiological result, with a mean RUST score of 11.58 ± 0.72 at the end of one year of follow-up, according to cross-sectional research. [109] Vishnusankar revealed that according to IOWA score 64 percent showed outstanding outcomes, 32 percent exhibiting good results, 4 percent exhibited fair results from his research of patients with tibial fractures treated with MIPO. [111]

MOST RELEVANT STUDIES:

Kumar et al. (2022)[114] reported that When compared to patients who underwent plating, patients who underwent nailing experienced considerably shorter surgical time and reduced fracture union times. Upon comparison of functional and radiological outcomes between the two surgical modalities, MIPO vs. Intra medullary Interlocking nail (IMIL)). Significantly less time was needed in the nailing group to achieve complete weight bearing and mobilisation compared to the plating group. **Madhukar et al. (2022)**[107] contrasted the outcomes of reduction and internal fixation using the open and MIPO approach for distal tibia fractures with those using the “Medial distal tibial locking compression plate.” In the MIPO group of 18 patients, 15 had outstanding results, 2 had acceptable results, and 1 had a fair outcome on the IOWA Ankle score. Twelve patients had ORIF, and eight of them had a successful outcome. The results of this research demonstrate that LCP using the MIPO approach results in faster fracture healing, quicker recovery, and fewer treatment-related problems.

Singh et al. (2021)[110] results from a prospective study of patients with distal tibia fractures who underwent MIPO with DTLP show that this therapy is very effective. When compared to traditional osteosynthesis, the advantages include a shorter recovery period, less risk of infection, and shorter operating time and smaller incisions.

H. P. Shobha et al. (2020)[115] research showed that the MIPO approach improved bone healing, reduced the risk of non-union, and eliminated the requirement for bone grafting. This method is recommended for distal tibia fractures that cannot be fixed by locked nailing, such as those with tiny distal metaphyseal fragments, vertical splits, or fractures that are highly comminuted.

Shah et al. (2019)[116] resulted in the conclusion that CRIF by MIPO with medial LCP is an effective treatment for distal tibia fractures. Using the IOWA knee and ankle grading system, all patients had a positive functional and radiological result.

Daragad et al. (2020)[117] MIPO with LCP gives biological benefit by protecting periosteal blood flow, which is especially crucial with distal tibia or pilon damage, according to a cross-sectional study of patients with distal tibia fractures performed by LCP.

Ganesan et al. (2018)[3] The majority of patients in a prospective trial who had MIPO for tibia fractures either with or without fibula fixation reported excellent or good functional outcomes, demonstrating the procedure's efficacy. Anatomical decrease was seen on radiographs if MIPO was performed in conjunction with fibula plating. Therefore, considered the management of choice, particularly for fractures that have intraarticular extension and displacement of fragments

Sreejith Thampy et al. (2018)[108] MIPO is a reliable technique preserving most of the osseous vascularity and fracture haematoma, thus providing for a more biological repair, as determined by a retrospective analysis of the outcome of distal tibia fractures managed with LCP plating, including the effect on ankle joint function, fracture union, operative difficulties encountered, and the incidence of complications. Consolidation of fractures occurs rapidly, and union time is improved.

Dhanasekharan et al. (2018)[106] According to the results of their research, medial Tibial locking compression plating is an effective method of treating distal tibial fractures, but only if performed within the first 24 hours of the injury, before the soft tissue swelling starts, or after a gap of about 8 to 12 days following which, the oedema has subsided and the wrinkle sign has appeared. They advised against operating on delicate tissues too soon or through damaged skin, but rather waiting until they were ready for operation.

Shukla et al. (2018)[118] Based on the results of their research, plating with MIPO is a viable option for treating closed distal one-third tibia fractures in terms of both union time and the incidence of comorbidities. When people are younger, they are more likely to heal quickly and return to normal function after surgery.

Vishnusankar (2017)[111] Research results demonstrating MIPO's efficacy as a functional enhancement were rated as Excellent or Good. Between 76 to 96, the functional ankle scores averaged 89.84. When MIPO was combined with fibula plating, the radiological score decreased, indicating anatomical improvement.

Kim et al. (2016)[105] found that the MIPO approach was an excellent surgical alternative for distal tibial metaphyseal fractures with good clinical and radiological findings, after analysing results and postoperative complications in patients with such fractures. Although the MIPO procedure has several benefits, it is important to avoid any difficulties after surgery.

Dhakar et al. (2016)[117] The functional and radiological outcomes of distal tibia fracture fixation with locking plates and MIPO were assessed, and it was shown that 96% of patients had union, with 4% of cases exhibiting delayed union that required 30 weeks to resolve. They found that MIPO with locking plates is a successful therapy for distal tibia fractures, and that it is linked with satisfactory functional results.

Bhat et al. (2016)[117] looked at the results of employing a locking plate for MIPO on closed distal tibia fractures and came to the conclusion that it is safe and effective for treating distal tibia fractures in carefully chosen patients.

Kundu et al. (2015)[25] discovered that the Minimally Invasive Post-Operative Management (MIPO) strategy, which involves the use of a pre-contoured metaphyseal LCP (locking compression plate), was an effective and safe method for treating distal tibial fractures with little soft-tissue injury. Through a delicate balancing act, bone biology is protected while devascularization and mechanical perfection are both achieved. More research is needed with longer follow-up periods and larger sample sizes.

Paluvadi et al. (2014)[119] patients who had MIPO surgery for closed distal tibial fractures with an anatomical locking plate. Researchers found that the MIPO approach resulted in satisfactory bone healing, although with a little prolonged recovery time, and reduced both the frequency of nonunion and the necessity for bone grafting. They suggested this method for distal tibia fractures that are difficult to fix with locked nailing, such as those with intra-articular extension, vertical splits, or tiny distal metaphyseal pieces.

Kiriwichian (2013)[120] operative time, bone union time, functional outcome, and incidence of superficial infection were not substantially different across groups for distal tibia fractures treated by ORIF and MIPO. No cases of malunion or delayed union were found in either cohort. Researchers found no statistically significant differences between ORIF and MIPO for distal tibia fractures.

LACUNAE IN LITERATURE:

Multiple external fixators, intramedullary nailing, and internal plate fixation are all viable options for treating distal tibia fractures. Numerous studies have been conducted on distal tibia fractures, and none have been able to conclusively prove one course of treatment to be better to any other. Therefore, it is challenging for a surgeon to choose the best course of action for a patient when considering the potential for further difficulties due to other presenting issues. In recent years, minimally invasive procedures have gained favour due to the expectation that they would provide superior results. The purpose of this research is to evaluate the functional and radiological result of MIPO treatment for distal tibial fractures in patients who sustain these injuries at or near our hospital.

AIMS AND OBJECTIVE

OBJECTIVES OF STUDY

1. “To assess the functional outcome in distal end tibia fractures treated by minimally invasive percutaneous osteosynthesis by Iowa ankle assessment score”
2. “To assess the radiological outcome in distal end tibia fractures treated by minimally invasive percutaneous osteosynthesis by Teeny-Weiss score”

MATERIALS AND METHODS

- **STUDY DESIGN:** Prospective study
- **STUDY PERIOD:** December 2020 to July 2022
- **SOURCE OF DATA:** Patients admitted in orthopedics ward from Casualty and OPD at R. L. Jalappa Hospital and Research center, attached to Sri Devaraj Urs Medical college, affiliated to SDUAHER meeting the inclusion criteria.
- **INCLUSION CRITERIA:** Patients above 18 years diagnosed with closed fractures of distal third tibia.
- **EXCLUSION CRITERIA:** Patients with pathological fracture, Compartment syndrome, Poor local skin conditions and associated neurovascular injury
- **METHOD OF COLLECTION OF DATA**
- **SAMPLE SIZE**:Siddhartha Venkata Paluvadi et al.[119] had reported that the 88% of the subjects who underwent "Minimally Invasive Plate Osteosynthesis "for fracture of distal third of tibia did not have post-operative infectionAssuming alpha error of 5% (95% confidence limit) and an absolute precision (d) of 13%. The required sample size was estimated to be 25.
- The sample size was derived from the following formula:
- Sample size (n) = (Z^2 (P*Q))/d^2

Z is the critical value for 95% Confidence Interval

D is the absolute precision

P is the expected proportion and q=1-p

The sample size was calculated using Open Epi software version 3.01 (Open-Source Epidemiologic Statistics for Public Health).

Methodology

All patients were evaluated by detailed history, clinical examination & radiographic findings. A sample size of 25 were selected meeting the inclusion and exclusion criteria. Patients underwent surgical fixation of distal third tibia by minimally invasive plate osteosynthesis under suitable anesthesia. Following surgery, patients were followed up at 3rd and 6th month. At the time of follow up patient were assessed with Teeny-Wiss radiological scoring system & iowa ankle evaluation score

Statistical Methods

Age, gender, etc. were considered as study relevant variables. Diabetes mellitus, mode of injury, etc. were considered as Primary outcome variables.

Descriptive analysis was carried out by mean and standard deviation for quantitative variables, frequency and proportion for categorical variables.

Data was also represented using appropriate diagrams like bar diagram, pie diagram etc.

The association between paired categorical variables was assessed by cross tabulation. Mcnemar test was used to test statistical significance.

The mean differences along with their 95% CI were presented. Paired t- test was used to assess statistical significance.P value < 0.05 was considered statistically significant.[121]

RESULTS

A total of 32 subjects were included in the final analysis.

Table 4: Descriptive analysis of Age in the study population (N=32)

Name	Mean ± S. D	Median	Minimum	Maximum	95% CI	
					Lower CI	Upper CI
Age	47.81±9.72	49.50	20.00	62.00	44.44	51.18

The mean age was 47.81±9.72 in the study population, minimum level was 20 and maximum level was 62 in the study population (95% CI 44.44 to 51.18). (Table 4)

Table 5: Descriptive analysis of Gender in the study population (N=32)

Gender	Frequency	Percentage
Male	28	87.50%
Female	4	12.50%

Among the study population, 28 (87.50%) participants were male and remaining 4 (12.50%) participants were female. (Table 5 & Figure 22)

Figure 22: Pie chart of Gender in the study population (N=32)

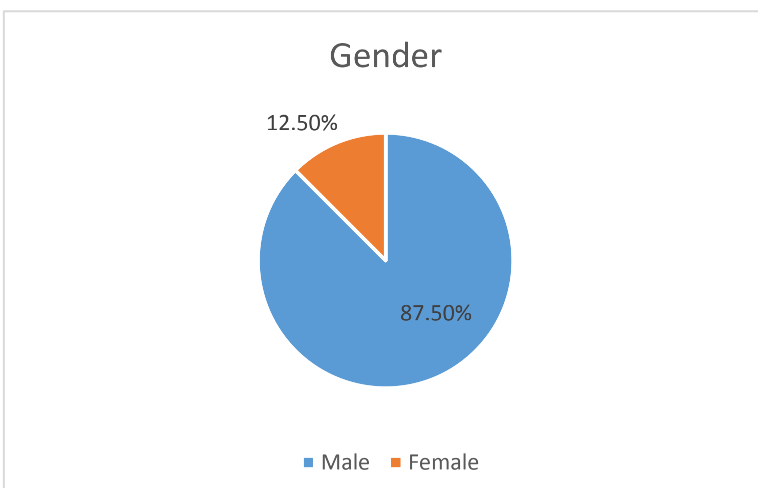


Table 6: Descriptive analysis of Diabetes Mellitus in the study population (N=32)

Comorbidities	Frequency	Percentage
Diabetes Mellitus		
Yes	11	34.38%
No	21	65.63%
Hypertension		
Yes	8	25.00%
No	24	75.00%

Among the study population, 11 (34.38%) people had diabetes mellitus and 8 (25.00%) people had hypertension. (Table 6)

Table 7: Descriptive analysis of Side in the study population (N=32)

Side	Frequency	Percentage
Right	19	59.38%
Left	13	40.63%

Among the study population, 19 (59.38%) participants were right side, and 13 (40.63%) were left side. (Table 7 & Figure 23)

Figure 23: Bar graph of Side in the study population (N=32)

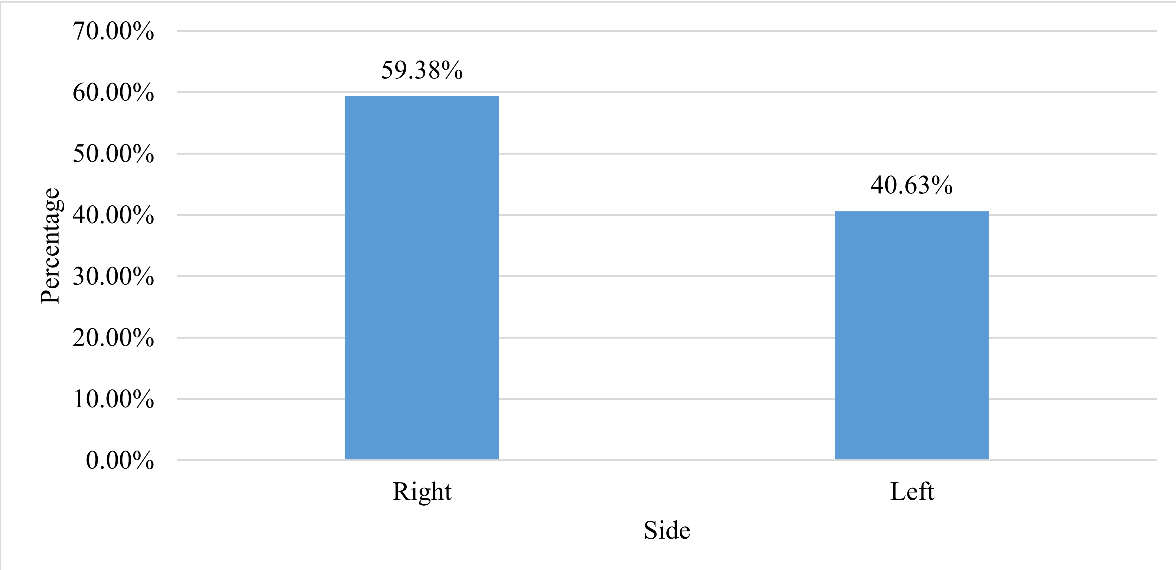


Table 8: Descriptive analysis of Diagnosis in the study population (N=32)

Diagnosis	Frequency	Percentage
"Closed displaced distal tibia fracture with ipsilateral fibula fracture."	21	65.63%
"Closed displaced distal tibia fracture with intraarticular extension and ipsilateral fibula fracture."	7	21.88%
"Closed, isolated distal tibia fracture"	1	3.13%
"Open displaced distal tibia fracture with intraarticular extension and ipsilateral fibula fracture."	1	3.13%
"Open displaced distal tibia fracture with ipsilateral fibula fracture."	2	6.25%

Figure 24: Bar graph of Diagnosis in the study population (N=32)

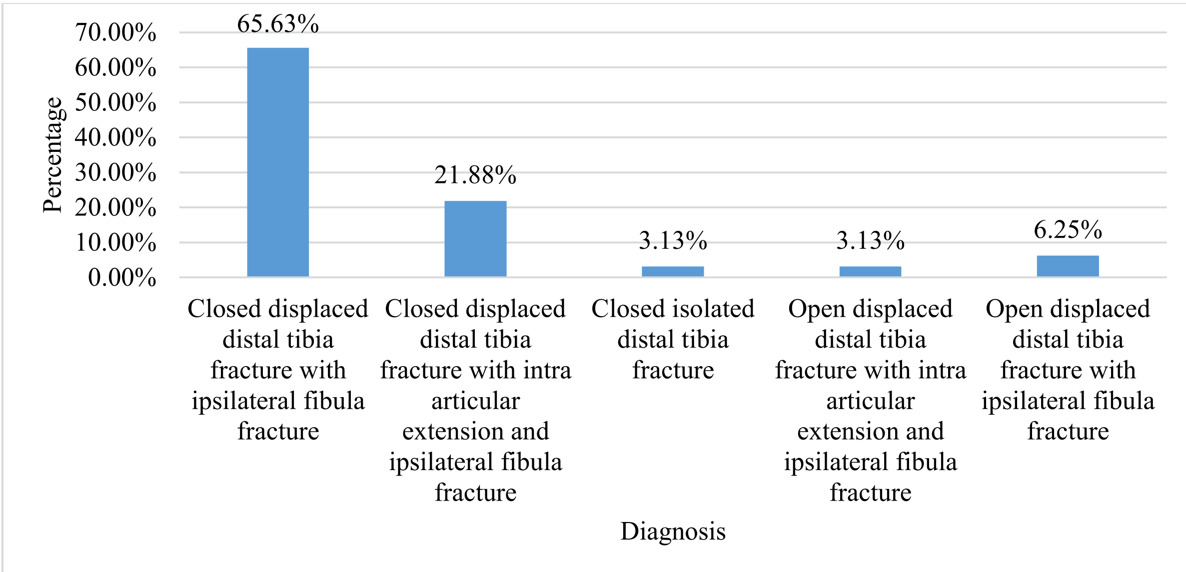


Table 9: Descriptive analysis of Mode of injury in the study population (N=32)

Mode of injury	Frequency	Percentage
RTA	27	84.38%
Fall from height	5	15.63%

Among the study population, 27 (84.38%) participants had RTA mode of injury and 5 (15.63%) had fall from height mode of injury. (Table 9)

Table 10: Descriptive analysis of External Fixator Application/ Duration in the study population (N=32)

External Fixator Application/ Duration	Frequency	Percentage
Yes	4	12.50%
No	28	87.50%

Among the study population, 4 (12.5%) participants were reported external fixator application. (Table 10)

Table 11: Descriptive analysis of External Fixator Application Duration (in days) in the study population (N=4)

Name	Mean ± SD	Median	Minimum	Maximum	95% CI	
					Lower CI	Upper CI
External Fixator Application Duration (in days)	8.25±1.50	8.00	7.00	10.00	6.78	9.72

The mean external fixator application duration (in days) was 8.25±1.50 in the study population, the minimum level was 7 and the maximum level was 10 in the study population (95% CI 6.78 to 9.72). (Table 11)

Table 12: Descriptive analysis of Fibula fixation in the study population (N=32)

Fibula fixation	Frequency	Percentage
CC screw fixation for fibula	1	3.13%
K wire fixation for fibula	12	37.50%
Rush pin fixation for fibula	3	9.38%
Semi tubular plate fixation for fibula	8	25.00%
Fibula not surgically fixed	8	25.00%

In the study population, 1 (3.13%) participant underwent CCscrew fixation for fibula fracture (37.5%) participants underwent K wire fixation for fibula procedure, 3 (9.38%) participants underwent Rush pin fixation for fibula procedure, 8 (25.00%) participants underwent Semi tubular plate fixation for fibula procedure and in 8 (25.00%) participants were Fibula not surgically fixed (Table 12 & Figure 25)

Figure 25: Bar graph of Fibula fixation in the study population (N=32)

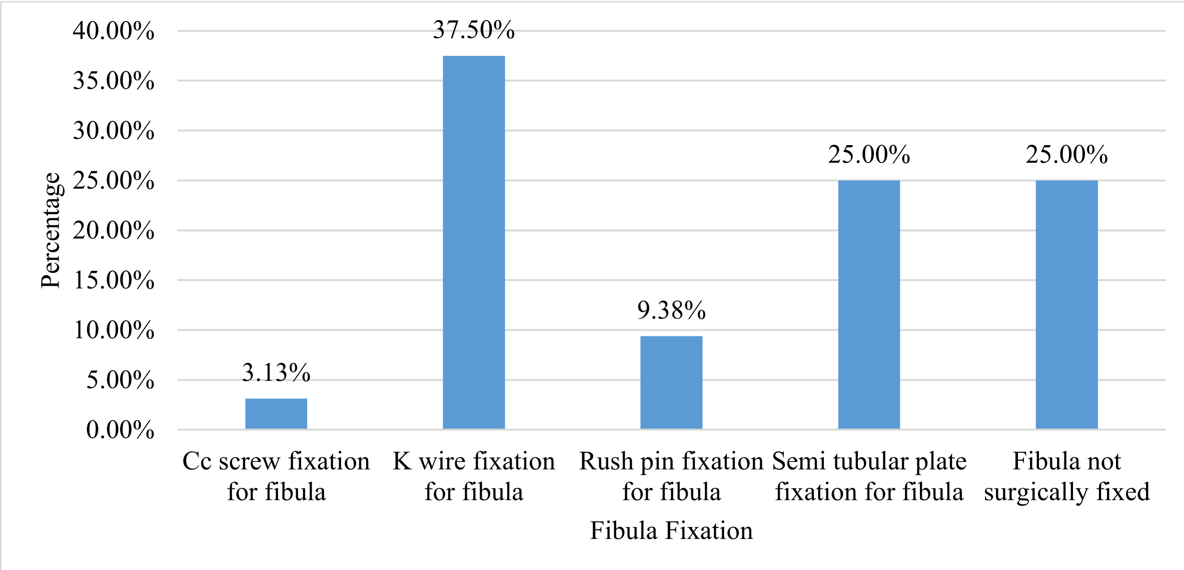


Table 13: Descriptive analysis of Complications in the study population (N=32)

Complications	Frequency	Percentage
Prominent hardware	4	12.50%
Wound gaping	2	6.25%
Superficial surgical site infection	2	6.25%
Deep surgical site infection	1	3.13%
Hypertrophic scar	1	3.13%
Delayed union	1	3.13%
Nil	21	65.63%

Among the study population, 4 (12.50%) participants had prominent hardware complications followed by wound gaping, and superficial surgical site infection b oth had 2 (6.25%). (Table 13)

Table 14: Descriptive analysis of Additional procedures in the study population (N=32)

Additional procedures	Frequency	Percentage
Bone marrow injection	1	3.13%
Wound debridement + Split skin grafting	1	3.13%
Nil	30	93.75%

Among the study population, 1 (3.13%) participant reported bone marrow injection and 1 (3.13%) was reported both wound debridement and split skin grafting. (Table 14)

Table 15: Descriptive analysis of IOWA score in the study population (N=32)

IOWA	Mean ± S. D	Median	Minimum	Maximum	95% CI	
					Lower CI	Upper CI
at 3rd month	80.47±4.73	79.00	70.00	90.00	78.83	82.11
at 6th month	90.47±5.25	92.00	70.00	96.00	88.65	92.29

The mean IOWA at 3^{rd} month was 80.47±4.73 in the study population, minimum level was 70 and maximum level was 90 in the study population (95% CI 78.83 to 82.11) and the mean IOWA at 6^{th} month was 90.47±5.25 in the study population, minimum level was 70 and maximum level was 96 in the study population (95% CI 88.65 to 92.29). (Table 15)

Table 16: Descriptive analysis of IOWA score in the study population (N=32)

IOWA	Frequency	Percentage
at 3rd month		
Fair	17	53.13%
Good	13	40.63%
Excellent	2	6.25%
at 6th month		
Fair	1	3.13%
Good	7	21.88%
Excellent	24	75.00%

In IOWA score at 3rd month, 17 (53.13%) participants were fair, 13 (40.63%) were good, 2 (6.25%) were excellent and in IOWA score at 6th month, 1 (3.13%) participant w fair, 7 (21.88%) were good and 24 (75.00%) were excellent. (Table 16)

Table 17: Descriptive analysis of TW score in the study population (N=32)

TW	Mean ± S. D	Median	Minimum	Maximum	95% CI	
					Lower CI	Upper CI
at 3rd month	10.16±1.25	10.00	9.00	15.00	9.72	10.59
at 6th month	9.28±1.22	9.00	8.00	14.00	8.86	9.71

The mean TW at 3rd month was 10.16±1.25 in the study population. Ranged between was 9.00 to 15.00 cm (95% CI 9.72 to 10.59) and the mean TW at 6th month was 9.28±1.22 in the study population. Ranged between was 8.00 to 14.00 cm (95% CI 8.86 to 9.71). (Table 17)

Table 18: Descriptive analysis of TW in the study population (N=32)

TW	Frequency	Percentage
at 3rd month		
Good	29	90.63%
Fair	3	9.38%
at 6th month		
Good	24	75.00%
Fair	2	6.25%
Anatomic	6	18.75%

In TW score at 3rd month, 29 (90.63%) participants were good, 3 (9.38%) were fair and in TW score at 6th month, 24 (75.00%) participants were good, 2 (6.25%) were fair and 6 (18.75%) were anatomic. (Table 18)

Table 19: Descriptive analysis of AO type in the study population (N=32)

AO type	Frequency	Percentage
43A1	11	34.38%
43A2	6	18.75%
43A3	7	21.88%
43B1	1	3.13%
43C1	2	6.25%
43C2	3	9.38%
43C3	2	6.25%

The majority of AO type, 11 (34.38%) people had 43A1 type, 6 (18.75%) had 43A2, 7 (21.88%) had 43A3, 1 (3.13%) had 43B1, 2 (6.25%) had 43C1, 3 (9.385) had 43C2 and 2 (6.25%) had 43C3 AO type. (Table 19)

Table 20: Descriptive analysis of Radiological Union (in weeks) in the study population (N=32)

Name	Mean ± S.D	Median	Minimum	Maximum	95% CI	
					Lower CI	Upper CI
Radiological Union (in weeks)	23.13±4.28	22.00	18.00	38.00	21.64	24.61

The mean radiological union was 23.13±4.28 in the study population. Ranged between was 18.00 to 38.00 cm (95% CI 21.64 to 24.61). (Table 20)

Table 21: Descriptive analysis of Duration of Surgery (in minutes) in the study population (N=32)

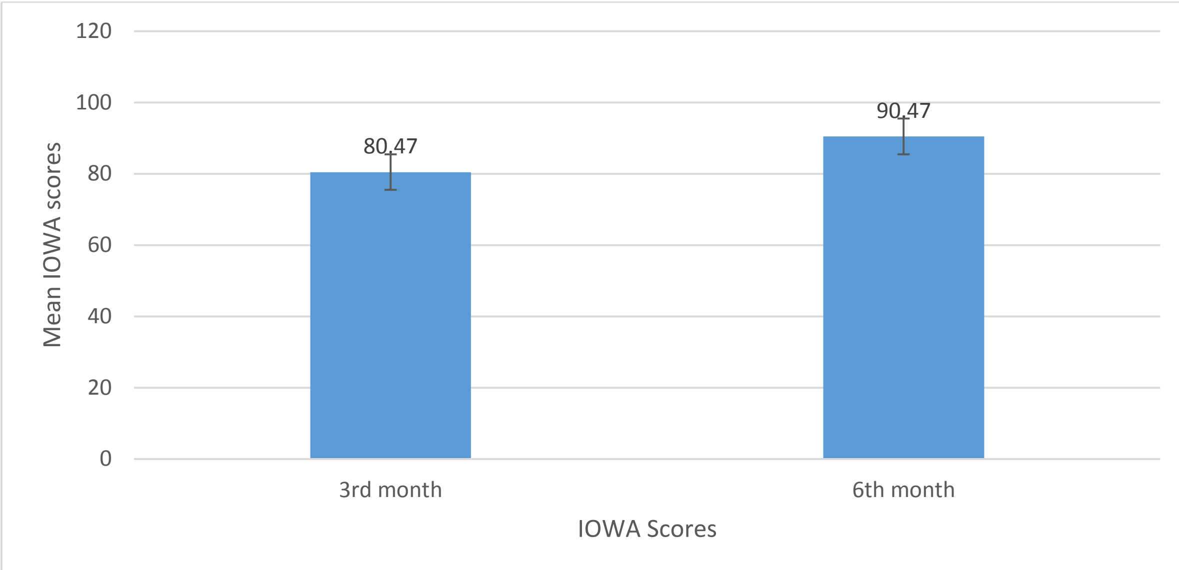
Name	Mean ± S.D	Median	Minimum	Maximum	95% CI	
					Lower CI	Upper CI
Duration of Surgery (in minutes)	92.41±11.34	92.00	75.00	120.00	88.48	96.33

The mean duration of surgery was 92.41±11.34 in the study population. Ranged between was 75.00 to 120.00 cm (95% CI 88.48 to 96.33). (Table 21)

Table 22: Comparison of IOWA mean in different follow-up periods (N= 32)

Follow-up periods	(Mean± STD)	Mean Difference	95% CI of mean difference		P-value
			Lower	Upper	
IOWA at 3rd month	80.47± 4.731	10.000	8.073	11.927	<0.001
IOWA at 6th month	90.47± 5.249				

Figure 26: Bar graph of Comparison of IOWA scores



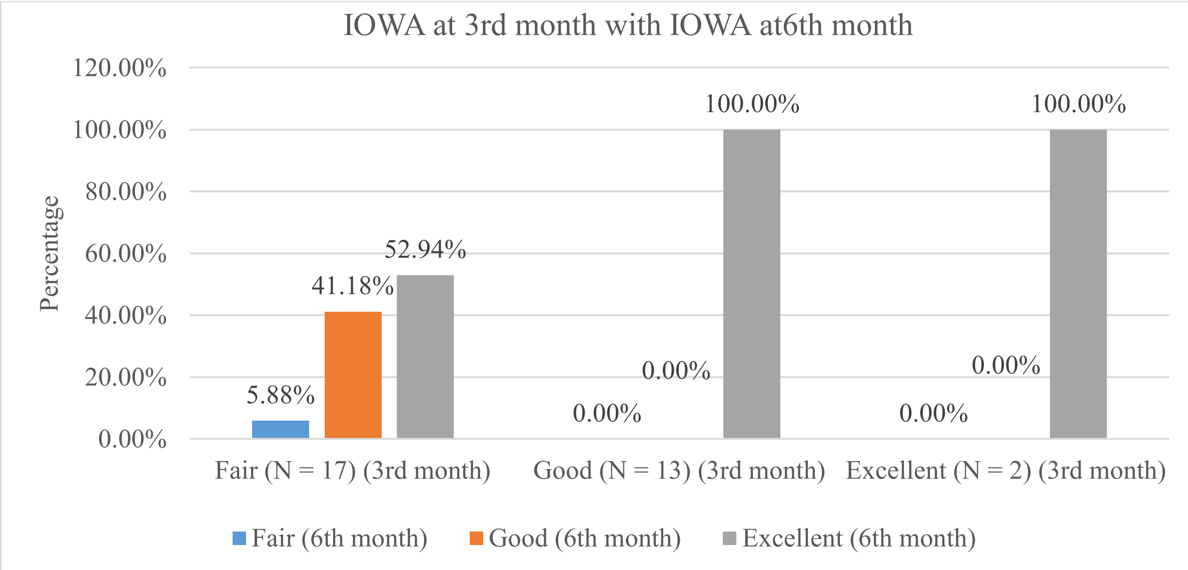
The mean IOWA score was 80.47± 4.731 at 3rd month follow up, 90.47± 5.249 at 6th month follow up. The differences in the IOWA score at 3rd month follow up period with 6th month were statistically significant (P value <0.001). (Table 22)

Table 23: Comparison of IOWA at 6th month with IOWA at 3rd month (N=32)

IOWA at 3rd month	IOWA at 6th month			P value
	Fair	Good	Excellent	
Fair (N = 17)	1 (5.88%)	7 (41.18%)	9 (52.94%)	*
Good (N = 13)	0 (0.00%)	0 (0.00%)	13 (100.00%)	
Excellent (N = 2)	0 (0.00%)	0 (0.00%)	2 (100.00%)	

Note: **No statistical test was applied- due to 0 subjects in the cells.*

Figure 27: Bar graph of Comparison of IOWA scores



In IOWA score at 3rd month whoever reported fair, 1 (5.88%) participant was reported fair, 7 (41.18%) were reported good and 9 (52.94%) were reported excellent at 6th month. In IOWA score at 3rd month whoever reported good, 13 (100.00%) were reported excellent at 6th month. In IOWA at 3rd month whoever reported excellent, 2 (100.00%) participants were reported excellent at 6th month. (Table 23)

Table 24: Comparison of TW mean in different follow-up periods (N= 32)

Follow-up periods	(Mean± STD)	Mean Difference	95% CI of mean difference		P-value
			Lower	Upper	
TW at 3rd month	10.16± 1.247	0.875	0.561	1.189	<0.001
TW at 6th month	9.28± 1.224				

The mean TW score was 10.16± 1.247 at 3rd month follow up and 9.28 ± 1.224 at 6th month follow up. The differences in the TW score at 6th month follow up period with 3rd month were statistically significant (P value <0.001). (Table 24 & Figure 28)

Figure 28: Bar graph of Comparison of TW mean in different follow-up periods

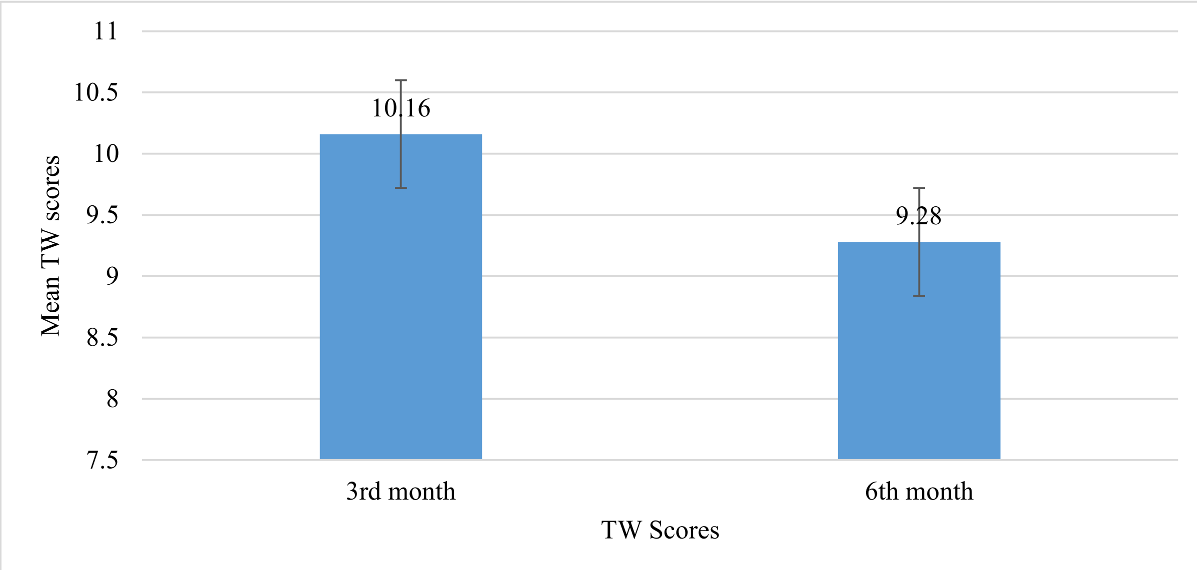


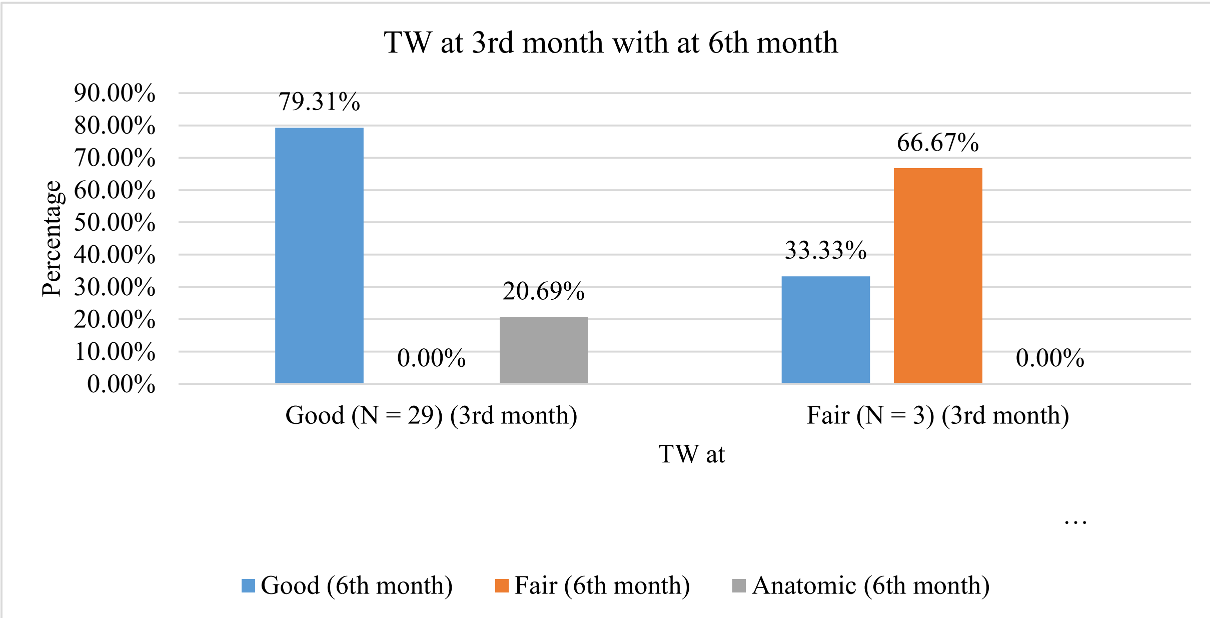
Table 25: Comparison of TW at 6th month with TW at 3rd month (N=32)

TW at 3rd month	TW at 6th month			P value
	Good	Fair	Anatomic	
Good (N = 29)	23 (79.31%)	0 (0.00%)	6 (20.69%)	*
Fair (N = 3)	1 (33.33%)	2 (66.67%)	0 (0.00%)	

Note: **No statistical test was applied- due to 0 subjects in the cells.*

In TW score at 3rd month whoever reported Good, 23 (79.31%) participants were reported good, 6 (20.69%) were reported anatomic at 6th month and in TW at 3rd month whoever reported Fair, 1 (33.33%) were reported good, 2 (66.67%) were reported fair at 6th month TW score. (Table 25 & Figure 29)

Figure 29: Bar graph of Comparison of TW mean in different follow-up periods



DISCUSSION

Because of their proximity to the ankle joint, fractures of the distal tibial metaphysis often include severe pain and significant soft tissue damage. Even a slight misalignment in this area will result in a gross mechanical alteration of the ankle, increasing pain and functional impairment. Distal tibial fracture surgical fixation can be challenging and requires meticulous preoperative planning. Numerous MIPO methods have been developed, and their union rates are rather high. The goal of this research was to evaluate the functional and radiological results of surgical treatment for distal tibia fractures using the Locking compression plate by MIPO technique. A total of 32 subjects were included in the final analysis with a mean age of 47.81±9.72 years. Ours is a predominantly male population with 87.50% males and 12.50% females. The high prevalence of distal tibial fracture in men in our Indian society can be attributed to the fact that women typically work indoors and do not travel much.

Shobha et al. had a relatively younger age group with mean age of 35 years in their study with 65% males. [115] The mean age was 41.92 years in Ganesan et al.'s study with 68% males,[3] and 32.8 years in Dhanasekaran et al.'s study with 60% females.[106] Comparable with our study, Kim et al.' study had a mean age of 53.1 years but with more of female population at 55.73%.[105] Kundu et al. had a predominantly male population at 75% in their study comparable to our study, with a mean age of 38.95 years.[25] In their study comparing IMILN and MIPO, Kumar et al. had mean age 41.42 ± 12.87 years in nailing group with 45.34 ± 16.34 years in MIPO group. In addition, 73.07 percent of the participants were male since men in the research region tended to engage in greater physical labour and outdoor pursuits. [114] Mean age was 36 years with majority belonging to 20-40 year age group with 70% male population in Paluvadi et al.'s study.[119]

In our study, 59.38% participants had right side fracture and 40.63% had left side. Shobha et al. had 68% with right side fracture and 32% left side fracture.[115] Ganesan et al.'s study had more left sided fractures (60%) and 40% left sided.[3]

Fracture type based on AO classification, 34.38% had 43A1 type, 18.75% had 43A2, 21.88% had 43A3, 3.13% had 43B1, 6.25% had 43C1, 9.385 had 43C2 and 6.25% had 43C3 AO type. The majority of participants in the research by Ganesan et al. had “A3 type fracture (48%), followed by A1 type (12%), A2 type (12%), followed by C1, C2, C3 and B1. [3] In Kim et al.’s study, per “AO/OTA” classification system; 18% cases were A1, 26.3% cases were A2, 29.5% cases were A3, 16.4% cases were B1, and 9.8% cases were B2.[105] As per AO classification in Kundu et al.’s study, 85% patients sustained type A fracture and 15% had type B-02 and type C-01.[25] Based on “Ruedi Allgower” types 26.67% belonged to Type A while 33.33%, 23.33%, 16.67% belonged to Types C1, C2, C3 respectively in Dhanasekharan et al.’s study.[106] The bulk of the fractures in the research by Paluvadi et al. were extra-articular (AO/OTA 43-A), accounting for 90%, while 6% were partly articular (AO/OTA 43-B), and 4% were intra-articular (AO/OTA 43-C)”.[119]

The mechanism of injury was RTA in majority of the cases (84.38%) with 15.63% having fall from height. This was comparable with that of Shobha et al.’s study, who had 80% of the patients sustaining injury due to RTA. Ganesan et al. reported 68% had RTA as mode of injury in their study.[3] Contrary to the above studies, Kundu et al. had 65% of the fractures precipitated by high energy trauma.[25] According to the research conducted by Kumar et al., motor vehicle accidents were the leading cause of fractures, followed by falls and football-related sports injuries. [114] The majority of patients in the research by Paluvadi et al. also sustained their injuries as a result of vehicular collisions.[119]

Majority of them had closed displaced distal tibia fracture with ipsilateral fibula fracture in our study at 65.63%, followed by 21.88% with closed displaced distal tibia fracture with intra articular extension and ipsilateral fibula fracture. In the research by Ganesan et al., 80% of the participants had fibula fractures higher than the syndesmosis, 8% had fractures at the syndesmosis, and 12% had intact fibulas.[3] Fibular fractures at the same level are seen in 53.33%, 26.67% had fibular fractures at a different level, and 20.0% had fibulae that were unbroken in Dhanasekharan et al.'s research. [106] In the research by Paluvadi et al., the majority of patients (70%) had a double fracture of the leg, with the fibula breaking at the same level as the tibia. This finding is consistent with a bending mechanism. [119]

According to research by Barei et al. a distal tibia fracture without a broken fibula is often seen as a less serious injury. When compared to C type fractures, a fibula that is still whole is considered to be less serious. Restoring the patient's fibular length was Ruedi and Allgower's initial treatment concept, and it remains critical to excellent outcomes.[1] In order to avoid the varus tilt, the rotational axis deviation and to achieve gross mechanical alignment, limb lengthening surgery with fibula fixation was performed. In our study 75% of the had associated fibula fracture and fibula fixation was done with Cc screw in 3.13%, K wire in 37.5%, Rush pin fixation in 9.38%, Semi tubular plate fixation in 25.00%. In Ganesan et al.'s study, 85% had fibular fracture and 40% had fibular fixation. Among those, 80% had fibular fixed with one-third tubular plate whereas in other 20% cases 3.5 mm recon plate was used.[3] Kundu et al. reported 20% cases were treated with fibular plating along with tibial fixation due to syndesmosis involvement in their study.[25] Even though the fibula was broken in several of these patients, only 22.8% required fibula fixation. Of these, half were fixed with one third tubular plates and the other half with rush nails in Paluvadi et al.'s study.[119]

The mean duration of surgery was 92.41±11.34 minutes in the study population. Kumar et al. found a statistically significant difference between the IMN group's mean operating time of 81.14±6.30 minutes and the locking plate by MIPO group's mean operating time of 87.67±5.55 minutes. [114] In the research by Paluvadi et al., the average operational time was 86.233 minutes, and it took longer for fractures that extended into the joint or required fibula fixation. [119]

Surgical complications included prominent hardware in 12.50%, wound gaping in 6.25%, 6.25% had superficial surgical site infection, 3.13% had deep surgical site infection, 3.13% hypertrophic scar had 3.13% had delayed union. According to data collected by Shobha et al., 12% of patients had superficial skin infection, 8% experienced varus malalignment, 4% experienced ankle stiffness, 4% experienced limb length disparity, and 4% experienced deep skin infection. Their research did not find any cases of nonunion. [115] Ganesan et al. observed

4% cases had superficial infection and 4% deep infection in their study. [3]. Dhanasekaran et al. had 10% cases with superficial infection of the surgical site and 8% of the total cases with deep surgical site infection in their study.[106] In Kim et al.'s study, 40% complained of impingement, particularly over the proximal end of the plate requiring removal of the implant. Overlying skin necrosis was seen in 4.91% cases at exposed plates at distal end of the plate.[105] Complications like superficial wound infection was seen in 10% cases, surgical wound breakdown with implant exposed in 5% and prominent hardware was seen in 5% cases which was asymptomatic in Kundu et al.' study.[25] Deep infections (15.38%) were the most prevalent problem in the MIPO group, followed by implant failure (7.69%) and delayed union (3.84%), while superficial infections (11.53%) were the most common complication in the IMIL group in Kumar et al.'s study. [114] Paluvadi et al. encountered superficial infection in 10% of the patients.[119]

The mean IOWA core at 3rd month was 80.47±4.73 in the study population, and the mean IOWA at 6th month follow up was 90.47±5.25 with significant improvement from 3rd to 6th, p value <0.001. This is comparable with Ganesan et al.'s study, who had a mean functional ankle scores per IOWA scale as 89.84 with a maximum of 96 and minimum of 76 at 9.9 months.[3] Similar readings were reported by Dhanasekaran et al. who had the mean functional ankle score of 80.5 with a maximum of 94 and minimum of 74 at 9.4 months. In 46.67% of the cases (AO types A, C1, and C2), MIPO was employed, and open reduction of the fractured articulating surface followed by fixation with a LCP was used to treat AO type C3 fractures. [106] Kumar et al. compared research comparing IMLN with MIPO, and they discovered that there was no statistically significant difference in result between the two groups (P = 0.75656). The mean functional score in IMIL groups was 84.84 ± 9.66 while it was 84.26 ± 11.79 in MIPO.[114]

Ganesan et al. found that throughout the course with average follow-up of 9.9 months, 64% of study population had excellent functional outcome 32% had good outcomes, and 4% had fair results. [3] Dhanasekaran et al. found a 90% good union and functional result using IOWA ratings, with a 10% fair outcome. [106] In the research by Kim et al., clinical outcomes were rated as exceptional in 37.7 percent, good in 54.1%, and fair in 8.2 percent, with 91.8% experiencing either excellent or good outcomes. [105] In our study, at the 3rd month follow-up, 6.25% had excellent functional outcome per IOWA score, 40.63% had good, and 53.13% had fair outcome. At 6th month follow up, these scores have improved impressively with 75.00% scoring excellent, 21.88% good and 3.13% fair comparable with Ganesan et al.'s[3] results and better outcome than Kim et al.[105] Among those who had fair IOWA score at 3rd month, 52.95% graduated to an excellent score by 6th month with all of the good IOWA score at 3rd month scoring excellent by 6th month.

The mean TW score at 3rd month was 10.16±1.25 and the mean at 6th month follow up was 9.28±1.22 in the study population. The differences in the TW score at 6th month follow up period with 3rd month were statistically significant (P value <0.001). Ganesan et al. found that 84% of patients had excellent anatomic reduction, 16% showed a good rating, and 4% showed a fair rating, as determined by the Teeny Wiss Radiological Scoring system. [3] According to the Teeny Wiss score, about 72% of the cases in the study by Dhanasekaran et al. were rated as having an excellent anatomic rating, 18% as having a decent rating, 8% as having a fair rating, and 2% as having a bad rating. [106] According to the Teeny and Wiss criteria 75% had excellent outcome and 10% had good outcome, and 10% with fair outcome and poor in 5% case in Kundu et al.'s study.[25] Kumar et al. found that 65.38 percent of IMlLN patients and 53.84 percent of MIPO patients had good functional outcomes from their procedures, with 36.53 percent having outstanding results (IMILN: 30.76 percent; MIPO: 42.30 percent). [114] At 3rd month follow up, as per the TW score, 90.63% scored good and 9.38% scored fair radiological outcome which improved to 18.75% showing excellent anatomic union by 6th month, 75.00% scoring good, 6.25% fair upon radiological evaluation comparable with the above studies.

The mean radiological union was 23.13±4.28 in our study population. In Kim et al.'s investigation, the mean time to bone union was 13.8 weeks, and radiographic evidence of bony union was achieved in all instances except one patient with diabetes. [105] In the research by Kundu et al., 75% of patients achieved radiologic union and complete weight bearing by week 16, while 25% did not reach either of these goals until week 17. [25] In the research by Shobha et al., all fractures healed in an average of 17 weeks. [115] In the research conducted by

Dhanasekharan et al., union occurred in all instances between 12 and 16 weeks. [106] In the research conducted by Paluvadi et al., the average time for radiological union was 21.4 weeks, with 32% of patients healed at 20 weeks and 96% achieving union within a period of 25 weeks. [119]

Even more convincing evidence of MIPO's efficacy comes from Ganesan et al.'s research, which found that the majority of their patients had an Excellent or Good functional result. When MIPO was combined with fibula plating, the radiological score decreased, indicating anatomical improvement. [3] Although the MIPO procedure offers several benefits, Kim et al. warned that extra surgery may be needed in certain individuals due to postoperative problems. [105] Kundu et al. found that MIPO is a successful approach for the therapy of distal tibial fractures, with a positive result in 85% of patients. [25] While the aforementioned studies revealed MIPO to be an effective method for treated distal tibia fractures, Kumar et al. found multidirectional locked nailing to be an effective approach for treating distal tibia fracture. For distal tibia fractures, they suggested IMIL nailing rather than MIPO. [114] With the majority of the osseous vascularity and fracture haematoma preserved, the MIPO method allows for a more biological healing, as determined by Paluvadi et al. [119] The results of our study are comparable with that of the above with regards to functional outcome, whereas radiological outcome was slightly less compared to the above studies. Overall, our study concurs with the above studies that MIPO is a reliable modality of management of distal tibial fractures.

Conclusions:

A total of 32 subjects included in the final analysis showed that most of the participants in our study were males with a mean age of around 47 years, which makes it clear that it is primarily seen in active individuals of the middle age group. The predominant side of injury was on the right side, with RTA being the mode of injury in most patients, followed by fall from height. Diabetes mellitus was the common co-morbidity encountered and was directly associated with the number of post-operative infections. The complications included prominent hardware in most cases, which was primarily cosmetic and did not impair function. Other complications like wound gaping, superficial surgical site infection, and deep surgical site infection were managed by antibiotics and wound debridement .one case of delayed union was treated with bone marrow injection, which later achieved bony union. Four cases underwent external fixator application due to unfavorable soft tissue conditions, and later, definitive fixation was done. The mean time for the radiological union was found to be about 24 weeks. The mean IOWA score at 3rd month as compared to the 6th-month follow-up, showed a statistically significant improvement. A 3rd-month to 6th-month follow-up, as per the TW score, showed a substantial decrease in the score, which is proportional to a better outcome. Our study found that the MIPO technique, with its stability and preservation of periosteal blood supply, minimal soft tissue handling, and indirect fracture reduction techniques, is an excellent option for managing distal tibia fractures. In conclusion, minimally invasive plate osteosynthesis (MIPO) is an effective modality for the treatment of distal third tibia fractures. The MIPO technique has been shown to have several advantages over traditional open techniques, such as reduced surgical trauma, improved cosmesis, and faster rehabilitation. Furthermore, our study is consistent with other studies which have shown that MIPO leads to similar or better outcomes in terms of fracture healing, functional recovery, and patient satisfaction. Thus, MIPO should be considered as a viable option for the treatment of distal third tibia fractures.

Limitations and recommendations:

- Our study consisted of a relatively short duration which may not be enough to assess long-term outcomes such as implant failure, infection, and non-union.
- Our study was a single-center study which limited the sample size. Which limits the generalizability of the findings. This may not be sufficient to draw definitive conclusions about the effectiveness of MIPO in all cases.
- Our study did not compare outcomes with other modalities of management,

It's important to note that while the limitations mentioned above should be taken into consideration, they do not detract from the overall conclusion that MIPO is an effective modality for the treatment of distal third tibia fractures, with several advantages over traditional open techniques. Further studies with larger sample sizes, prospective design, and long-term follow-up are needed to confirm the safety and efficacy of MIPO for distal third tibia fractures

Summary:

When dealing with distal tibial fractures, orthopaedic surgeons have a particularly difficult issue. Treatment options for distal tibia fractures have included intramedullary nailing (IMIL), external fixation, open reduction and internal fixation (ORIF), and minimally invasive plate osteosynthesis (MIPO). When comparing IMIL to plate fixation for distal tibia fractures, studies have found that IMIL has a much higher risk of malalignment. [122] Extensive dissection during ORIF, particularly when using the anterolateral technique, has been linked to an increased risk of wound complications such as dehiscence, full-thickness necrosis, and infection. Fractures of the distal tibia may also be fixed using minimally invasive percutaneous osteosynthesis (MIPO). Soft tissue problems after substantial anterolateral plate osteosynthesis have been reduced. [123] This prospective study was undertaken at R. L. Jalappa Hospital and Research centre on patients admitted in orthopedics ward from Casualty and OPD to analyze the functional outcome of MIPO for the treatment closed fractures of distal third tibia. Our study included 32 subjects with a mean age of 47.81±9.72 years, a predominantly male population with 87.50% males and 12.50% females. 84.38% had RTA mode of injury. At 3rd month follow-up, 6.25% had excellent functional outcome per IOWA score, 40.63% had good, and 53.13% had fair outcome. At 6th month follow up, these scores have improved impressively with 75.00% scoring excellent, 21.88% good and 3.13% fair, showing significant improvement from 3rd to 6th month. At 3rd month follow up, as per the TW score, 90.63% scored good and 9.38% scored fair radiological outcome which improved to 18.75% showing excellent anatomic union by 6th month, 75.00% scoring good, 6.25% fair upon radiological evaluation. Among those who had fair IOWA score at 3rd month, 52.95% graduated to an excellent score by 6th month and those with good IOWA score at 3rd month scoring did well by the 6th month follow up scoring excellent on IOWA scale. Our study demonstrated good functional and radiological outcome of distal tibia fractures treated with MIPO by six months from the surgery. This technique provides a good healing rate and excellent functional outcome with minimal wound healing complications.

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ANNEXURES

Annexure – I

Instuments and plates used in MIPO

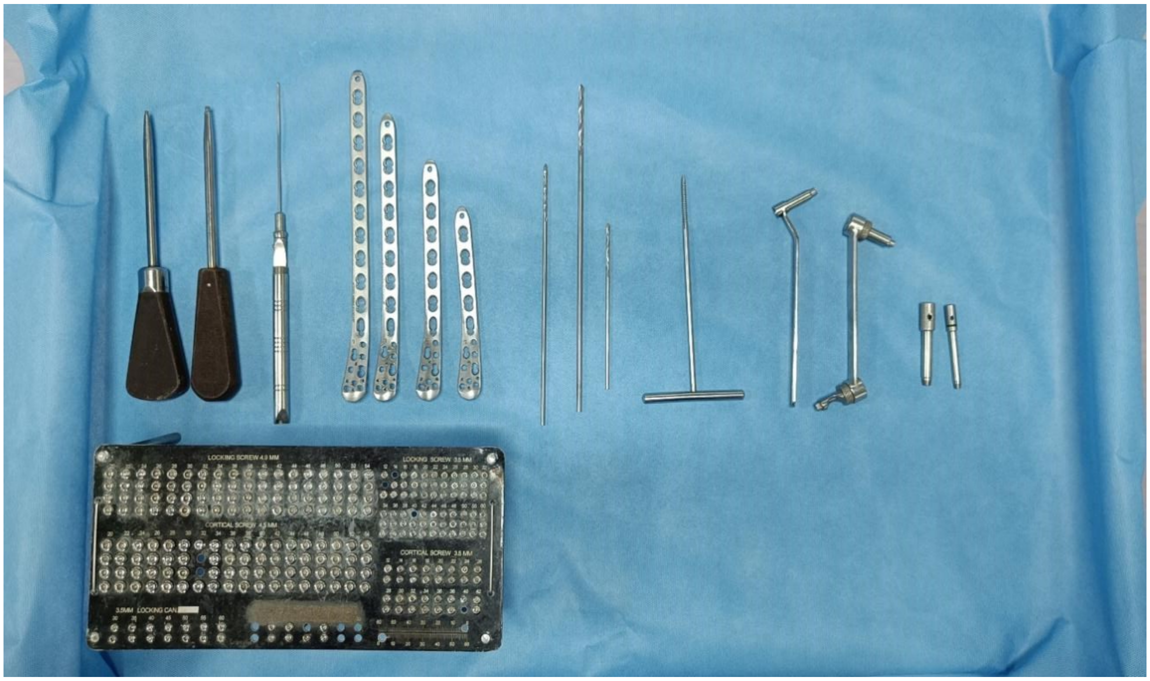


Figure: instruments and plates used in MIPO plating

Figure: Contoured distal tibia plates for anatomic reduction

Figure: the underside of the plate showing grooves that reduces the bone-to-plate contact surface area

Surgical steps

Figure: the surgical site is marked 5 cm from the tip of the medial malleoli

Figure: Tunnel is   made through the submuscular plane for passing the plate

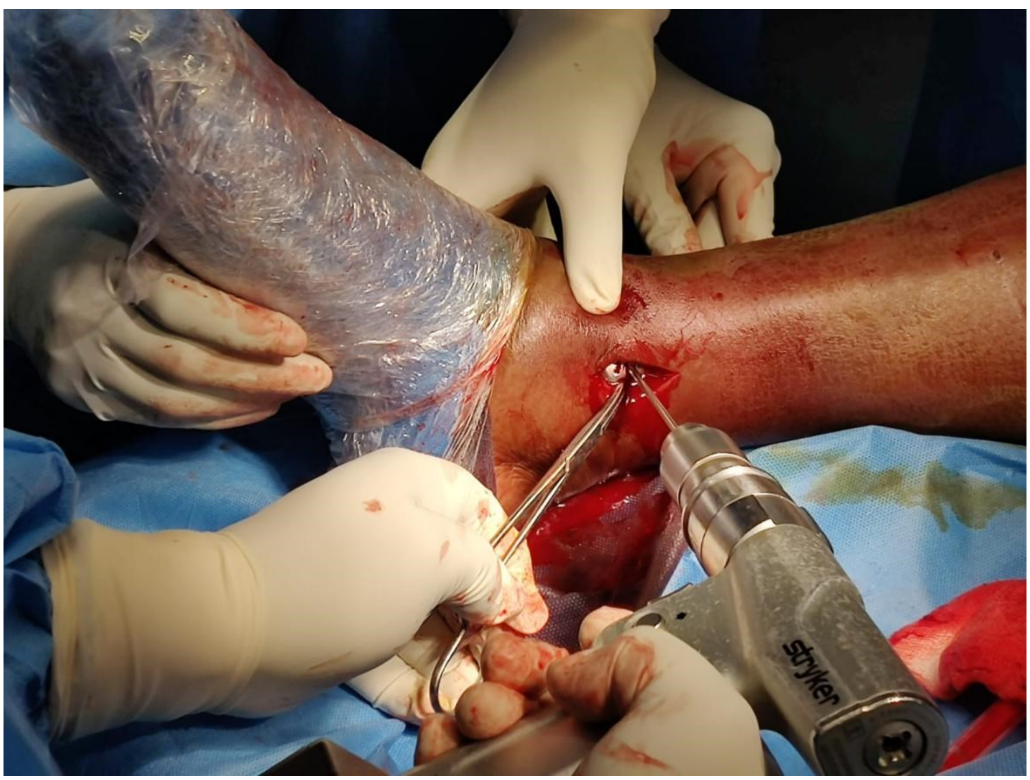


Figure: The plate is passed and secured temporarily with a k- wire

Figure: The proximal incision is made under C arm guidance, and screws are fixed after achieving reduction

Cases

Case 1

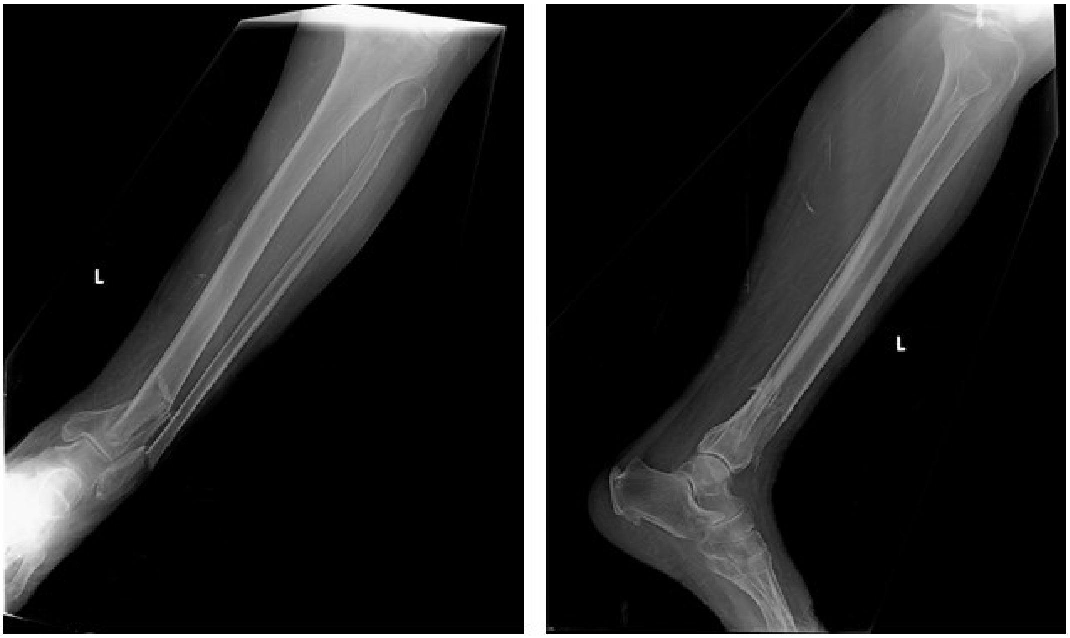
pre-op xrays

Post op Xrays at three months

Post op xrays at 6th month


6 months after surgical fixation patient shows excellent range of months

Case 12



Pre op xrays

Post operative xray at third month

Post operative xray at 6 months

6 months after surgical fixation patient shows good range of motion

Case 3

Pre op xrays

Post op xrays at 3rd month

Post op xrays at 6th month


Patient showing excellent range of movements 6 months post-operatively

Case 27

Figure : Patient presented 6 months post operatively with surgical site infection

Figure: Through wound bedridement done and I.V antibiotics started according to culture and sensitivity

Figure: Shows the wound healing over surgical site

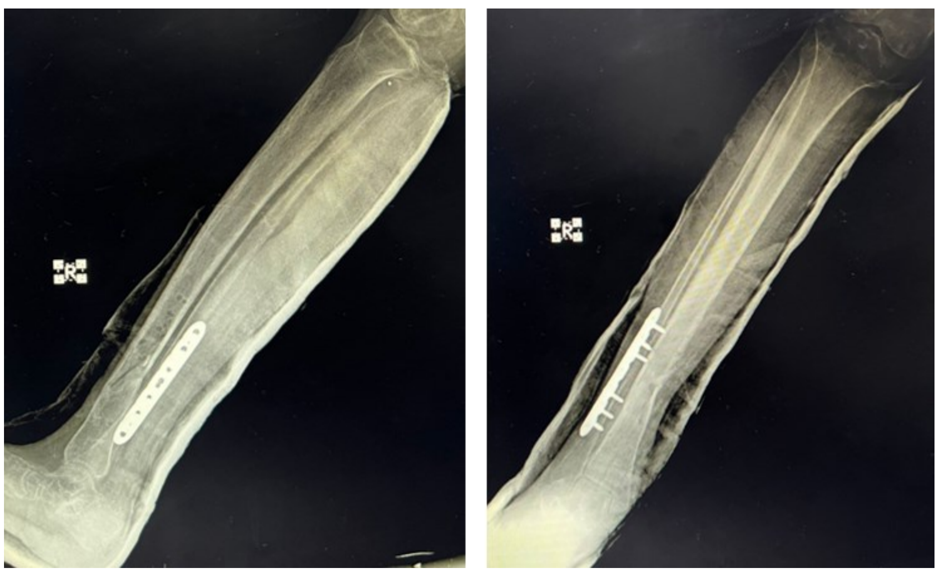


Figure : Patient was immobilized in below knee cast

Patient made a complete recovery

ANNEXURE - II

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH

TAMAKA, KOLAR - 563101.

<u>INFORMED CONSENT FORM</u>

<u>Case no</u>:

<u>IP no</u>:

TITLE: TO EVALUATE FUNCTIONAL AND RADIOLOGICAL OUTCOME OF DISTAL THIRD TIBIA FRACTURES MANAGED BY MINIMALLY INVASIVE PLATE OSTEOSYNTHESIS

I, the undersigned, agree to participate in this study and authorize the collection and disclosure of personal information as outlined in this consent form.

I understand the purpose of this study, the risks and benefits of the technique and the confidential nature of the information that will be collected and disclosed during the study. The information collected will be used only for research.

I have had the opportunity to ask questions regarding the various aspects of this study and my questions have been answered to my satisfaction.

I understand that I remain free to withdraw the participation from this study at any time and this will not change the future care.

Participation in this study does not involve any extra cost to me.

Name	Signature	Date	Time
Patient:			
Witness:			
Primary investigator			

[illegible], [illegible] - **563101.**

<u>ತಿಳಿವಳಿಕೆಯ ಸಮ್ಮತಿ ನಮೂನೆ</u>

ಕೇಸ್ ಸಂಖ್ಯೆ:

ಐಪಿ ಸಂಖ್ಯೆ:

<u>[illegible]:</u>

[illegible], [illegible],

[illegible].

[illegible],
[illegible].
[illegible].

[illegible].

[illegible].

[illegible].

[illegible]	[illegible]/[illegible]	[illegible]	[illegible]
[illegible]			
[illegible]			
[illegible]/ [illegible]			

PROFORMA

Case no:

IP no:

TITLE: **TO EVALUATE FUNCTIONAL AND RADIOLOGICAL OUTCOME OF DISTAL THIRD TIBIA FRACTURES MANAGED BY MINIMALLY INVASIVE PLATE OSTEOSYNTHESIS**

1. BASIC DATA

Name Age/Sex

Address

Mobile No.

Date of Procedure

Date of Admission/OP

Date of Discharge

History:

Mechanism of injury:

General physical examination:

Vitals: Pulse- B.P-

RR- Temp-

Systemic examination:

CVS-

RS-

PS-

CNS-

Pre existing systemic illness:

Diabetes/Thyroid disorder/ Cervical Spine/ CVS/RS/ CNS/locomotor/ TB/ anaemia/ Hypertension/ malnutrition/others

Local examination:

Side : Left/Right/Bilateral

Deformity : Present/Absent

Swelling : Present/Absent

Tenderness : Present/Absent

ROM @ ankle : Full / Restricted

Distal sensation : Present/Absent

Distal pulsation : Palpable/Absent

2. DIAGNOSIS:

3. INVESTIGATIONS:

CBC, BT, CT, Blood grouping

Blood urea, serum creatinine, RBS

Serum electrolytes

RBS

HIV, HBsAg status

X ray

4. TREATMENT:

Operation on –

5. POST PROCEDURE

Observation in surgical ICU

Immobilization of leg

NSAID's

Antibiotics Prophylactic/therapeutic/Nil

Systemic complications

Bleeding, infection, neurovascular injury, shock, ICU admission, malunion, non-union

Local Complications

1. Necrosis of skin

2. Infection:

a) suspected/established.

b) superficial/deep.

c) mild/moderate/severe.

3. Hematoma

4. Others

Further treatment of complications

None/Hematoma aspirated/open dressing/debridement/suction irrigation/plastic procedure/Physiotherapy

IOWA SCORE

- **SCORING SYSTEM**
- **IOWA ANKLE EVALUATION SCORE**
- **Function [40]**
- 1. Does housework or job without difficulty (8)
- 2. Climb stairs (10)
- 3. Carries heavy objects, such as suitcase (4)
- 4. Is able to run, or work at heavy labour (4)
- 5. Walk enough to be independent (8)
- 6. Has no difficulty getting in or out of an automobile (6)
- **Freedom from pain: [40]**
- 1. No pain [40]
- 2. Pain only with fatigue or prolonged use [30]
- 3. Pain with weight bearing [20]
- 4. Pain with motion [10]
- 5. Pain with rest or continuous motion [0]
- **Gait: [10]**
- 1. No limp [10]
- 2. Antalgic gait [8]
- 3. Use cane or one crutch [2]
- 4. Uses wheelchair or can't walk [0]
- **Range of motion [10]**
- 1. Dorsiflexion and plantarflexion
- (2 points for every 20 degrees)
- TOTAL SCORE: __ /100

- **1. EXCELLENT:100-90**
- **2. GOOD :89-80**
- **3. FAIR 79 -70**

3^{RD} MONTH	6^{TH} MONTH

Teeny and Weiss scoring

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

Anatomic 8 Good 9-11 Fair 12-15 Poor >15

3^{RD} MONTH	6^{TH} MONTH

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, TAMAKA, KOLAR - 563101.

PATIENT INFORMATION SHEET

STUDY TITLE: : TO EVALUATE FUNCTIONAL AND RADIOLOGICAL OUTCOME OF DISTAL THIRD TIBIA FRACTURES MANAGED BY MINIMALLY INVASIVE PLATE OSTEOSYNTHESIS

Study location: R L Jalappa Hospital and Research Centre attached to Sri Devaraj Urs Medical College, Tamaka, Kolar.

Details- Patients diagnosed with fracture neck of femur admitted in orthopedics ward from OPD and casualty at R.L.J. HOSPITAL AND RESEARCH CENTRE, attached to SRI DEVARAJ URS MEDICAL COLLEGE, TAMAKA, KOLAR

Patients in this study will have to undergo routine Blood Investigations: -CBC, BT, CT, Blood grouping, RBS, RFT,HIV, HBsAg status,.Radiological investigations

Please read the following information and discuss it with your family members. You can ask any question regarding the study. If you agree to participate in the study we will collect information (as per proforma) from you or a person responsible for you or both. Relevant history will be taken. This information collected will be used only for dissertation and publication.

All information collected from you will be kept confidential and will not be disclosed to any outsider. Your identity will not be revealed. This study has been reviewed by the Institutional Ethics Committee and you are free to contact the member of the Institutional Ethics Committee. There is no compulsion to agree to this study. The care you will get will not change if you don't wish to participate. You are required to sign/ provide thumb impression only if you voluntarily agree to participate in this study.

CONFIDENTIALITY

Your medical information will be kept confidential by the study doctor and staff and will not be made publicly available. Your original records may be reviewed by your doctor or ethics review board. For further information/ clarification, please contact

Dr. SIYAD M NAZAR (Post Graduate),

Department Of ORTHOPAEDICS,

SDUMC , Kolar

Mobile No: 8593815319

ಶ್ರೀ ದೇವರಾಜ್ ಯುಆರ್ಎಸ್ ಉನ್ನತ ಶಿಕ್ಷಣ ಮತ್ತು ಸಂಶೋಧನೆ ಅಕಾಡೆಮಿ,

ತಮಕ, ಕೋಲಾರ – 563101

ರೋಗಿಯ ಮಾಹಿತಿ ಹಾಳೆ

ಅಧ್ಯಯನದ ಶೀರ್ಷಿಕೆ: : ಕನಿಷ್ಠ ಆಕ್ರಮಣಕಾರಿ ಪ್ಲೇಟ್ ಆಸ್ಟಿಯೊಸಿಂಥೆಸಿಸ್‌ನಿಂದ ನಿರ್ವಹಿಸಲ್ಪಡುವ ಡಿಸ್ಟಲ್ ಥರ್ಡ್ ಟಿಬಿಯಾ ಮುರಿತಗಳ ಕ್ರಿಯಾತ್ಮಕ ಮತ್ತು ರೇಡಿಯೊಲಾಜಿಕಲ್ ಫಲಿತಾಂಶವನ್ನು ಮೌಲ್ಯಮಾಪನ ಮಾಡಲು

ಅಧ್ಯಯನ ಸ್ಥಳ: ಆರ್ ಎಲ್ ಜಾಲಪ್ಪ ಆಸ್ಪತ್ರೆ ಮತ್ತು ಸಂಶೋಧನಾ ಕೇಂದ್ರವು ಶ್ರೀ ದೇವರಾಜ್ ಅರಸ್ ವೈದ್ಯಕೀಯ ಕಾಲೇಜು, ಟಮಕ, ಕೋಲಾರ.

ವಿವರಗಳು- ಒಪಿಡಿಯಿಂದ ಮೂಳೆಚಿಕಿತ್ಸೆಯ ವಾರ್ಡ್‌ನಲ್ಲಿ ದಾಖಲಾದ ಎಲುಬಿನ ಕುತ್ತಿಗೆ ಮುರಿತದಿಂದ ಬಳಲುತ್ತಿರುವ ರೋಗಿಗಳು ಮತ್ತು ಆರ್.ಎಲ್.ಜೆ. ಆಸ್ಪತ್ರೆ ಮತ್ತು ಸಂಶೋಧನಾ ಕೇಂದ್ರ, ಶ್ರೀ ದೇವರಾಜ್ ಯುಆರ್‌ಎಸ್ ವೈದ್ಯಕೀಯ ಕಾಲೇಜು, ತಮಕ, ಕೋಲಾರಕ್ಕೆ ಲಗತ್ತಿಸಲಾಗಿದೆ

ಈ ಅಧ್ಯಯನದಲ್ಲಿ ರೋಗಿಗಳು ವಾಡಿಕೆಯ ರಕ್ತ ತಪಾಸಣೆಗೆ ಒಳಗಾಗಬೇಕಾಗುತ್ತದೆ: -CBC, BT, CT, ರಕ್ತದ ಗುಂಪು, RBS, RFT, HIV, HBsAg ಸ್ಥಿತಿ,.ರೇಡಿಯೊಲಾಜಿಕಲ್ ತನಿಖೆಗಳು

ದಯವಿಟ್ಟು ಕೆಳಗಿನ ಮಾಹಿತಿಯನ್ನು ಓದಿ ಮತ್ತು ಅದನ್ನು ನಿಮ್ಮ ಕುಟುಂಬ ಸದಸ್ಯರೊಂದಿಗೆ ಚರ್ಚಿಸಿ. ಅಧ್ಯಯನಕ್ಕೆ ಸಂಬಂಧಿಸಿದಂತೆ ನೀವು ಯಾವುದೇ ಪ್ರಶ್ನೆಯನ್ನು ಕೇಳಬಹುದು. ನೀವು ಅಧ್ಯಯನದಲ್ಲಿ ಭಾಗವಹಿಸಲು ಸಮ್ಮತಿಸಿದರೆ ನಾವು ನಿಮ್ಮಿಂದ ಅಥವಾ ನಿಮ್ಮಿಂದ ಅಥವಾ ಇಬ್ಬರಿಗೂ ಜವಾಬ್ದಾರರಾಗಿರುವ ವ್ಯಕ್ತಿಯಿಂದ (ಪ್ರೊಫಾರ್ಮಾ ಪ್ರಕಾರ) ಮಾಹಿತಿಯನ್ನು ಸಂಗ್ರಹಿಸುತ್ತೇವೆ. ಸಂಬಂಧಿತ ಇತಿಹಾಸವನ್ನು ತೆಗೆದುಕೊಳ್ಳಲಾಗುವುದು. ಸಂಗ್ರಹಿಸಿದ ಈ ಮಾಹಿತಿಯನ್ನು ಪ್ರಬಂಧ ಮತ್ತು ಪ್ರಕಟಣೆಗೆ ಮಾತ್ರ ಬಳಸಲಾಗುತ್ತದೆ.

ನಿಮ್ಮಿಂದ ಸಂಗ್ರಹಿಸಲಾದ ಎಲ್ಲಾ ಮಾಹಿತಿಯನ್ನು ಗೌಪ್ಯವಾಗಿ ಇರಿಸಲಾಗುತ್ತದೆ ಮತ್ತು ಯಾವುದೇ ಹೊರಗಿನವರಿಗೆ ಬಹಿರಂಗಪಡಿಸಲಾಗುವುದಿಲ್ಲ. ನಿಮ್ಮ ಗುರುತನ್ನು ಬಹಿರಂಗಪಡಿಸಲಾಗುವುದಿಲ್ಲ. ಈ ಅಧ್ಯಯನವನ್ನು ಸಾಂಸ್ಥಿಕ ನೀತಿಶಾಸ್ತ್ರ ಸಮಿತಿಯು ಪರಿಶೀಲಿಸಿದೆ ಮತ್ತು ನೀವು ಸಾಂಸ್ಥಿಕ ನೀತಿಶಾಸ್ತ್ರ ಸಮಿತಿಯ ಸದಸ್ಯರನ್ನು ಸಂಪರ್ಕಿಸಲು ಮುಕ್ತರಾಗಿದ್ದೀರಿ. ಈ ಅಧ್ಯಯನವನ್ನು ಒಪ್ಪಿಕೊಳ್ಳಲು ಯಾವುದೇ ಒತ್ತಾಯವಿಲ್ಲ. ನೀವು ಭಾಗವಹಿಸಲು ಬಯಸದಿದ್ದರೆ ನೀವು ಪಡೆಯುವ ಕಾಳಜಿಯು ಬದಲಾಗುವುದಿಲ್ಲ. ಈ ಅಧ್ಯಯನದಲ್ಲಿ ಭಾಗವಹಿಸಲು ನೀವು ಸ್ವಯಂಪ್ರೇರಣೆಯಿಂದ ಸಮ್ಮತಿಸಿದರೆ ಮಾತ್ರ ನೀವು ಸಹಿ/ಹೆಬ್ಬೆರಳಿನ ಗುರುತನ್ನು ಒದಗಿಸಬೇಕಾಗುತ್ತದೆ.

ಗೌಪ್ಯತೆ ನಿಮ್ಮ ವೈದ್ಯಕೀಯ ಮಾಹಿತಿಯನ್ನು ಅಧ್ಯಯನ ವೈದ್ಯರು ಮತ್ತು ಸಿಬ್ಬಂದಿ ಗೌಪ್ಯವಾಗಿಡುತ್ತಾರೆ ಮತ್ತು ಸಾರ್ವಜನಿಕವಾಗಿ ಲಭ್ಯವಾಗುವಂತೆ ಮಾಡಲಾಗುವುದಿಲ್ಲ. ನಿಮ್ಮ ಮೂಲ ದಾಖಲೆಗಳನ್ನು ನಿಮ್ಮ ವೈದ್ಯರು ಅಥವಾ ಎಥಿಕ್ಸ್ ರಿವ್ಯೂ ಬೋರ್ಡ್ ಪರಿಶೀಲಿಸಬಹುದು. ಹೆಚ್ಚಿನ ಮಾಹಿತಿ / ಸ್ಪಷ್ಟೀಕರಣಕ್ಕಾಗಿ, ದಯವಿಟ್ಟು ಸಂಪರ್ಕಿಸಿ

ಡಾ. ಸಿಯಾದ್ ಎಂ ನಜರ್ (ಸ್ನಾತಕೋತ್ತರ ಪದವೀಧರರು),

ಆರ್ಥೋಪೆಡಿಕ್ಸ್ ವಿಭಾಗ,

SDUMC, ಕೋಲಾರ

ಮೊಬೈಲ್ ಸಂಖ್ಯೆ: 8593815319

Clinical image

MASTER CHART:

Sr. No.	AGE	Gender	SIDE	Diagnosis	MODE OF INJURY	EXTERNAL FIXATOR APPLICATION /DURATION	EXTERNAL FIXATOR APPLICATION DURATION (in days)	Procedure Done
1	34	Male	LEFT	closed displaced distal tibia fracture with ipsilateral fibula fracture	RTA	No		CC SCREW FIXARION FOR FIBULA
2	55	Male	RIGHT	closed displaced distal tibia fracture with ipsilateral fibula fracture	RTA	No		FIBULA NOT SURGICALLY FIXED
3	40	Male	LEFT	closed displaced distal tibia fracture with ipsilateral fibula fracture	RTA	No		K WIRE FIXATION FOR FIBULA
4	56	Female	LEFT	closed displaced distal tibia fracture with intraarticular extension and ipsilateral fibula fracture	RTA	No		SEMITUBULAR PLATE FIXATION FOR FIBULA
5	45	Female	RIGHT	closed displaced distal tibia fracture with ipsilateral fibula fracture	FALL FROM HEIGHT	No		RUSH PIN FIXATION FOR FIBULA
6	54	Male	LEFT	closed displaced distal tibia fracture with intraarticular extension and ipsilateral fibula fracture	RTA	No		K WIRE FIXATION FOR FIBULA
7	62	Male	LEFT	closed displaced distal tibia fracture with ipsilateral fibula fracture	RTA	No		K WIRE FIXATION FOR FIBULA
8	45	Male	RIGHT	open displaced distal tibia fracture with intraarticular extension and ipsilateral fibula fracture	RTA	Yes	7	K WIRE FIXATION FOR FIBULA
9	60	Male	RIGHT	open displaced distal tibia fracture with ipsilateral fibula fracture	FALL FROM HEIGHT	Yes	10	FIBULA NOT SURGICALLY FIXED
10	45	Male	RIGHT	closed displaced distal tibia fracture with ipsilateral fibula fracture	RTA	No		FIBULA NOT SURGICALLY FIXED
11	49	Male	LEFT	closed isolated distal tibia fracture	FALL FROM HEIGHT	No		FIBULA NOT SURGICALLY FIXED
12	50	Male	RIGHT	closed displaced distal tibia fracture with ipsilateral fibula fracture	RTA	No		K WIRE FIXATION FOR FIBULA
13	50	Male	RIGHT	closed displaced distal tibia fracture with ipsilateral fibula fracture	RTA	No		SEMITUBULAR PLATE FIXATION FOR FIBULA
14	20	Male	LEFT	closed displaced distal tibia fracture with ipsilateral fibula fracture	RTA	No		FIBULA NOT SURGICALLY FIXED
15	34	Male	RIGHT	closed displaced distal tibia fracture with ipsilateral fibula fracture	FALL FROM HEIGHT	No		SEMITUBULAR PLATE FIXATION FOR FIBULA
16	56	Male	RIGHT	closed displaced distal tibia fracture with ipsilateral fibula fracture	RTA	Yes	7	SEMITUBULAR PLATE FIXATION FOR FIBULA

17	50	Male	RIGHT	closed displaced distal tibia fracture with ipsilateral fibula fracture	RTA	No		SEMITUBULAR PLATE FIXATION FOR FIBULA
18	42	Male	RIGHT	closed displaced distal tibia fracture with ipsilateral fibula fracture	RTA	No		SEMITUBULAR PLATE FIXATION FOR FIBULA
19	38	Male	LEFT	closed displaced distal tibia fracture with intraarticular extension and ipsilateral fibula fracture	RTA	No		FIBULA NOT SURGICALLY FIXED
20	56	Male	RIGHT	closed displaced distal tibia fracture with ipsilateral fibula fracture	RTA	No		K WIRE FIXATION FOR FIBULA
21	45	Male	RIGHT	closed displaced distal tibia fracture with ipsilateral fibula fracture	RTA	No		K WIRE FIXATION FOR FIBULA
22	60	Male	RIGHT	closed displaced distal tibia fracture with intraarticular extension and ipsilateral fibula fracture	RTA	No		K WIRE FIXATION FOR FIBULA
23	40	Female	LEFT	closed displaced distal tibia fracture with intraarticular extension and ipsilateral fibula fracture	RTA	No		RUSH PIN FIXATION FOR FIBULA
24	41	Male	LEFT	closed displaced distal tibia fracture with ipsilateral fibula fracture	RTA	No		RUSH PIN FIXATION FOR FIBULA
25	54	Male	LEFT	closed displaced distal tibia fracture with intraarticular extension and ipsilateral fibula fracture	RTA	No		K WIRE FIXATION FOR FIBULA
26	55	Female	RIGHT	closed displaced distal tibia fracture with ipsilateral fibula fracture	FALL FROM HEIGHT	No		SEMITUBULAR PLATE FIXATION FOR FIBULA
27	48	Male	RIGHT	closed displaced distal tibia fracture with ipsilateral fibula fracture	RTA	No		K WIRE FIXATION FOR FIBULA
28	56	Male	LEFT	closed displaced distal tibia fracture with ipsilateral fibula fracture	RTA	No		K WIRE FIXATION FOR FIBULA
29	48	Male	RIGHT	closed displaced distal tibia fracture with ipsilateral fibula fracture	RTA	No		FIBULA NOT SURGICALLY FIXED
30	52	Male	RIGHT	closed displaced distal tibia fracture with ipsilateral fibula fracture	RTA	No		SEMITUBULAR PLATE FIXATION FOR FIBULA
31	60	Male	LEFT	closed displaced distal tibia fracture with intraarticular extension and ipsilateral fibula fracture	RTA	No		K WIRE FIXATION FOR FIBULA
32	30	Male	RIGHT	open displaced distal tibia fracture with ipsilateral fibula fracture	RTA	Yes	9	FIBULA NOT SURGICALLY FIXED

COMPLICATIONS	ADDITIONAL PROCEDURES	IOWA 2ND (3rd month)	IOWA 2ND (3rd month) cat	IOWA 3RD (6th month)	IOWA 3RD (6th month) cat	TW 2ND (3rd month)	TW 2ND (3rd month) cat	TW 3RD (6 month)	TW 3RD (6 month) cat	AO type	Comorbidities	DM	HTN	RADIOLOGICAL UNION (in weeks)	DURATION OF SURGERY (in mintes)
NIL	NIL	88	Excellent	96	Excellent	10	Good	10	Good	43A1	NIL	No	No	18	80
PROMINENT HARDWARE	NIL	86	Good	95	Excellent	10	Good	11	Good	43A1	NIL	No	No	22	78
NIL	NIL	88	Good	96	Excellent	9	Good	8	Anatomic	43A2	NIL	No	No	20	75
DEEP SURGICAL SITE INFECTION	WOUND DEBRIDEMENT + SPLIT SKIN GRAFTING	77	Fair	89	Good	15	Fair	14	Fair	43C2	DM ,HTN	Yes	Yes	36	90
WOUND GAPING	NIL	90	Excellent	94	Excellent	10	Good	8	Anatomic	43A2	DM	Yes	No	24	88
PROMINENT HARDWARE	NIL	77	Fair	82	Good	11	Good	10	Good	43C2	HTN	No	Yes	24	96
NIL	NIL	79	Fair	90	Excellent	9	Good	9	Good	43A3	DM HTN	Yes	Yes	26	92
NIL	NIL	70	Fair	91	Excellent	10	Good	9	Good	43C1	HTN	No	Yes	22	78
DELAYED UNION	BONEMARROW INJECTION	86	Good	92	Excellent	11	Good	9	Good	43A1	DM,HTN	Yes	Yes	38	82
NIL	NIL	84	Good	93	Excellent	10	Good	9	Good	43A2	NIL	No	No	22	92
PROMINENT HARDWARE	NIL	85	Good	92	Excellent	10	Good	8	Anatomic	43A1	NIL	No	No	20	90
NIL	NIL	84	Good	90	Excellent	10	Good	8	Anatomic	43A1	DM	Yes	No	22	100
NIL	NIL	85	Good	92	Excellent	9	Good	9	Good	43A1	NIL	No	No	20	96
NIL	NIL	79	Fair	88	Good	11	Good	9	Good	43A1	NIL	No	No	18	92
PROMINENT HARDWARE	NIL	84	Good	94	Excellent	9	Good	9	Good	43A2	NIL	No	No	22	82
NIL	NIL	79	Fair	89	Good	10	Good	9	Good	43A2	HTN	No	Yes	20	102
WOUND GAPING	NIL	85	Good	92	Excellent	9	Good	9	Good	43A3	DM	Yes	No	26	96
SUPERFICIAL SURGICAL SITE INFECTION	NIL	78	Fair	92	Excellent	11	Good	9	Good	43A3	DM	Yes	No	22	92

NIL	NIL	81	Good	92	Excellent	9	Good	8	Anatomic	43A3	NIL	No	No	24	76
NIL	NIL	77	Fair	90	Excellent	10	Good	10	Good	43C3	NIL	No	No	26	120
NIL	NIL	78	Fair	92	Excellent	10	Good	8	Anatomic	43A1	NIL	No	No	20	110
SUPERFICIAL SURGICAL SITE INFECTION	NIL	78	Fair	80	Good	9	Good	9	Good	43C2	DM,HTN	Yes	Yes	26	102
NIL	NIL	78	Fair	92	Excellent	9	Good	9	Good	43C1	NIL	No	No	24	100
NIL	NIL	80	Good	90	Excellent	9	Good	9	Good	43A1	NIL	No	No	22	76
NIL	NIL	75	Fair	94	Excellent	9	Good	9	Good	43B1	DM	Yes	No	24	82
NIL	NIL	74	Fair	92	Excellent	10	Good	9	Good	43A2	DM	Yes	No	24	80
NIL	NIL	75	Fair	86	Good	10	Good	9	Good	43A3	NIL	No	No	20	100
NIL	NIL	78	Fair	94	Excellent	11	Good	10	Good	43A1	NIL	No	No	22	106
NIL	NIL	84	Good	94	Excellent	10	Good	9	Good	43A3	DM HTN	Yes	Yes	20	104
NIL	NIL	76	Fair	86	Good	12	Fair	10	Good	43A3	NIL	No	No	24	102
NIL	NIL	77	Fair	70	Fair	12	Fair	12	Fair	43C3	NIL	No	No	22	106
HYPERTROPHIC SCAR	NIL	80	Good	96	Excellent	11	Good	9	Good	43A1	NIL	No	No	20	92