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In partial fulfillment of the requirements for the degree of

MASTER OF SURGERY
IN
ORTHOPAEDICS

"STUDY OF THE FUNCTIONAL OUTCOME OF OPEN TIBIAL FRACTURES TREATED USING A LOCKING COMPRESSION PLATE AS AN EXTERNAL FIXATOR"

By

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I hereby declare that this dissertation entitled **"STUDY OF THE FUNCTIONAL OUTCOME OF OPEN TIBIAL FRACTURES TREATED USING A LOCKING COMPRESSION PLATE AS AN EXTERNAL FIXATOR"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. D. SATYARUP**, Professor, Department of Orthopaedics, Sri Devaraj Urs Medical College, Kolar in partial fulfillment of University regulation for the award "**M.S. DEGREE IN ORTHOPAEDICS**", the examination to be held in May 2019 by SDUAHER. This has not been submitted by me previously for the award of any degree or diploma from the university or any other university.

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ABSTRACT

BACKGROUND:

Tibia is one of the most commonly fractured long bone of the body. It is a subcutaneous bone, so there are more chances of open type of fractures, greater tendency of displacement and increased chances of post-op infection. Due to its poor blood supply and less soft tissue coverage there is an increased incidence of delayed union and nonunion. Locking Compression Plate as an external device is superior and advantageous than other conventional fixators. One stage external plate fixation as a definitive treatment decreases both costs and surgical injuries.

OBJECTIVE:

To evaluate the functional and radiological outcome of open tibial fractures treated using locking compression plate as external fixator using Johner and Wruh's criteria.

MATERIALS AND METHODS:

The study is conducted in 30 patients, who presented with open tibial fractures to the department of orthopaedic surgery in RL Jalappa Hospital attached to Sri Devaraj Urs Medical College, Tamaka, Kolar from November 2016 to June 2018.

Patients were screened to find their eligibility for the study. Consent was taken and they were included in the study. The patients underwent one stage definitive fixation using locking compression plate as an external fixator.

All the patients were followed up post operatively at 6, 18, and 24 weeks. Results were analyzed both clinically and radiologically using Johner and Wruh's criteria. Photographs were taken wherever necessary.

RESULTS:

Out of 30 patients, 26 were males and 4 females. Minimum age of patient included was 25 years and maximum of 70 years. Mean age of patients was 43 years. Right side was affected in 12 patients and left in 18 patients. Mode of injury was RTA in 25 patients and self-fall in 5 patients. 18 patients had Gustilo-Anderson type II and 12 had type IIIA fractures. Average fracture union time was 21 weeks. As per Johner and Wruh's criteria, 80% patients had excellent and fair results. In 4 patients secondary procedure in form of intramedullary interlocking locking nail was done in view of nonunion.

CONCLUSION:

This study observes that supracutaneous LCP is a reliable, cost effective, efficient, aesthetically acceptable, safe mode of treatment in open tibial fractures.

KEY WORDS:

Locking Compression Plate, Supracutaneous, Open Tibial Fractures, External Fixator, Johner and Wruh’s Criteria.

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DR. ABHISHEK YADAV

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LIST OF ABBREVIATIONS

AO	-	Arbeitsgemeinschaft für Osteosynthesefragen
AP	-	Antero-posterior
ASIF	-	Association for the Study of Internal Fixation
CNS	-	Central Nervous System
CRIF	-	Closed Reduction Internal Fixation
CVS	-	Cardiovascular System
DCP	-	Dynamic Compression Plate
EPF	-	External Plate Fixation
IMIL	-	Intramedullary Interlocking
IPF	-	Internal Plate Fixation
HSS	-	Hospital for Special Surgery
LCP	-	Locking Compression Plate
LC-DCP	-	Limited Contact Dynamic Compression Plate
LISS	-	Less Invasive Stabilization System
MIPPO	-	Minimally Invasive Percutaneous Plate Osteosynthesis
ORIF	-	Open Reduction Internal Fixation
PC-FIX	-	Point Contact Fixator

RBS	-	Random Blood Sugar
ROM	-	Range Of Motion
RTA	-	Road Traffic Accident
RS	-	Respiratory System
No.	-	Number
IR	-	Internal Rotation
ER	-	External Rotation

INTRODUCTION

Road traffic accidents (RTA) are on the rise over the past few years, leading to complex fractures.[1] The management of these fractures, especially open tibial fractures is challenging because of the scarcity of soft tissue, their subcutaneous nature, and poor vascularity. Conventional techniques like open reduction and internal fixation with plates and screws requires extensive dissection of soft tissue along with stripping of periosteum which results in higher rates of delayed union and nonunion with associated infections.[2,3,4,5]

Minimally invasive plating techniques not only reduce soft tissue damage and injury to bone vascularity, and also preserves osteogenic potential of fracture hematoma.[5] This concept is essentially integral to the management of open tibial fractures owing to its vulnerable blood supply and scant soft tissue coverage.[6]

Locking compression plates (LCP) have biomechanical properties of internal and external fixators, with superior holding power, because of fixed angular stability through the head of locking screws independent of friction fit.[7]

Conservative treatment by cast application for open tibial fracture requires prolonged immobilization, leading to ankle and knee stiffness affecting quality of life.[8]

Intramedullary nailing and plate fixation represent two viable approaches to internal fixation of extra-articular fractures in tibia. Although both of these techniques yield good results in maintaining proper reduction and union, the distinct advantages and disadvantages of each technique, should be considered carefully during surgical planning.[9]

However with increasing use of internal fixation there has been an increased risk of implant associated deep infections.[10] The concerns regarding internal fixation in open fractures are predominantly due to the difficulty of treating infections once established. This is commonly due to adherence of bacteria onto the implant and the presence of a biofilm which is impermeable to most antibiotics.[11,12]

Compared with a conventional plate, a locking plate provides a higher degree of stability, better protection against primary and secondary losses of reduction along with minimizing contact with bone.[13,14]

The soft tissue coverage of tibia is not only easily compromised in trauma, but also during internal fixation, which poses a challenge in subsequent wound healing.[15,16] The standard protocol followed in managing Gustilo-Anderson type II & III fractures is fracture fixation after a primary wound debridement.[17,18,19,20]

Generally this fracture fixation is achieved by external fixators, as instability at fracture site following debridement, will lead to compromised wound healing and increased chances of infection.[21,22,23,24,25]

The commonly used external fixator devices for tibia are bulky and cumbersome for the patient, thereby causing inconvenience in activities of daily living including gait disturbance. LCP, as an external fixator is also described for treating open fractures, septic arthritis, nonunion and even as a adjunct in distraction osteogenesis.[26,27]

The fundamental goal in treatment of open tibial fractures is restoration of a normal or a near normal alignment with minimal soft tissue injury which can be achieved with application of supracutaneous locking compression plate. In the present study, we have used the novel technique of using locking compression plate as an external fixator for definitive management of open tibial fractures. This is being carried out as a newer modality of treatment in very few centers across the world.

OBJECTIVE OF STUDY

- To evaluate the functional and radiological outcomes in open tibial fractures treated with locking compression plate as an external fixator using Johner and Wruh's criteria.

REVIEW OF LITERATURE

The prehistoric times stand witness to fractures and their knowledge as evident by the Egyptian mummies. For centuries together, fractures were managed by utilising bark and linen bandages. Another option being clay and lime mixed together with egg white, nevertheless wood occupied the center stage.

The dawn of first modern external fixator began in 1897, designed by Dr. Clayton and Park Hill from Denver.[28,29] Soon after, a similar external fixator was developed by Dr. Albeit Lambotte in 1906.[30] Both fixators were essentially unilateral that allowed for two sets of screws which needed to be fixed on to each bone fragment.

Continuing the timeline, Dr. Roger Anderson, in 1934, modelled a frame with trans-fixation pins.[31] Four years thence, Dr. Raowl Hoffman fashioned the Hoffman fixator, in 1938, which was duly modified by Dr. Vidal and Dr. Adrey by utilising multiplanar frame to remarkably enhance the rigidity which came to be known as the Hoffman Vidal system. Unfortunately, the downside being this frame was rigid as well as static and impeded union.[32,33]

Ramotowski W and Granowski R (1991) applied Zespol in 1295 cases of osteosyntheses (850 fractures and 445 pseudoarthroses) . The usual healing time of fractures was 18 weeks, and in cases of nonunions was 21 weeks. Second operation was required in 5.1% of cases, generally with good or fair results. The overall final results were 97.9% good and fair, and 2.1% poor.[34]

Marti R K, Van Der Werken C (1991) were the first to use standard AO plates as an external fixator in 12 patients. The main indications were not only compound fractures of forearm but also pseudoarthroses at different sites.

In all the 10 cases, the fixation provided good stability to allow bone healing. The surgical technique is simple, convenient for the patient and no special equipment is required. Rigid fixation of the screw heads to the plate was obtained by using both nuts and washers, this involved placing a nut on the undersurface of the plate that turned the device into an angular stable construct. A secondary correction was made by contouring the plate with bending pliers.[35]

Kerhoff Lim M J et al (2003) used standard AO plates as external fixator in 31 cases in different conditions like nonunion, compound fractures and found that good stability can be achieved with an inexpensive and relatively simple construction. The low profile of frame is an advantage for patients.[27]

Peter Kloen in the year 2009 coined the term supracutaneous plating after achieving good to excellent results by using LCP as an external fixator in complex post traumatic patients. Because of angular stable screw fixation, it was successful as a part of staged reconstruction procedures.[36]

Colin Y L, Merng Koon and Tet Sen Howe in 2009 used external application of an internal fixator. It was found that LCP as an external fixator, facilitated mobilization and were more manageable and aesthetically acceptable than traditionally used bar and schanz pin fixator.[37]

Sven A K Tulner, Simon D Strackee, Peter Kloen in 2012 after their study concluded that contoured metaphyseal LCP as an external fixator can be used not only as a temporary external fixator but can also be continued as definitive treatment. Out of seven cases, for four patients plates were left insitu until full bone healing was obtained and in other three, external fixator was replaced by internal fixation with plates or intramedullary nail. No significant difference was found on follow up. All patients were weight bearing with well healed tibia.[38]

Gupta S K V, Parimala S P, after a long term follow up of one and half years, published their study in 2013 which described the advantages of contoured LCP as an external fixator which included increased stability by multiple distal locking screws, less radiographic silhouette for easy assessment of fracture healing. The other advantages include controlled dynamization, minimal chance of screw site infection and more accepted by patients as clothing can conceal it.[39]

Ching-Hou Ma et al (2013) evaluated both outcome, biomechanical properties and performance when LCP is used as external fixator in the definitive management of compound tibial fractures. They have used finite element analysis, for analysing biomechanical performance of external and internal metaphyseal locked plates in treating proximal tibial fractures. Eight open tibial patients were treated using a metaphyseal locked plate as a low-profile definitive external fixator. Then, finite element models of internal (IPF) as well as two different external plate fixations (EPFs) for proximal tibial fractures were reconstructed. The offset distances from the bone surface to the EPFs were 6 cm and 10 cm. Both axial stiffness and angular stiffness were calculated to evaluate the bio-mechanical performance of these three models. The finite element finding revealed that axial stiffness and angular stiffness was found to be decreased when distance between offset and bone surface increased. Compared to the IPF models, in the two EPF models, axial stiffness decreased by 84-94%, whereas the angular stiffness decreased by 12-21%. The locking plate used as a definitive external fixator provided a high rate of union. While the locking plate is not totally rigid, it is clinically stable and thus promoting fracture healing by callus formation. All the patients experienced a comfortable clinical course, good knee and ankle joint motion, satisfactory functional results and an acceptable complication rate.[40]

Xu-Sheng Qiu et al in 2013 used locking plate as a definitive external fixator for treating tibial fractures with compromised soft tissue envelop in twelve patients. Time to union, nonunion, malunion, leg shortening, range of motion and function for the knee and ankle, deep infection, pin tract infections were evaluated. Eventually, all of the fractures united in acceptable positions. There were no cases of deep infection. Pin tract infection was seen in one patient (8.3 %), no loosening or failure of the external fixator was seen. All patients had excellent or good functional results and were fully weight bearing with a well-healed tibia at the final follow-up. The locking plate used as a definitive external fixator provided a high rate of union. The patients experienced a comfortable clinical course, excellent knee and ankle joint motion, satisfactory functional results and an acceptable complication rate.[41]

Xianfeng He et al (2014) did study on surgical treatment of extra-articular or simple intra-articular distal tibial fractures. They compared the results of supracutaneous plating with closed reduction and minimally invasive percutaneous plating in the treatment of distal tibial fractures. Forty-eight matched patients were divided according to age, sex, injury severity score, and fracture pattern into the MIPPO group and the supracutaneous plating group. No patient had nonunion, hardware breakdown or deep infection. Patients in the supracutaneous plating group had a significantly shorter mean operative time, hospital stay and union time. In the MIPPO group, 15 (62.5%) patients reported implant impingement or discomfort and there was one incidence of stripping of periosteum at the time of locking screw removal, whereas in the supracutaneous plating group, no patient reported skin irritation, and removal of the supracutaneous plate was easily performed in clinic without anaesthesia. Distal tibial fractures may be treated successfully with MIPPO or supracutaneous plating. However, the supracutaneous plating technique may represent a superior surgical option because it offers advantages in terms of mean operative time, hospital stay, union time, skin irritation, and implant removal.[42]

Zhang Z, Tang X (2014) used locking compression plate as external fixation in the treatment of open fracture of the tibial shaft. They retrospectively reviewed thirty two patients with open tibial shaft fractures treated with LCP as external fixator. Four patients had delayed union, two required minor adjustment of external plate and the other two required secondary iliac crest bone grafting. Based on Johner and Wruh's criteria, the final results were rated as twenty five excellent, four good and three fair. This shows that LCP applied as an external fixator is a safe and effective alternative for some types of open tibial shaft fractures.[43]

Xianfeng He et al (2014) worked on the treatment of segmental tibial fractures with supracutaneous locking plates used as external fixators in twenty patients. They underwent external plating (supracutaneous plating) of the segmental tibial fractures using a less-invasive stabilisation system locking plate. In all patients fracture union was achieved. Functional results were excellent in seventeen and good in three patients. Delayed union of the fracture occurred in two patients. All patients' radiographs showed normal alignment. No rotational deformities and leg shortening were seen. No incidences of deep infection or implant failures occurred. Minor screw tract infection occurred in two patients. A new one stage protocol using supracutaneous plating as a definitive fixator for segmental tibial fractures is less invasive, has a lower cost, and has a shorter hospitalisation time.[44]

Nabil A Ebraheim et al in 2014 worked on two cases of proximal tibial fracture treated with external LCP fixation as the second stage of a two-stage treatment. The first stage being a temporary standard external fixator and second stage being a definitive external LCP. In the first case, the fracture healed uneventfully whereas the second case required further open reduction with internal fixation because correct alignment could not be achieved with an external LCP. It shows that the correct alignment of proximal tibial fractures followed by use of an external LCP can achieve favourable outcomes.[45]

Zhang J et al (2015) prospectively evaluated thirty five patients with fresh proximal tibial metaphyseal fractures. The femoral LISS plate was used to fix these fractures, which was placed on the antero-medial aspect of the tibia as an external fixator. He found that all fractures healed in a mean time of fourteen weeks (range ten to twenty weeks). There was no case of nonunion, deep infection, loosening of screws and plates. One month after the appearance of cortical bridging on biplanar radiographs, the locking plate was removed within three minutes in the clinic without any difficulty. According to the Hospital for Special Surgery (HSS) knee scoring system and American Orthopaedic Foot & Ankle Society (AOFAS) ankle scoring system, good to excellent results were obtained at the final follow up. Hence he concluded that for proximal metaphyseal fracture of the tibia, external fixation using the femoral LISS plate is a safe and reliable technique with minimal complications and excellent outcomes. Its advantages include ease of performing the surgery, use of a less invasive technique, and convenience of plate removal after fracture healing.[46]

Rajasekaran S and Jayakumar B (2016) performed supracutaneous plating using LCP as an external fixator in compound fractures in four patients. They concluded that using LCP as an external fixator in open tibial fractures is tolerated very well by the patients and addresses the challenging problems of compound wound healing, nonunion and infection.[47]

Ang B F H et al (2017) compared the biomechanical properties of externalised locking compression plate to the unilateral external fixator and concluded that LCP as an external fixator provides a viable and an attractive alternative to traditional unilateral external fixator as its low profile makes it more acceptable to patients while not compromising on axial and torsional stiffness.[48]

ANATOMY

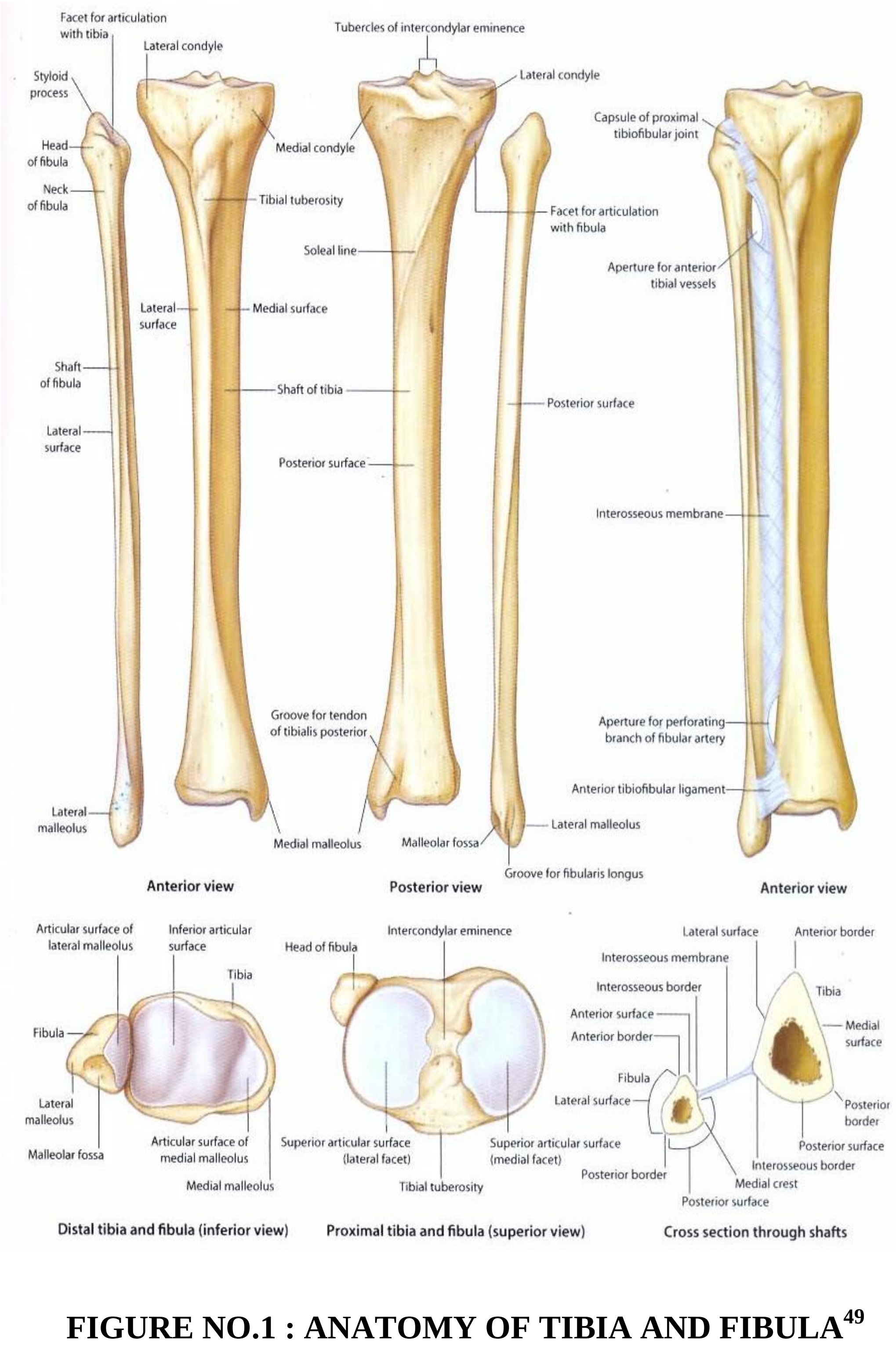

FIGURE NO.1 : ANATOMY OF TIBIA AND FIBULA[49]

TIBIA:

Tibia is the main weight bearing bone of the leg and takes part in the formation of knee and ankle joint. Tibia has upper end, shaft and lower end. Upper end or proximal tibia is wide medio-laterally to form the two condyles which extend beyond the posterior surface of tibial shaft.

The proximal end includes the medial condyle, the lateral condyle, inter-condylar area and tuberosity.

Medial tibial condyle is larger than the lateral tibial condyle, it is concave in centre and oval shaped in antero-posterior direction.Lateral tibial condyle even though it is small, overhangs the shaft, greater than the medial condyle. It articulates with fibula via its postero-inferior aspect.

Gerdy's tubercle is flattened impression over its anterior aspect. Intercondylar area is the rough area between the two condyles. Tibial tuberosity is the prominence over the anterior aspect which forms the anterior limitation to the intercondylar area.

Tibial shaft is a long tubular bone, which is broadened at its proximal end for supporting condyles but expands moderately at its distal end to articulate with talus. As like other long bones the tibial shaft is made of compact bone. On cross section proximal shaft is triangular while the distal shaft is roughly round to quadrangular making it weakest and vulnerable to fractures.

Tibial shaft has three borders and three surfaces.

Anterior, medial and interosseous borders.

Lateral, medial and posterior surfaces.

Muscles cover most of the lateral and posterior surfaces. The anterior border and medial surface is subcutaneous all through the length, leading to increased risk of periosteal stripping, open fractures.[50]

Interosseous membrane:

It connects tibia and fibula thereby closing the space between them, except at the upper end which provides passage for anterior tibial vessels. It helps in distributing the indirect forces on tibia to fibula.

MUSCLES OF LEG :

A muscular envelope surrounds tibia which is divided into three compartments.

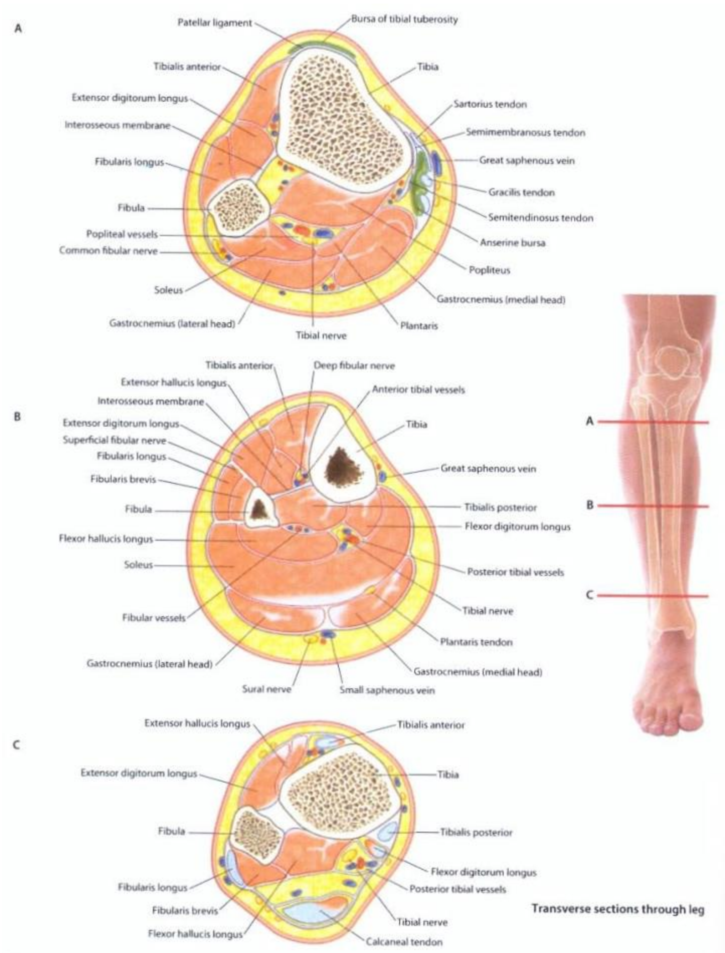

FIGURE NO.2 : TRANSVERSE SECTIONS THROUGH LEG[49]

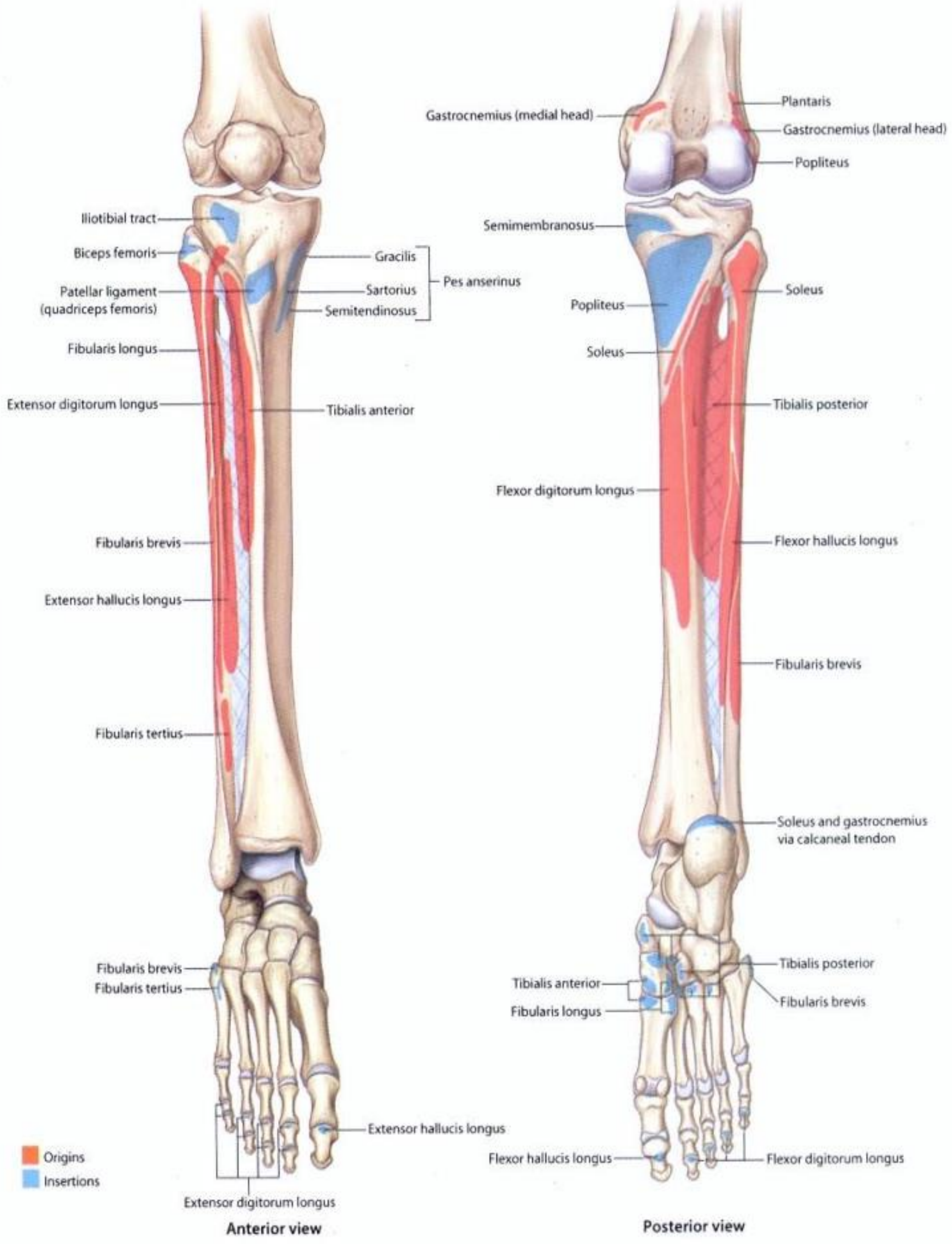

FIGURE NO.3 : ORIGIN AND INSERTION OF LEG MUSCLES[49]

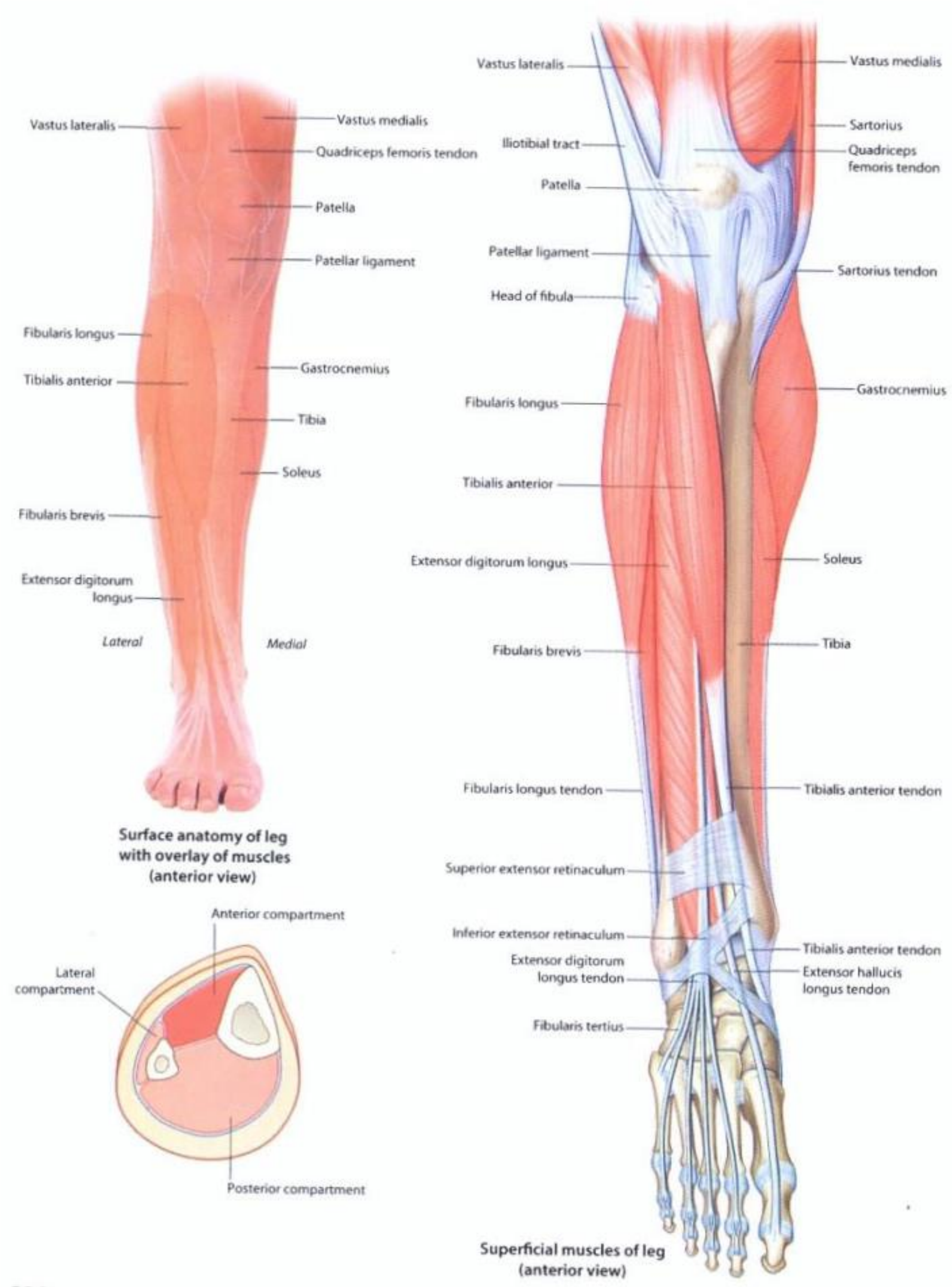

FIGURE NO.4 : SURFACE ANATOMY AND SUPERFICIAL MUSCLES OF LEG[49]

ANTERIOR COMPARTMENT OF LEG:

There are four muscles Tibialis anterior, Extensor digitorum longus, Extensor hallucis longus and the Peroneus tertius. It is a compact compartment with tibia and fibula forming medial and lateral border respectively whereas anteriorly it is bounded by anterior investing fascia and posteriorly by interosseous membrane. As the walls of this compartment are unyielding, increase in tissue pressure can result in compartment syndrome which may be secondary to a tibial fracture.[50]

LATERAL COMPARTMENT OF LEG:

Peroneus longus and brevis muscles constitute the lateral compartment covering and thereby protecting fibular shaft except at the ankle. The course of superior fibular nerve is between the extensor digitorum longus and the peronei.[50]

POSTERIOR COMPARTMENT OF LEG:

Posterior compartment is divided into superficial and deep groups by deep fascia. The muscles in the superficial group include gastrocnemius, soleus and plantaris. Popliteus, tibialis posterior, flexor hallucis longus and flexor digitorum longus form the deep group. The posterior tibial nerve, the posterior tibial artery and its large branch peroneal artery also run in the posterior compartment. They are well protected by these muscles.[50]

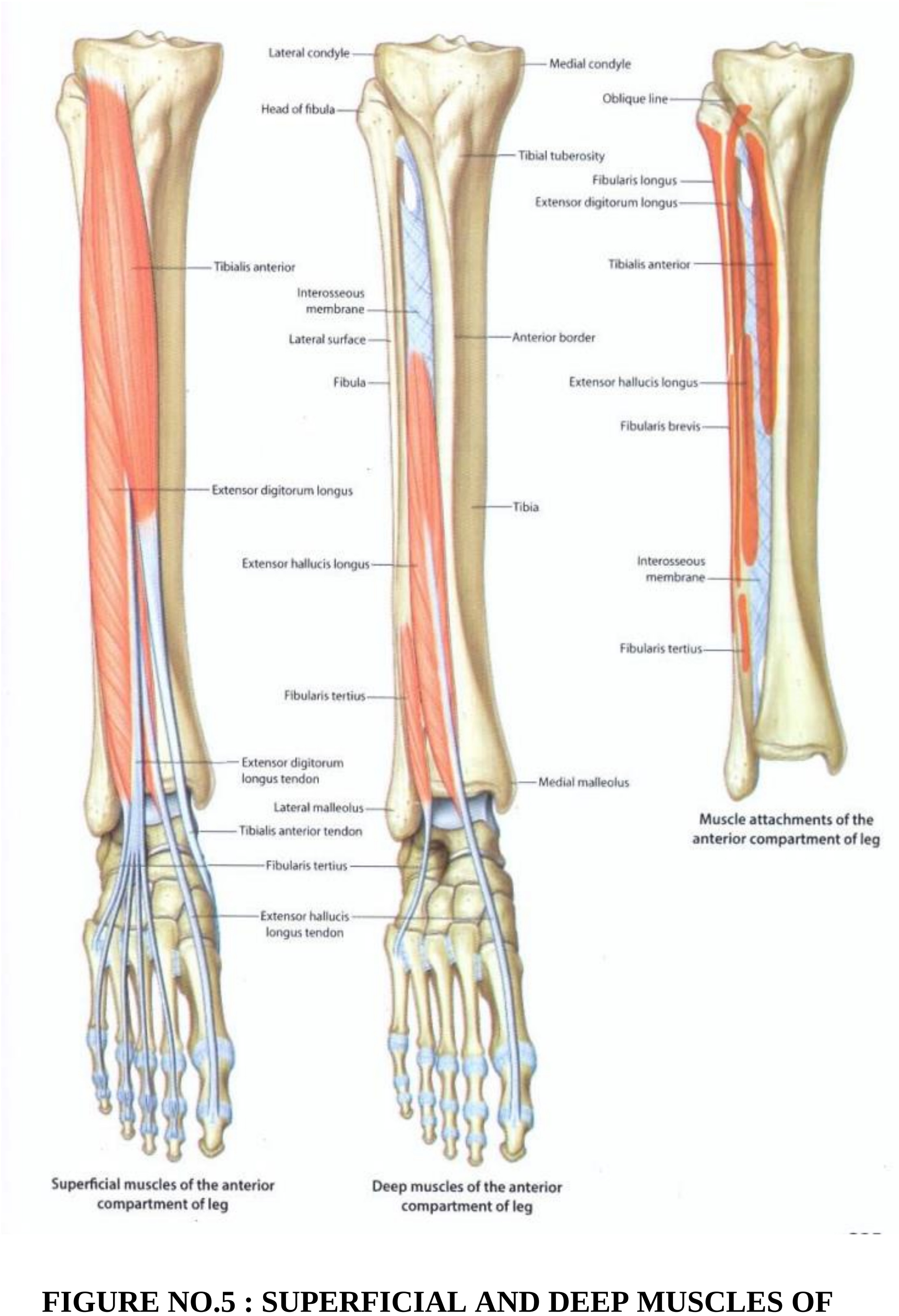

FIGURE NO.5 : SUPERFICIAL AND DEEP MUSCLES OF ANTERIOR COMPARTMENT OF LEG[49]

TABLE NO.1 : ANTERIOR COMPARTMENT OF LEG[51]

MUSCLE	ORIGIN	INSERTION	NERVE	ACTION
Tibialis anterior [TA]	Lateral surface of tibia, inter-osseous membrane	Medial cuneiform, base of 1st metatarsal	Deep peroneal	Dorsiflexion & invertion of foot
Extensor hallucis longus [EHL]	Medial surface of fibula, inter-osseous membrane	Base of distal phalanx of great toe	Deep peroneal	Extension of great toe& dorsi-flexion of foot
Extensor digitorum longus [EDL]	Lateral tibia condyle & proximal half of medial surface of fibula	Base of middle & distal phalanges (4 toes)	Deep peroneal	Dorsi-flexion of foot & extension of lateral 4 toes
Perones tertius	Distal fibula, inter-osseus membrane	Base of 5th metatarsal	Deep peroneal	Dorsiflexion & Evertion of foot

TABLE NO.2 : MUSCLES OF LATERAL COMPARTMENT OF LEG[51]

MUSCLE	ORIGIN	INSERTION	NERVE	ACTION
Peroneous longus	Proximal and lateral surface and head of fibula	Medial cuneiform, base of 1st Metatarsal (plantarly)	Superficial peroneal	Evert, plantar flex foot
Peroneus brevis	Distal two third of lateral fibula	Base of 5th metatarsal	Superficial peroneal	Evert foot

TABLE NO. 3: SUPERFICIAL POSTERIOR COMPARTMENT[51]

MUSCLE	ORIGIN	INSERTION	NERVE	ACTION
Gastrocnemius	Lateral and medial femoral condyles	Calcaneus (via Achilles tendon)	Tibial	Plantar flexion of ankle
Soleus	Posterior fibular head/soleal line of tibia	Calcaneus (via Achilles tendon)	Tibial	Plantar flexion of ankle
Plantaris	Lateral femoral supracondylar line	Calcaneus	Tibial	Plantar flexion of ankle

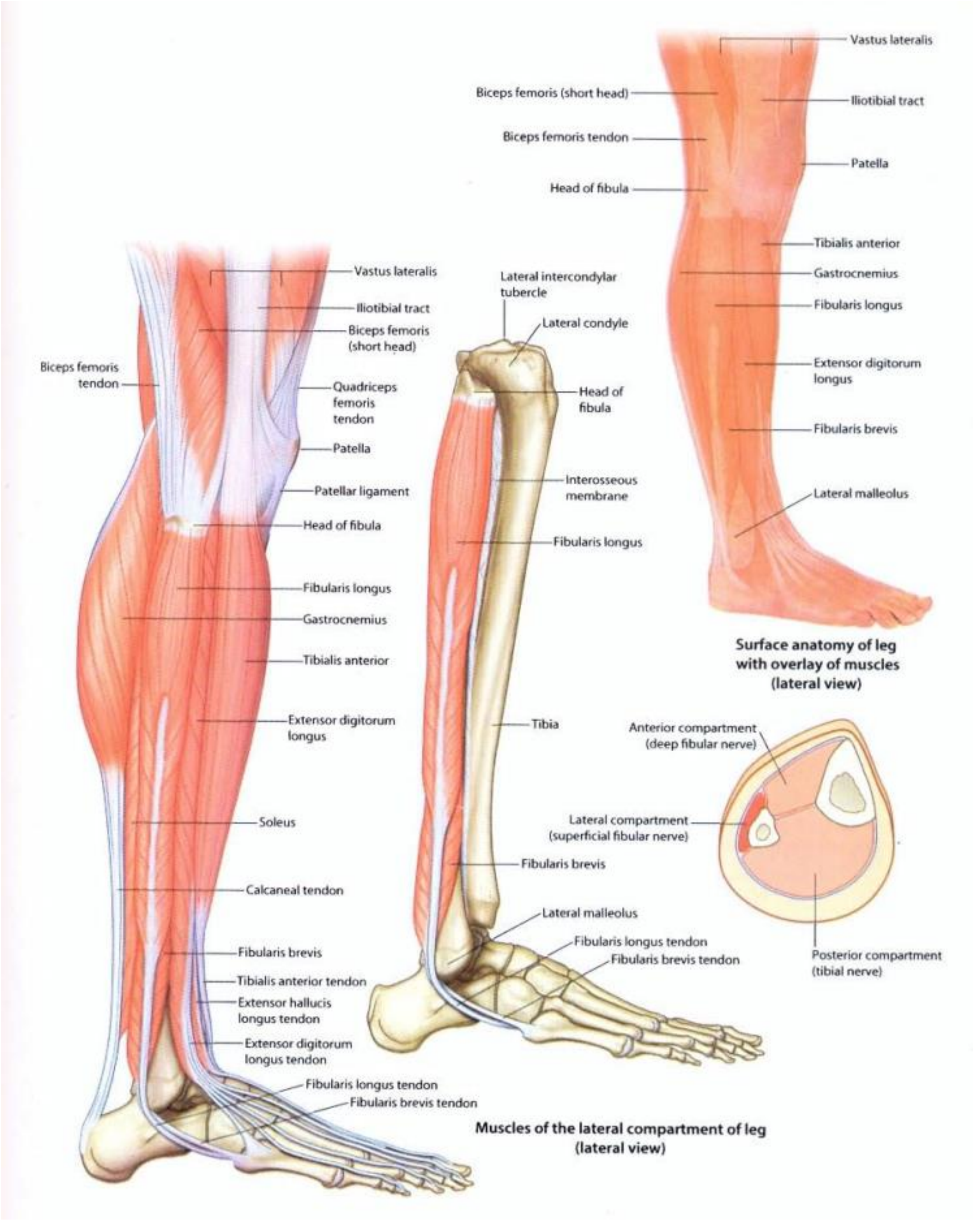

FIGURE NO.6 : MUSCLES OF LATERAL COMPARTMENT OF LEG[49]

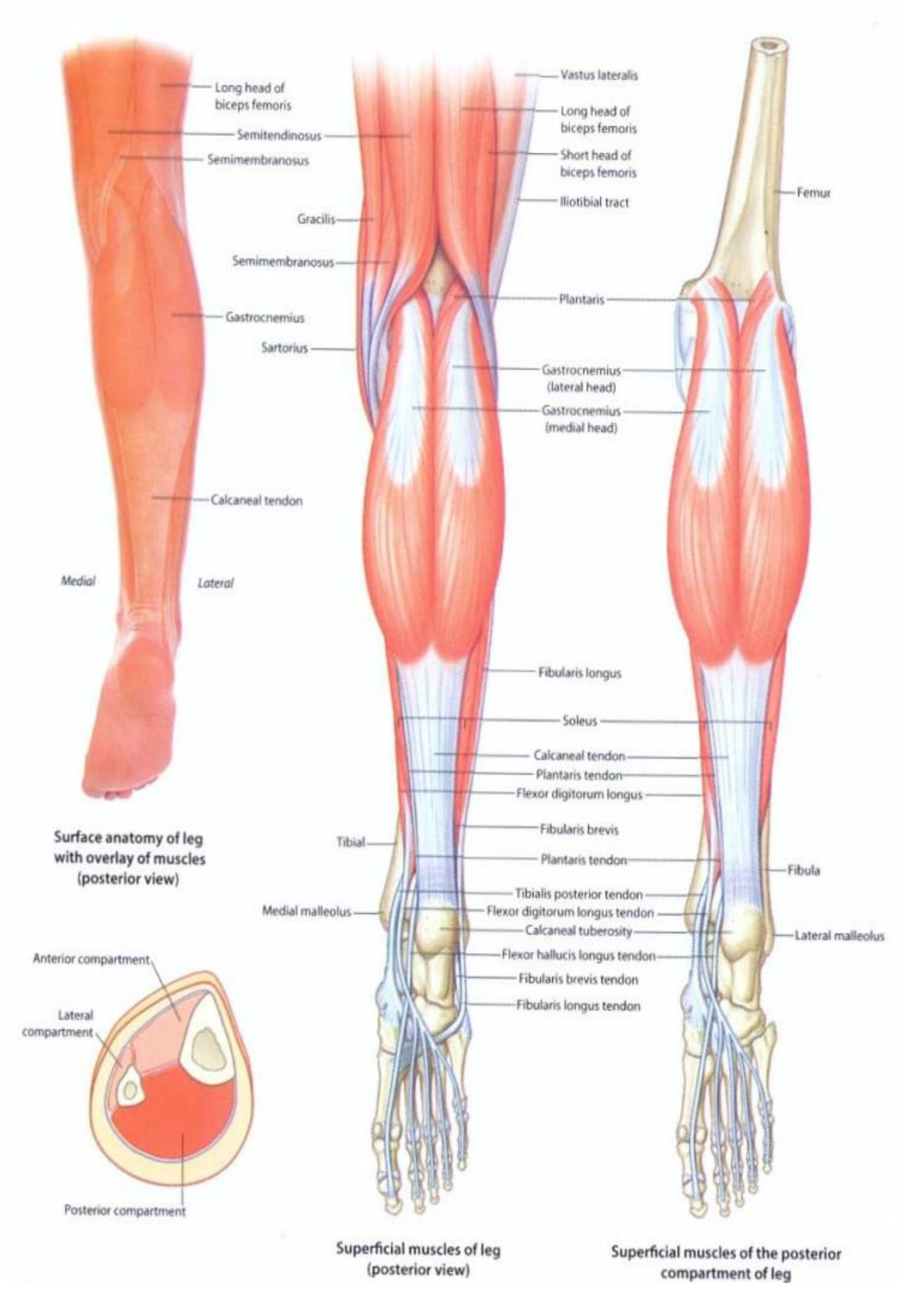

FIGURE NO.7 : MUSCLES OF SUPERFICIAL POSTERIOR COMPARTMENT OF LEG[49]

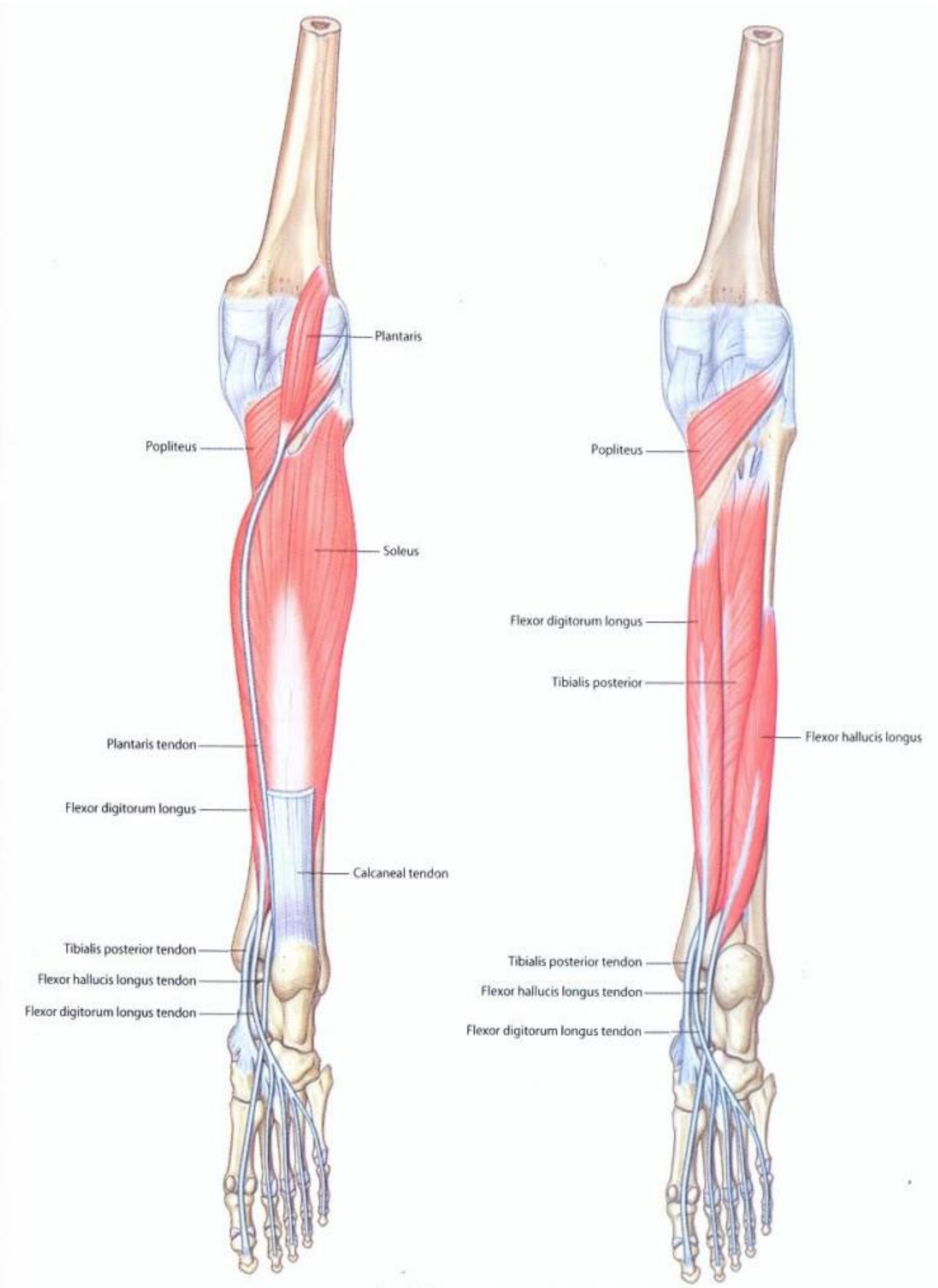

FIGURE NO.8 : MUSCLES OF DEEP POSTERIOR COMPARTMENT OF LEG[49]

TABLE NO. 4: DEEP POSTERIOR COMPARTMENT[51]

MUSCLE	ORIGIN	INSERTION	NERVE	ACTION
Popliteus	Lateral femoral condyle	Proximal surface of posterior tibia	Tibial	Stabilizaton and unlocking of knee
Flexor hallucis longus [FHL]	Posterior surface of fibula	Base of distal phalanx of great toe (plantarly)	Tibial	Plantar flexion of great toe
Flexor digitorum longus [FDL]	Medial side of posterior surface of tibia	Bases of distal phalanges of 4 toes (plantarly)	Tibial	Plantar flexion of lateral 4 toes
Tibialis posterior [TP]	Posterior surface of interosseous membrane, tibia, fibula	Navicular tuberosity, cuneiforms, metatarsals	Tibial	Plantar flexion & inversion of ankle

Blood supply to tibia:

The tibial blood supply is derived from three main sources;

1. The epiphyseal and metaphyseal arteries.
2. The nutrient arteries
3. Periosteal arteries

Blood supply for the tibial shaft is provided by both posterior and anterior tibial artery. From posterior tibial artery, a nutrient artery arises which enters the posterolateral cortex near the soleal line and supplies the endosteal surface by dividing into three ascending branches. The anterior tibial artery supplies periosteum during its course.

Blood vessels and nerves of leg :

Anterior compartment:

Anterior tibial artery supplies the anterior compartment, which originates from popliteal artery posteriorly and run anteriorly through the gap in the proximal interosseus membrane and courses distally to continue as dorsalis pedis artery.

Deep fibular nerve, arising from the common fibular nerve, innervates all the muscles of anterior compartment and courses along anterior tibial artery and continues to dorsal aspect of foot.

Lateral compartment:

Branches of the peroneal artery from the posterior compartment penetrate to supply the lateral compartment muscles.

Superficial peroneal nerve arising from the common peroneal nerve, supplies the lateral compartment muscles. Later in the course distally it penetrates the deep fascia and continues to dorsal aspect of foot.

Popliteal artery enters into superficial posterior compartment and gives off two sural arteries which supplies gastrocnemius, soleus and plantaris, then enters deep posterior compartment to divide into anterior and posterior tibial arteries. It terminates as plantar arteries after supplying deep posterior compartment muscles. Tibial nerve, a branch of sciatic nerve supplies all the muscles in the posterior compartment and enters foot to supply skin and intrinsic muscles.

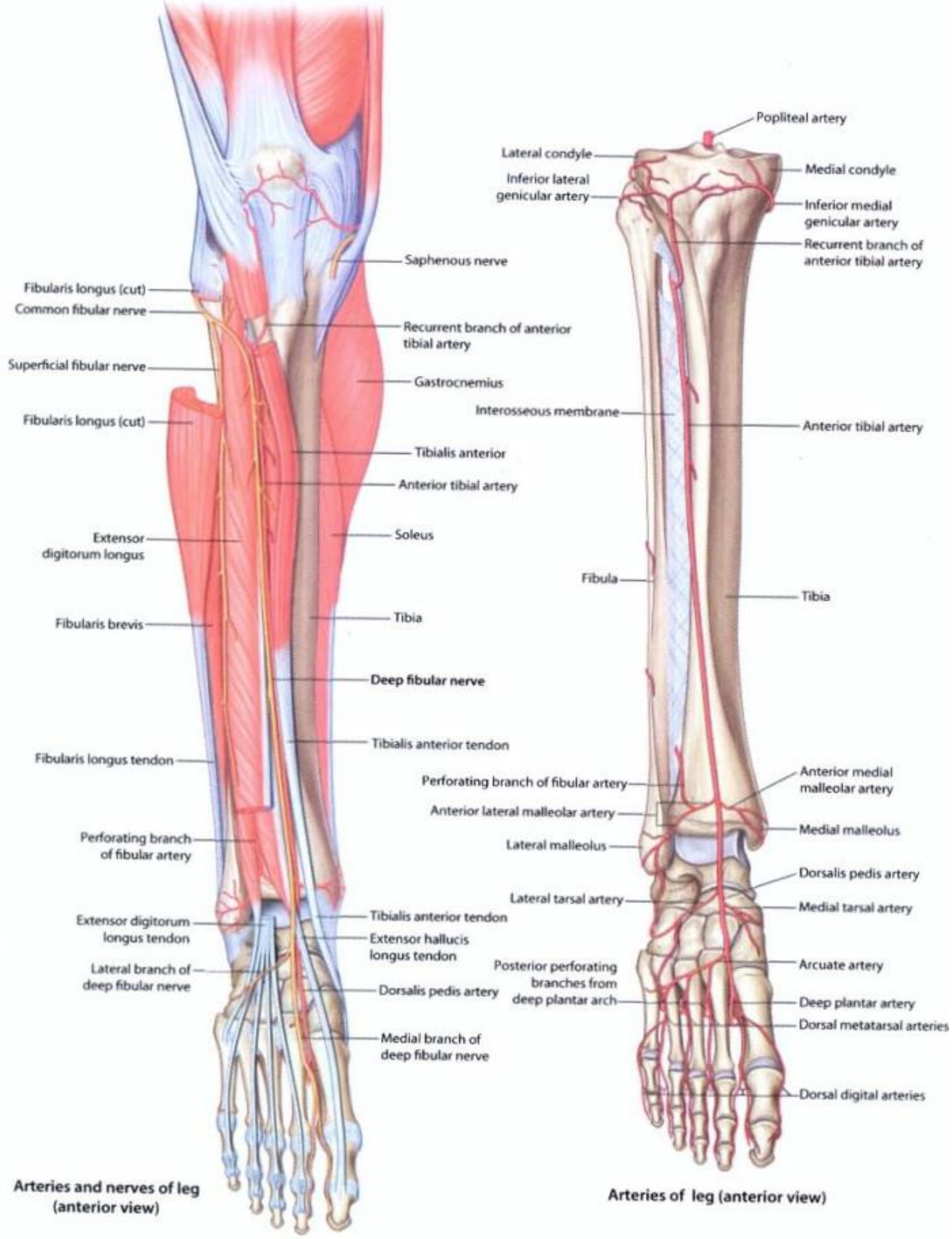

FIGURE NO.9 : ARTERIES AND NERVES - ANTERIOR ASPECT OF LEG[49]

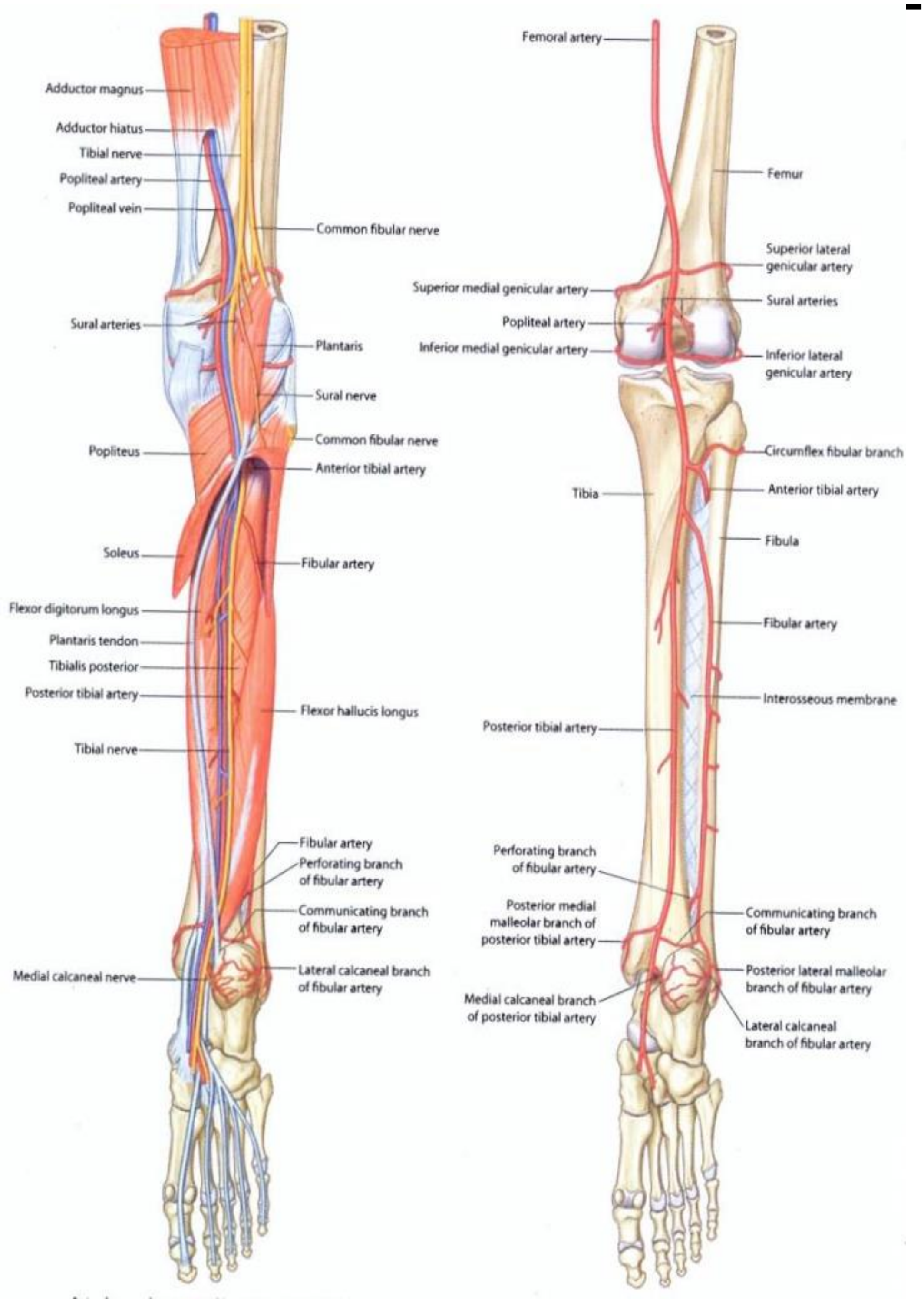

FIGURE NO.10 : ARTERIES AND NERVES - POSTERIOR ASPECT OF LEG[49]

MECHANISM OF INJURY:

These include five principal causes - falls, sports injuries, direct blows or assaults, motor vehicle accidents and gunshot injuries.

Direct Injury:

The highest incidence is seen in motor vehicle accidents usually affecting the motor cyclists, pedestrians and automobile passengers.

Axial loading injuries:

The stress strain curve is shifted by loading because of viscoelasticity of the bone. Rapid axial loading sequentially absorbs and subsequently at failure releases excessive energy. The soft tissue bears the brunt of the released energy. The articular surface, partially or in entirety, may be affected. The injury may be limited to an epiphyseal area just superior to the joint, or it may be confined to the epiphysis and metaphysis with or without an extension to the diaphysis. The precise vector of force and the foot position when it is applied results in varying presentation in fracture patterns.

TABLE NO. 5: SOFT TISSUE INJURY CLASSIFICATION (TSCHERNE H, OESTERN HJ)[52]

Grade	Open soft tissue injuries
O1	Skin lacerated by bone fragment. No or minimal contusion to the skin
O2	Skin laceration with circumferential skin or soft-tissue contusion and moderate contamination
O3	Extensive soft-tissue damage with major vessel or nerve injury
O4	Subtotal and total amputations with separation of all important anatomical structures

O - Open fractures

TABLE NO. 6: OPEN INJURY - GUSTILO-ANDERSON CLASSIFICATION [53]

I	Open fracture, clean wound, wound <1 cm in length
II	Open fracture, wound > 1 cm but < 10 cm in length without extensive soft tissue damage, flaps, avulsions
III	Open fracture with extensive soft tissue laceration (>10 cm), damage, or loss or an open segmental fracture. This type also includes open fractures caused by farm injuries, fractures requiring vascular repair, or fractures that have been open for 8 hours prior to treatment
IIIA	Type III fracture with adequate periosteal coverage of the fracture bone despite the extensive soft tissue laceration or damage
IIIB	Type III fracture with extensive soft tissue loss and periosteal stripping and bone damage. Usually associated with massive contamination. Will often need further soft tissue coverage procedure (i.e. free or rotational flap)
IIIC	Type III fracture associated with an arterial injury requiring repair, irrespective of degree of soft tissue injury.

CLINICAL FINDINGS:

Patient usually provides a clear history of some form of either direct or indirect injury to the leg. The vast majority of fractures will result from a fall from a height, a fall during a sport activity or a motor vehicle accident.

The involved distal tibia goes in valgus, varus, antero-posterior translation or rotational. Most commonly there is combination of all of the above.

Physical examination reveals tenderness, directly over the fracture site. Usually swelling, bruising, and ecchymoses at the fracture site, as well as deformity with displaced fracture. Because of this malposition of the distal fragment and ankle joint, inspection of the patient from front reveals varus or valgus angulation. Inspection from side reveals antero-posterior translation. But sometimes, it is difficult to know displacements because of the massive swelling.

Shortening of the limb should be measured clinically with a measuring tape. A mark is made from anterior superior iliac spine to medial malleolus (true length), another measurement is from xiphi-sternum to medial malleolus, take measurement of both sides. If any hip or spine pathology is present, modify measurement according to condition.

A careful neurologic and vascular examination of the involved limb is mandatory, as surgical intervention is contemplated. If a deficit is not noted pre-operatively, then it may be incorrectly attributed to the surgery, which has prognostic, medicolegal, and treatment implications.

Gentle palpation and manipulation will usually produce crepitus. All the movements of knee and ankle joints are generally painful.

ASSOCIATED INJURIES:

Associated injuries may be divided into:

1. Associated skeletal injuries.
2. Vascular injuries.
3. Nerve injury.

- Skeletal injuries may include fibula fracture.
- Head and neck injuries.
- Fracture of the rib.
- Associated with dislocation – disruption of ankle articulation.
- Vascular injuries include laceration, occlusion, spasm or acute compression.
- The vessel most commonly injured is the posterior tibial artery.
- Injury to common peroneal nerve is often associated with vascular injury.

RADIOGRPAHIC EVALUATION

Radiographic evaluation must include the entire tibia (antero-posterior and lateral view) with visualization of ankle and knee joint. Following features will be seen on xrays. (AP and lateral radiograph).

• The presence of comminution.

• The distance that bone fragments have displaced.

• Osseous defect.

• Quality of bone.

• Osteoarthritis or the presence of a knee arthroplasty.

• Air in the soft tissue (for presence of gas gangrene, necrotizing fasciitis or other anaerobic infection).

TREATMENT:

The preferred method of treatment of a open tibia fracture depends on several factors including the age, medical condition of the patient, the location of the fracture and associated injuries. It is important to achieve antero-posterior and lateral alignment of the fracture of the tibia. In adults with open tibia fractures, the goal of treatment as with other fractures is to achieve healing of bone with minimal morbidity, loss of function and residual deformity. General methods of treatment of fractures can be broadly grouped into the following ways–

- Conservative or non-operative treatment.
- Operative treatment.

NON-OPERATIVE TREATMENT:

The main principles of non-operative treatment historically have included the following points. Fracture reduction followed by application of long cast with progressive weight can be used for isolated closed low energy fracture with minimal displacement and comminution.

• Cast with the knee in 0 to 5 degree of flexion to allow for weight bearing with crutches as soon as tolerated by patients, with advancement to full weight bearing by second to fourth week.

• After 3 to 6 weeks, the long leg cast may be exchanged for patella tendon bearing cast or fracture brace.

• Union rates as high 97% are reported, although with delayed weight bearing related to delayed union or non-union. Hind foot stiffness is the major limitation.

• Maintenance of reduction.

Advantages:

• Cost effective.

• For high risk patients, casting is treatment of choice.

Complications:

- Hind foot stiffness.
- Knee and ankle stiffness.

If not applied properly, chances of compartment syndrome and other plaster related complications like pressure sores over both malleoli and heel edema can occur.

OPERATIVE TREATMENT:

It may be by any of these methods.

1. Internal fixation with plates and screws.
2. External fixation.
3. Intramedullary fixation.

Indications:

Indications for operative treatment of tibia fractures are:

A. Fracture Specific.

1. Open fractures.

2. Antero-posterior angulation >10 degree.

3. >10 degree of rotational deformity. Internal rotation is not acceptable.

4. Segmental fractures

5. Varus/valgus angulation >15 degree

6. Vascular injury requiring repair.

7. Progressive neurologic deficit.

B. Associated Injuries

1. Polytrauma with requirement for early lower extremity weight bearing.

2. Patient motivation for rapid return of function (e.g. elite sports or the self-employed professional).

I. INTRAMEDULLARY DEVICES :

Before the advent of LCP, intramedullary nailing system was used for fixation of tibia fracture.

Advantages:

- It can be performed through a small skin incision.
- It requires minimal soft tissue stripping.
- It does not cause damage to fracture hematoma.
- It is technically easy

Disadvantages:

Intramedullary fixation in cases of open tibial fractures is associated with increased chances of deep infections.[54]

II. PLATE AND SCREWS :

Biomechanically, plate fixation is superior to intramedullary fixation because it better resists the bending and torsional forces that occur during the movement of knee and ankle.

Types of plate used:

1. 4.5 mm dynamic compression plate
2. Low contact dynamic compression plate
3. Locking compression plate

- In relatively simple fractures, standard locking compression plates are used.

- The 4.5 mm compression plate with its lower profile and its ability to be contoured in two planes to tibia more easily, is the preferred implant. However it doesn’t provides stability in osteoporotic bone.
- The low-contact dynamic compression plate, allows ease of contouring with uniform plate bending. Smaller contact area with the underlying bone leading to less disruption of the underlying blood supply.
- Locking Compression plate come pre-contoured with smaller contact area of bone leading to less disruption of blood supply and stable fixation.

Advantages:

- For transverse fractures, compression across the fracture site is achieved
- For oblique fractures or butterfly fragments, lag screw fixation impossible with the plate functioning in a neutralization mode.
- Rotational control of the fracture is achieved.
- Also, a relatively rigid fixation is provided so that the patient can bear minimal weight on the extremity as well as can utilise the upper limb for daily chores.

Disadvantages:

- Excessive exposure and soft tissue stripping is needed for plate fixation.
- Nerves crossing through the surgical field can possibly be damaged.
- The plate being seated in subcutaneous tissue can result in irritation and poor cosmesis.

Locking compression plates :

The principle of the locking compression plate (LCP) is represented by the combination of two completely different anchorage technologies and two opposed principles of osteosynthesis in one implant. It combines the principles of conventional plate osteosynthesis for direct anatomical reduction with those of bridging plate osteosynthesis. Since the LCP can be used as a conventional plate using only dynamic compression, as a pure internal fixator using locking head screws, or as both combined, it provides the surgeon with multiple variations. Nevertheless, these new possibilities mean that pre-operative planning and an understanding of the different biomechanical principles of osteosynthesis are essential if good clinical outcomes are to be achieved and maximum benefit is to be attained from the options offered by the LCP system.[55]

III. EXTERNAL FIXATION:

It may be indicated for severe open fracture with poor quality of the overlying skin and infected nonunion after plate removal.

COMPLICATIONS OF OPERATIVE TREATMENT:

A. Malunion :

Adults have no remodeling potential, so shortening or angulation may occur after displaced tibia fractures. Patients with shortening of the tibial segment of more than 2.5 cm at follow-up examination had significantly more pain than those without these findings. So it is recommended not to accept shortening in case of adults.

B. Nonunion:

- Tibial nonunion is defined as failure to show clinical or radiographic progression of healing at 6 to 8 months.
- At 18 weeks period as long as some potential for healing was present it is called delayed union.
- The incidence of nonunion probably much higher than previously thought with an incidence of 15 to 25%.

Factors predisposing to nonunion of the tibia are –

1. **Inadequate immobilization**: Tibia is one of the most difficult bones to immobilize properly and completely after fracture.
2. **Severity of trauma**: Since tibia being subcutaneous bone it is subjected to severe soft-tissue injury, so up to half of this fractures result in non-union.
3. **Refracture:** Because the vascular anatomy of a fractured bone remains altered for a long period even after fracture union, re-injury might in some way prevent this altered blood supply from reaching to the new fracture.
4. **Location of fracture :** The fractures of tibia are more susceptible for nonunion because -

a) Of fracture instability and the increased tendency of displacement of fracture fragments by the muscle pull.

b) These fractures usually result from severe trauma and are associated with soft tissue injury.

5. **Degree of displacement :** Marked displacement is frequently associated with myriad factors such as soft tissue injury, open fracture and also soft tissue interposition which considerably impede the healing process**.**

6. **Primary open reduction:** Extensive soft tissue dissection, periosteal stripping and infection have been attributed to high rate of nonunion in fractures treated with internal fixation. But it is probable that the operative fractures also included difficult cases (those associated with severe trauma, soft tissue damage and associated injuries), thus contributing to the poor results. One cannot over look the fact that most of the surgical complications are related to poor fixation techniques and it is not the concept of surgical treatment that is the problem but rather the choice of fixation.

C. Neurovascular sequelae:

In adults, late neurovascular sequelae can follow both united and nonunited fractures. Abundant callus or significant fracture deformity in some patients may narrow the compartment of leg and can cause neurovascular deficit.

D. Posttraumatic arthritis:

This can occur with prolonged immobilization and improper fixation.

E. Hard ware problems :

As with fresh fracture fixation, inadequate purchase or plate size or collapse of the intercallary graft are important predictors of failures like plate loosening, plate angulation, plate breakage which may be treated by replating. In most high energy trauma cases, tibia fractures are comminuted and in this setting, LCP act as bridging plate.

F. Infection

Infection following operative management for fracture and/or non-union can be completely devastating. Reconstruction is invariably tedious for deep infection and/or osteomyelitis typically in the non-union situation, where extensive and comprehensive bone loss occurs. Initial treatment comprises of debridement. However, retaining a stable graft can be a viable option. If fracture fixation configuration is unstable, all graft and hardware should be removed, along with intravenous administration of antibiotics for 6 weeks. Notably, a revision surgery can be offered once apparent infection is controlled. In case of a major bone loss, vascularised graft may be needed.

REHABILITATION:

Objectives:

Improve and restore the function of the knee and ankle for activities of daily living, vocational and sports activities.

Duration:

The expected duration of rehabilitation is for 10 to 12 weeks.

Rehabilitation protocol:

- **Day 1 to day 10**: Limb is immobilized. Patient is allowed to do toe movements. Isometric quadriceps exercise is adviced**.**

- **10 day to 4 weeks :** After suture removal, gentle knee and ankle exercises are permitted if patient tolerates pain.
- **At 4 to 6 weeks:** After 6 weeks, patient is allowed for gentle and gradual active range of motion for knee joint and ankle. Patient is allowed for walking with support without bearing weight after 4weeks.
- **At 6 to 12 weeks:** After evaluation of x-ray finding, patient is instructed for partial weight bearing.

STATISTICAL ANALYSIS

Data was entered into microsoft excel data sheet and was analyzed using statistical package for the social sciences (SPSS) 22 version software. Categorical data was represented in the form of frequencies and proportions.

The present study is a purely descriptive study and the observations are tabulated with graphical representations of data. Microsoft excel and microsoft word was used to obtain various types of graphs such as bar diagram, pie diagram, line diagram. Hence statistical analysis is not necessary.

MATERIAL AND METHODS

The study is conducted in 30 patients, who presented with open tibial fractures to the department of orthopaedic surgery in RL Jalappa Hospital attached to Sri Devaraj Urs Medical College, Tamaka, Kolar from November 2016 to June 2018.

INCLUSION CRITERIA :

1. Patients diagnosed with Gustilo-Anderson open type II, IIIa fractures with or without fibular fractures.
2. Adults (more than 18 years of age).
3. Segmental and comminuted fractures.

EXCLUSION CRITERIA :

1. Pathological fractures.
2. Associated ipsilateral lower limb fractures.
3. Patients with pre-existing neurological and vascular diseases.

General information including name, age, sex, occupation, address were taken. A detailed history eliciting mode of injury, any history of road traffic accident, any associated direct injury to leg. Enquiry pertaining to site of pain was made and any swelling over the affected leg was also noted. Past medical and surgical illness history and family history were duly recorded. General condition of the patients was examined for pallor, pulse rate and blood pressure. Respiratory and cardiovascular system were examined for any abnormalities.

Local examination was done in the following steps:

1. **On inspection the following points were noted:** Abnormal swelling was present in the leg fracture. The condition of the skin over the tibia was noted for any abrasion, laceration and contusion.
2. **On palpation the following points were noted:** Palpation of the entire length of the affected tibia and fibula shows tenderness over fracture. The fractured tibia and fibula was also palpated for any abnormal mobility and crepitus.
3. **Movements:** The movements of the affected side ankle were restricted due to pain.

The distal neurovascular status of the affected lower limb was examined and also the associated injuries along with fractured tibia and fibula were noted.

Plain radiograph of entire tibia and fibula in antero-posterior and lateral views were taken to assess the site of fracture and the fracture type (displacement and comminution). The fractures were classified according to Gustilo-Anderson classification of open fractures. The affected lower limb was immobilized in above knee slab.

Routine investigation like haemoglobin %, total count, differential count, ESR, blood urea, sugar, serum creatinine, blood grouping with typing and ECG were done. HbsAg and HIV test were done before surgery on all patients.

All patients were operated as early as possible once the general condition of the patients were stable and the patients were fit for surgery as assessed by the anaesthetist.

Pre-operative preparation of patients:

- Patients were kept fasting for 6 hours before surgery.
- A written informed consent for surgery was taken.
- Local part preparation was done.
- Inj.Xylocaine test dose were given and noted if any hypersensitivity reaction occurred.
- Injection tetanus toxoid stat.
- Tranquilizers were given as advised by the anaesthetist.

- A systemic antibiotic usually injection amoxicillin + clavulanic acid 1.2 gm was administered intravenously 30 minutes before surgery to all patients. All patients were operated under spinal anaesthesia.

Instruments used for supracutaneous Locking compression plate fixation:

- 4.5 mm Locking Compression Plate.
- 2.7 mm drill-bit.
- 3.5 mm universal drill guide.
- Manmann / Synthes drill.
- 3.5 mm tap for cortical screw.
- Depth gauge.
- 3.5 mm cortical screw of varying sizes (12-22 mm).
- Hexagonal screwdriver.
- General orthopaedic instruments like retractor, periosteal elevator, reduction clamps and bone lever.

FIGURE NO. 11 : INSTRUMENTS USED FOR SUPRACUTANEOUS LOCKING COMPRESSION PLATE FIXATION

GENERAL PRINCIPLES OF LCP[56,57]

The basic principles of an internal fixation procedure using a conventional plate and screw system are direct, anatomical reduction and stable internal fixation of the fracture. Wide exposure of the bone is usually necessary to gain access to and provide good visibility of the fracture zone to allow reduction and plate fixation to be performed.

This procedure plate requires pre-contouring of the plate to match the anatomy of the bone, the screws are tightened to fix the plate onto the bone, which then compresses the plate onto the bone. This actual stability results from friction between the plate and bone. Anatomical reduction of the fracture was the goal of conventional plating technique, but over time, a technique of over bridging plate synthesis has been developed for multi fragmentary shaft fracture, that thanks to reduction of vascular damage to bone, permits healing with the callus formation, as seen after locked nailing. Since the damage to the soft tissue and the blood supply is less extensive, more rapid fracture healing can be achieved.

The newly developed, so called locked internal fixators consists of plate and screw system where the screws are locked in plate. This locking minimize the compressive forces exerted by the plate on to bone, the plate does not need to touch the bone at all, which is of particular to achieve stability. Advantage so called minimal invasive percutaneous plate osteosynthesis, precise anatomical contouring of a plate is no longer necessary, because the plate does not need to be pressed to achieve on to the bone stability. This prevents primary dislocation of the fracture caused by exact contouring of a plate. The LISS plates are pre-contoured to match the average anatomical form of the relevant site and, therefore do not have to be further adapted intraoperatively. The development of the locked internal fixator method has been based on scientific insights into bone biology especially with reference to its blood supply. The basic locked internal fixation technique aims at flexible elastic fixation to initiate spontaneous healing, including its induction of callus formation. This technology supports what is currently known as MIPPO. The development of the LCP has only been possible based on the experience gained with PC-FIX and LISS. With reference to the mechanical, biomechanical and clinical results, the new AO LCP with combination holes can be used, depending on the fracture situation, as a compression plate, a locked internal fixator, or as an internal fixation system combining both techniques.

The LCP with combination holes can also be used, depending on the fracture situation, in either a conventional technique, bridging technique, or a combination technique. A combination of both screw type offers the possibility to achieve a synergy of both internal fixation methods.

If the LCP is applied as a compression plate, the operative technique is much the same as conventional technique, in which existing instruments and screws can be used. The internal fixator method can be applied through an open but less invasive or an MIPPO approach. An indirect closed reduction method is necessary when using the LCP in the internal fixator bridging the fracture zone. A combination of both plating technique is possible and valuable depending on the indication. It is important to command knowledge of both technique and their different features.

BIOMECHANICS OF LCP[58]

Internal fixation devices rely on some of mechanical interface between the devices and the bone to hold the construct together. The traditional DC plates and the later LC-DC plates used as friction fit between the plate and the bone. The external fixator relies instead on mechanical fit between the pins and the bars by way of the clamps. The idea of locked screw plate or internal fixator came about in an attempt to extract the benefits each of the systems and ideas where avoiding their less desirables attributes. This became necessary because of the poor performance of standard implants in the realm of minimally invasive fracture work as well as bridging fixation, the threaded screw concept of locked plating devices is designed use a mechanical interface between plate and the screw, to bear the loads and stabilize the construct. As the screw is advanced the final 3 to 4 turns, the male threads on the screw mate with the female threads on the plate to form a mechanical lock between the two.

The idea for this locking design concept bearing that this construct will provide axial and angular stability and therefore not permit screw back out, screw toggle, or many of the causes of hardware failure in osteosynthesis application additionally because compression between plate and bone is not required, there will be less disruption to the cortical blood supply.

THE BENEFITS OF LOCKING COMPRESSION PLATE BIOMECHANICAL AND CLINICAL FINDINGS.[56]

1. The plate and screws from one stable system and the stability of the fracture depends on the stiffness of the construct. Locking the screw into the plate ensure angular as well as axial stability, eliminates the possibility of the screw to toggle, slide or dislodge and thus strongly reduces the risk of postoperative loss of reduction.
2. Multiple angle stable screw fixation in the epiphyseal and metaphyseal region allows for fixation of many fractures that are not treatable with standard devices.
3. Improved stability in multi fragmentary, complex fractures, which have loss of medial / lateral buttress or have bone loss – double plating method.
4. The fixed angle stability avoids subsidence of fixation in metaphyseal areas. This allows for less precise contouring of the plate, as fixation depends on plate screw construct rather than friction between plate bone interface.
5. Improve biology for healing, this is achieved by avoiding compressive forces on bone and also by elastic fixation in bridging techniques.
6. Improved biology and fixation lead to better clinical outcomes and faster healing.
7. Better fixation in osteoporotic bone, especially in epiphyseal and metaphyseal areas divergent locked screws improve the pull out of

resistance of entire construct. These locked systems have higher core diameter and resist cantlier and bending forces at screw cortex junction and fixed angle devices are not subject to the toggling seen with unlocked screws which improves fixation in osteoporotic bone.

8. No or less for primary bone graft as more fractures fixed with bridging technique with elastic fixation and also became of angle stable constructs avoiding post operative collapse.

BENEFITS OF LCP ARE SEEN ESPECIALLY IN THE FOLLOWING SITUATION.

1. Epiphyseal / metaphyseal fractures (short articular block, little bone mass for purchase, angular stability)
2. In situation where the MIPPO technique is possible, because accurate contouring of plate is not mandatory.
3. Fractures with severe soft tissue injuries.
4. Fractures in osteoporotic bone.
5. Shaft fractures in children.

LCP AS AN EXTERNAL FIXATOR :

Conceptually, the angle-stable LCP is an internally placed unibody, monolateral fixator. Although designed for epi-periosteal application, increasing the plate to bone distance for locations with a pronounced muscle sleeve results in submuscular placement, desirable where comminution is present to bridge fragments while preserving vascularity. For subcutaneous bones such as tibia, ulna and clavicle, increasing the plate-to-bone distance lifts the LCP into an extra-corporeal location, while preserving it's inherent characteristics of flexibility (long-span) and stability (locked-screw).[59] This concept has been previously elaborated up on by Ramotowski and Granowski, who defined the possible depths of plate fixation as para-osseous, subcutaneous and external osteosynthesis for femur, humerus and tibia or ulna respectively.[34]

Standard and circular external fixators for the tibia are often bulky and uncomfortable for the patient. Most patients also find them aesthetically unacceptable. External fixation with an anatomically shaped LCP metaphyseal plate as described, imparts a much lower profile. Peter Kloen et al were the first to describe the use of LCP as external fixator.[36] The low profile external fixator plate is easily concealed under regular clothing, and there is minimal tendency for the plate to strike the opposite leg in the swing phase of gait of either leg during ambulation.

From the surgeon's perspective, the multiple locking holes of the proximal and distal metaphyseal LCP provide many options for fixation, versus the more standard usage of two large external fixator pins.

Despite its low profile, external fixation with the metaphyseal LCP seems strong enough to withstand the forces acting on the tibia.

During plate application, both plate and bone fragment can move independently, making accurate screw placement difficult as small shifts will cause the plate to translate to great deviations at level of the bone.

Notwithstanding the traditional fixation, mono-axial nature of locking head screw trajectory lowers the ability to duly compensate for imperfect placement, mandating an absolute achievement of anatomical reduction of the fracture prior to the placement of the first screw. While traditional constructs can be additionally strengthened by using stacking connecting rods, same is not possible for LCP external fixation. In such cases, which need increased stability, double LCP fixation must be used according to Kloen's strategy.[36]

The prevalence of open tibia nonunions is known to increase with increased severity of open fractures. The periosteal and endosteal blood supply, which are considered as most important for fracture healing, are frequently compromised with open fracture.[26] Role of LCP as an external device serves two purposes; it helps in stabilizing the fracture and also in preserving the vascularity of the bone and promotes union. Non-union secondary to infection in open fractures of the tibia is a commonly encountered event that can be avoided by external stabilization devices.[25] However, LCP acting as an external device is seen to be superior and more advantageous than other conventional external fixators.

Supracutaneous LCP removal can be performed comfortably under local anaesthesia. Also it imparts a lesser conspicuous radiographic silhouette as compared to the traditional fixators thereby enabling the treating surgeons for easier assessment of fracture healing. Stress shielding at the fracture site is reduced by small amount of axial micromotion.

TECHNIQUE FOR PLATE AND SCREW FIXATION :

Type of Anesthesia - Spinal (Lumbar sub-arachnoid block)

Patient Position - Supine with affected leg elevated on a pillow/sandbag

Surgical technique and protocol :

Plate selection :

- The plates were selected from the available various lengths and configurations depending on the fracture type, pattern and location.
- If necessary, a bending template was used to determine plate length and configuration.
- The bending instruments were used to contour the locking compression plate if required.

- **Reduction :**
- After administering spinal anaesthesia, the involved limb of the patient was prepared and draped in standard sterile protocol. Pre-operative antibiotic was given. Also, tourniquet was not used; so as to intravenous antibiotic reach the open fracture site to effectively reach. The fracture is reduced preliminarily by manual traction and use of pointed reduction forceps. Adequate reduction of the fracture is confirmed using an image intensifier.
- An appropriate and thorough debridement with generous wound wash was given. Fracture fragments were reduced before the wound closure. Concomitant fibula

fracture at the same level plays an important role in reduction. Fixation of distal fibula fracture is advocated before fixation of the tibia to achieve a better alignment and to prevent valgus / varus malalignment. Routine fixation of the distal fibula fracture was done in the present study with rush nail.

- Following, an LCP for the tibia of precisely appropriate length was chosen. Next the plate was fixed initially to proximal and distal fragments along the anteromedial aspect of tibia using k-wires after ascertaining fracture reduction under fluoroscopy guidance. Plate positioning is over the anteromedial aspect of tibia as it substantially reduces the risk of neurovascular injury. It is technically easier as anteromedial aspect of tibia is clearly palpated facilitating easy, fast and accurate insertion of screws. The medially placed screws have less influence on the activity of muscles. The laterally placed plate had many disadvantages.

- The distance between plate and bone is large, resulting in increased offset. Additionally, the screws may only achieve unicortical purchase. These factors decreased the stiffness of the fixation construct. At the same time, laterally placed screws passed through the muscles on the anterolateral aspect of tibia can compromise the activity of muscles and cause discomfort, pin site effusion, and even cause neurovascular injuries.[60] LCP was placed in close proximity to the bone as possible, yet still allowing some space for swelling and regular wound care, to increase the mechanical stability of fixation. A spacer of uniform thickness is placed between the plate and skin. Bicortical locked screws were preferred while using LCP as the external fixator. For the tibial fracture management, a minimum of 4 screws proximally and distally, three to four screws are preferred.

- Successive holes were drilled over locking drill-guides through stab incisions and screws were placed distally first and subsequenty in the proximal fragment after achieving adequate reduction. Closure of compound wound was generally done in one layer after placement of supracutaneous LCP. Subsequently regular sterile dressing of the screw tract and compound wound dressings were carefully done.

INTRAOPERATIVE PICTURES

Figure No.12 : Operative limb after painting and draping

Figure no.13 : Plate was fixed over anteromedial aspect of tibia using k-wires

Figure No.14 : Drilling for application of locking screw over the distal fracture fragment

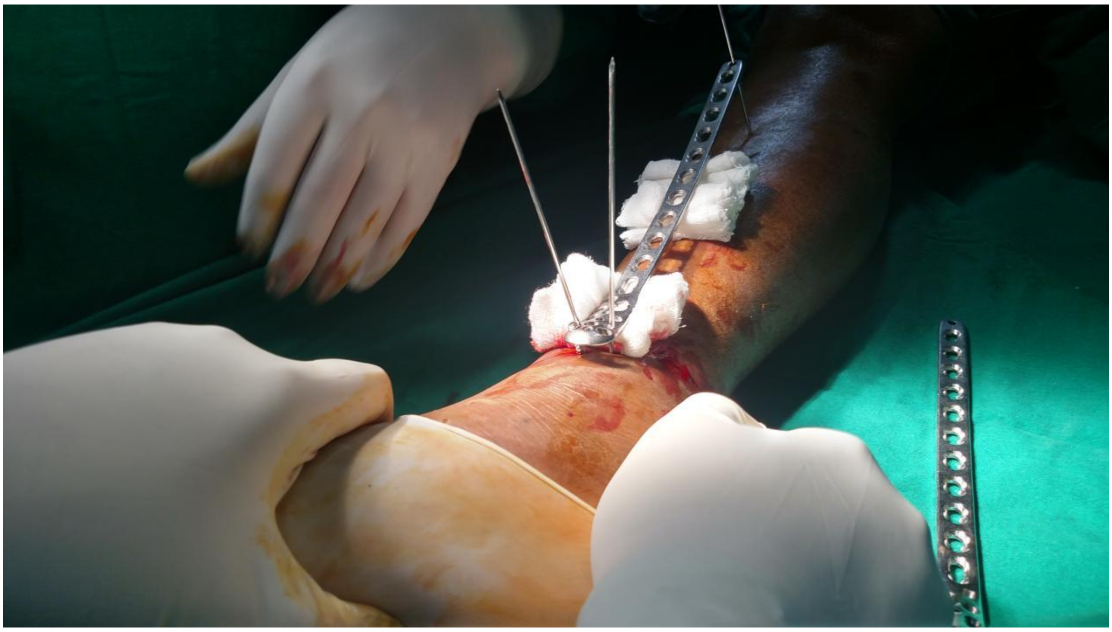

Figure no.15 : Space is created between plate and skin

Figure no.16 : Proximal locking screw application

IMPLANT REMOVAL

Figure No.17 : Draped and painted for implant removal

Figure No.18 : Unlocking of screw heads

Figure No.19 : Post plate and screws removal

Post-operative treatment:

Post-operative treatment with locking compression plates does not differ from conventional internal fixation procedures.

Post-Operative care:

- Patients were kept nil by mouth for 4 to 6 hours post-operatively.
- Adequate intravenous fluids and analgesics were administered as needed.
- Antibiotics were given for 14 days.
- Analgesics were given as per the patient's requirements.
- The operated limb was splinted.
- ROM exercises of toes started immediately.
- Check x-rays were taken.
- The wound was inspected at 2nd post-operative day.
- Removal of sutures was done on 10th post-operative day.
- All patients were given appropriate advice and counselling at discharge.
- Rehabilitation of the affected limb was commenced at the end of 2 weeks. Gentle exercises of the knee and ankle were allowed. At 4 to 6 weeks active range of motion of the knee and ankle was allowed.

Follow up :

- All the patients were followed up post operatively at 6, 18 and 24 weeks.
- Local examination of the affected tibia and fibula for tenderness, instability, deformity, knee and ankle movements were assessed.
- X-rays were taken at each follow up visits to know about progressive fracture union and implant position.

• Rehabilitation of the affected extremity were done according to the stage of fracture union and time duration from day of surgery.

• Implant was removed 4 weeks following fracture union.

• Patients were followed up till 6 months.

The final functional outcome was assessed by Johner and Wruh's criteria[61] at the final follow up.

Johner & Wruh's Criteria for Evaluation of Final Results

Sl. No.	Criteria	Excellent (Left=Right)	Good	Fair	Poor
1.	Non-unions, ostetitis, amputation	None	Non	None	Yes
2.	Neurovascular disturbances	None	Minimal	Moderate	Severe
3.	Deformity				
	Varus/ Valgus	None	2-5°	6-10°	>10°
	Anteversion/ Recurvation	0-5°	6-10°	11-20°	>20°
	Rotation	0-5°	6-10°	11-20°	>20°
4.	Shortening	0-5mm	6-10mm	11-20mm	>20 mm
5.	Mobility				
	Knee	Normal	>80%	>75%	<75%
	Ankle	Normal	>75%	>50%	<50%
	Subtalar	>75%	>50%	<50%	--
6.	Pain	None	Occasional	Moderate	Severe
7.	Gait	Normal	Normal	Insignificant limp	Significant limp
8.	Strenuous activities	Possible	Limited	Severely limited	Impossible
9.	Radiological union	Consolidated	Consolidated	Union	Not consolidated

RESULTS AND OBSERVATIONS

The present study consists of 30 patients of open tibial fractures which were treated surgically with supracutaneous locking compression plate fixation at Sri Devaraj Urs Medical College, Kolar. All the patients were followed up post operatively at 6, 18 and 24 weeks. Results were analyzed both clinically and radiologically using Johner and Wruh's criteria.

AGE DISTRIBUTION :

In present study, patient age group ranged from 25 to 70 years with mean age being 43 years.

TABLE NO.7 : AGE DISTRIBUTION

Age in years	No. of Patients	Percentage
21-30	5	16.7%
31-40	9	30%
41-50	9	30%
51-60	4	13.3%
61-70	3	10%
Total	30	100%

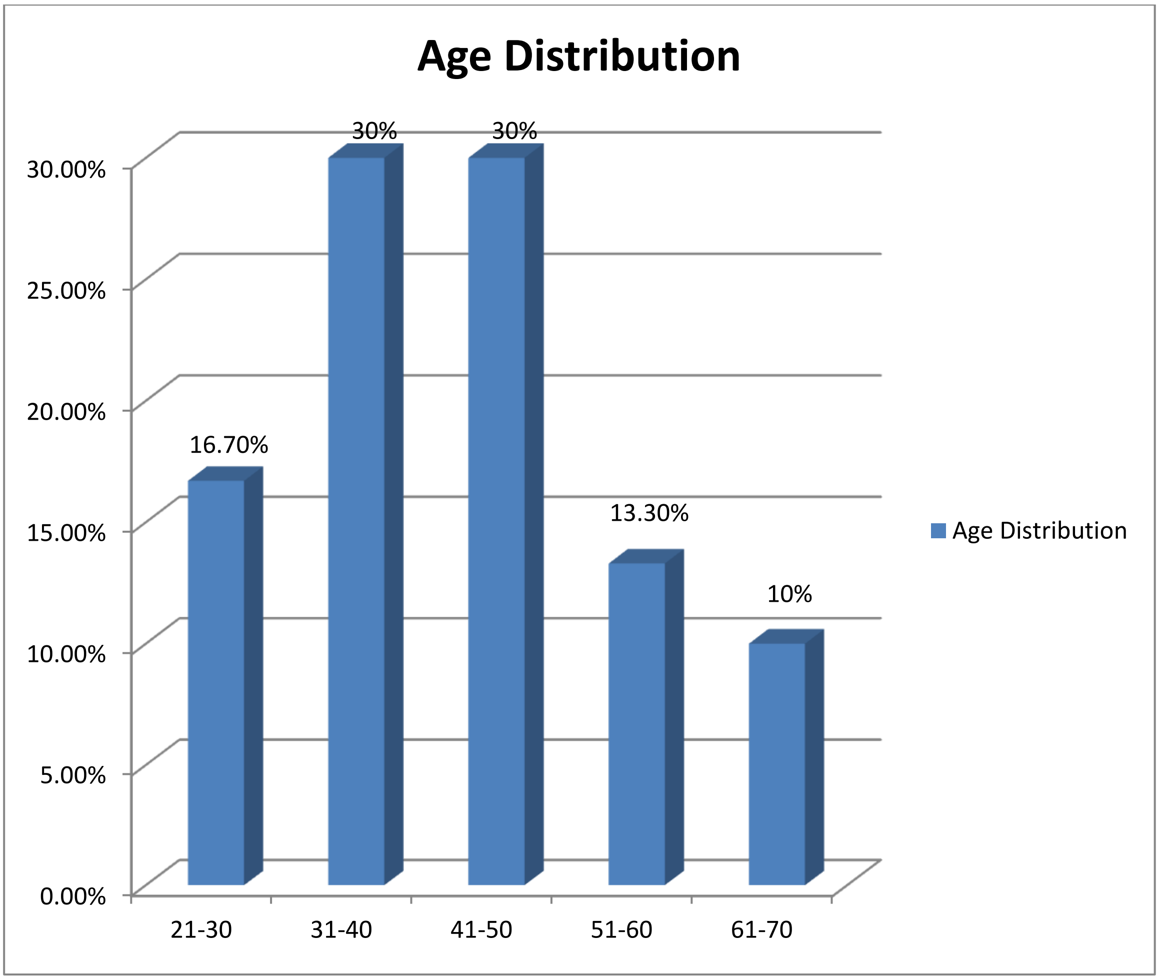

CHART NO.1 : BAR DIAGRAM SHOWING AGE DISTRIBUTION

GENDER DISTRIBUTION :

In present study, out of 30 patients 86.7% were male and 13.3% were female patients. Male to female ratio is 6.5:1.

TABLE NO.8 : GENDER DISTRIBUTION

Gender	No. of patients	Percentage
Male	26	86.7%
Female	04	13.3%
Total	30	100%

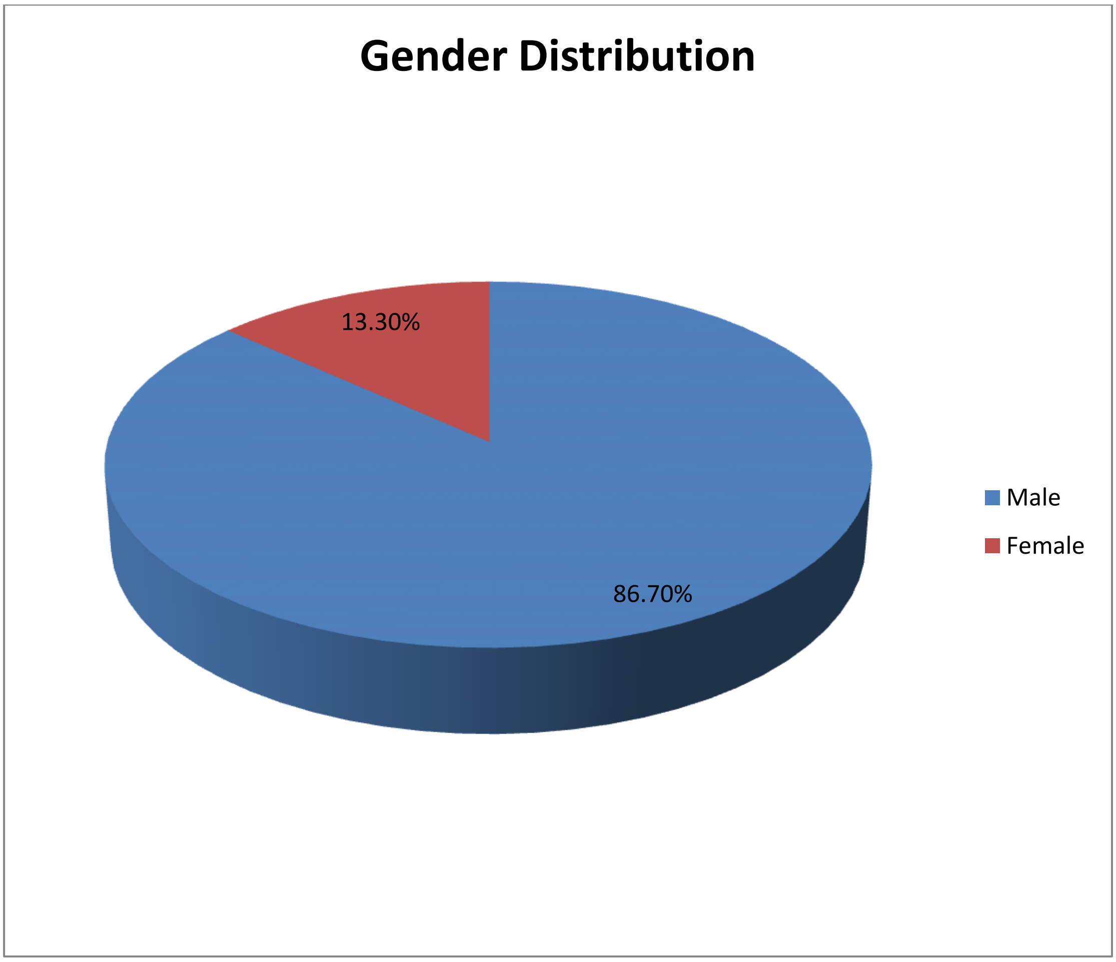

CHART NO.2 : PIE CHART SHOWING GENDER DISTRIBUTION

SIDE AFFECTED :

In present study, out of 30 patients right leg was affected in 40% patients, while left leg was affected in 60% patients.

TABLE NO.9 : SIDE AFFECTED

Side	No. of Patients	Percentage
Right	12	40%
Left	18	60%
TOTAL	30	100%

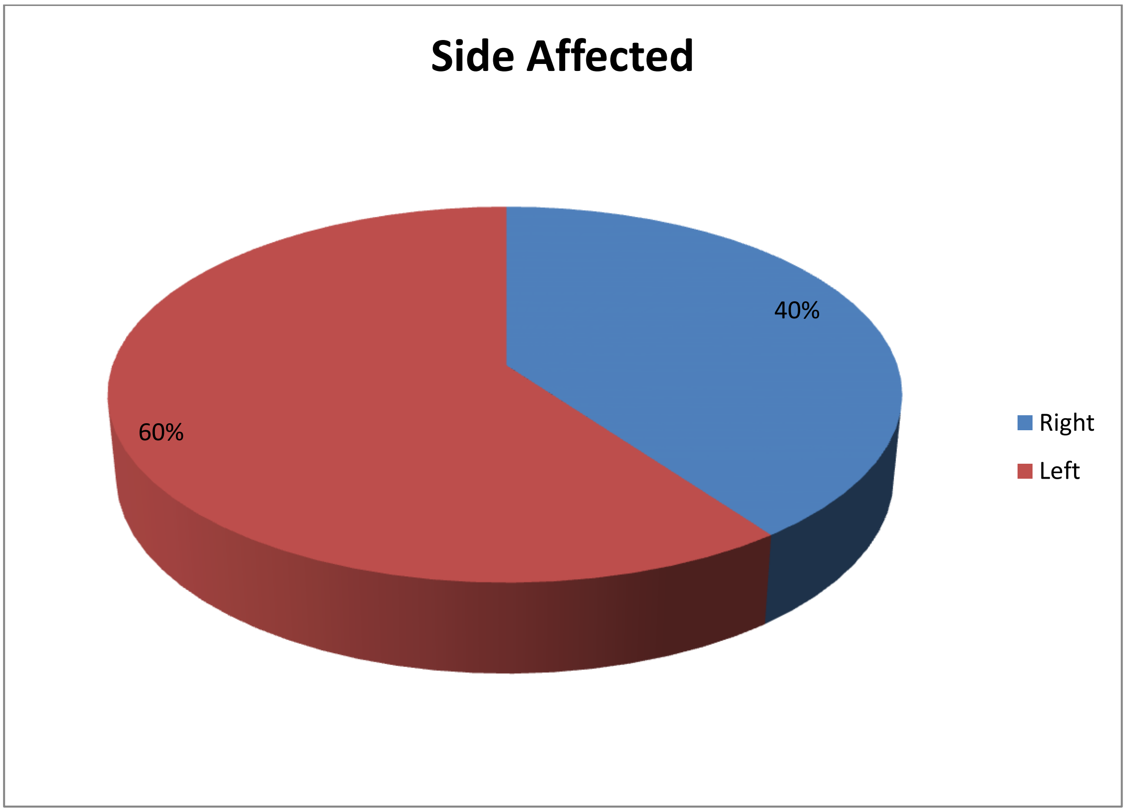

CHART NO.3 : PIE CHART SHOWING SIDE AFFECTED

MODE OF INJURY:

In present study, out of 30 patients mode of injury was RTA in 83.3% of patients while it was self fall in 16.7% of patients.

TABLE NO.10 : MODE OF INJURY

Mode of injury	No. of patients	Percentage
RTA	25	83.3%
Self fall	05	16.7%
Total	30	100%

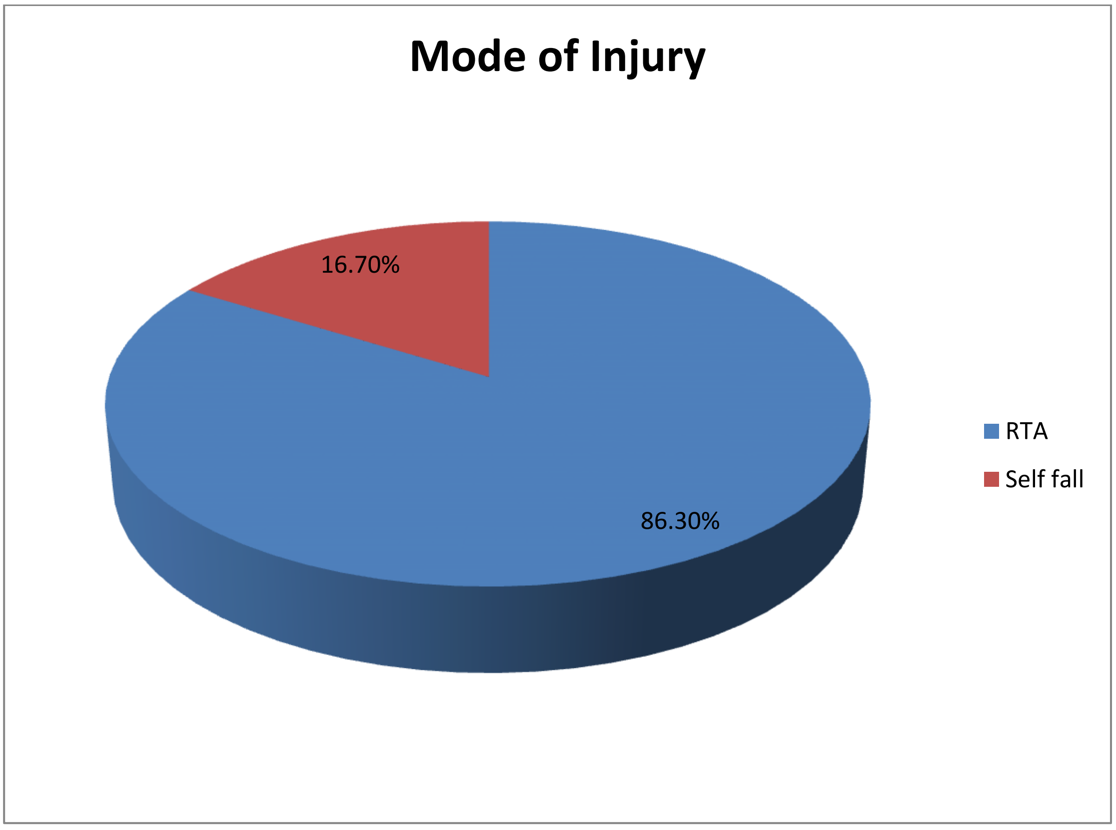

CHART NO.4 : PIE CHART SHOWING MODE OF INJURY

OPEN FRACTURE TYPE :

In present study, out of 30 patients 60% patients were under Type II in Gustilo-Anderson classification, while 40% patients were under Type IIIA.

TABLE NO.11 : OPEN FRACTURE TYPE

TYPE	No. of Patients	Percentage
Type-II	18	60%
Type-IIIA	12	40%
Total	30	100%

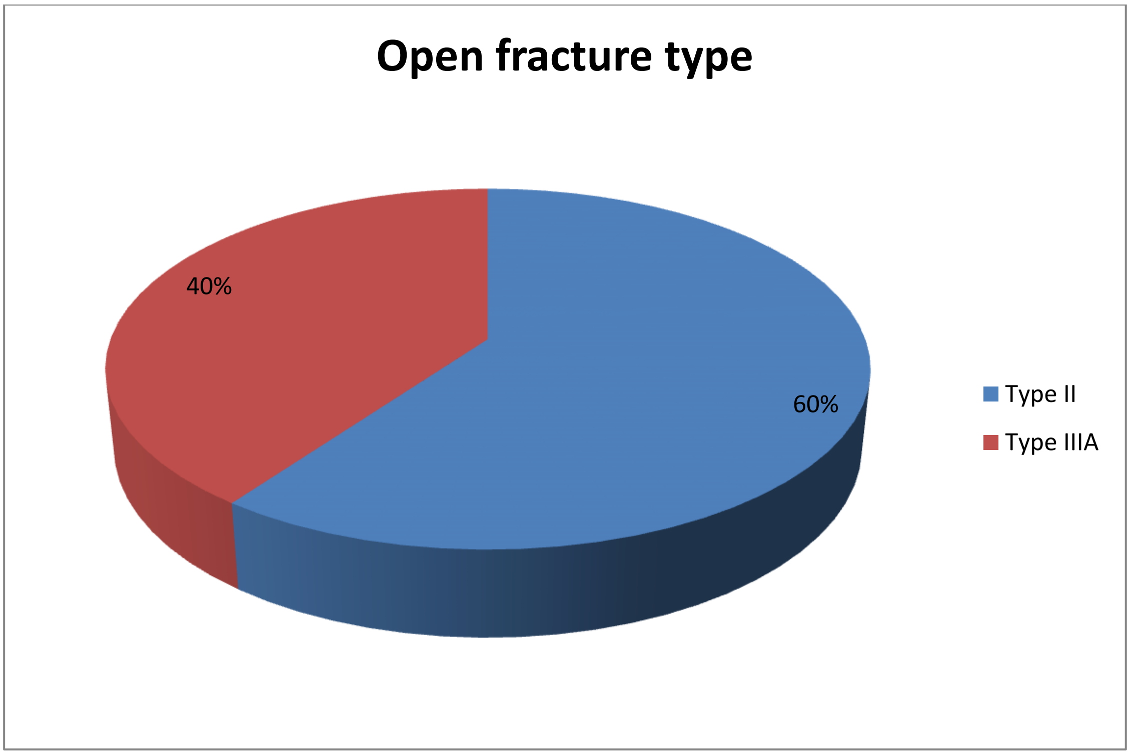

CHART NO.5 : PIE DIAGRAM SHOWING OPEN FRACTURE TYPE

SITE OF FRACTURE AT TIBIA :

In present study, out of 30 patients proximal third, middle third and distal third fractures accounted for 10%, 10% and 80% respectively.

TABLE NO.12 : SITE OF FRACTURE AT TIBIA

Location	No. of Patients	Percentage
Proximal third	03	10%
Middle third	03	10%
Distal third	24	80%
Total	30	100%

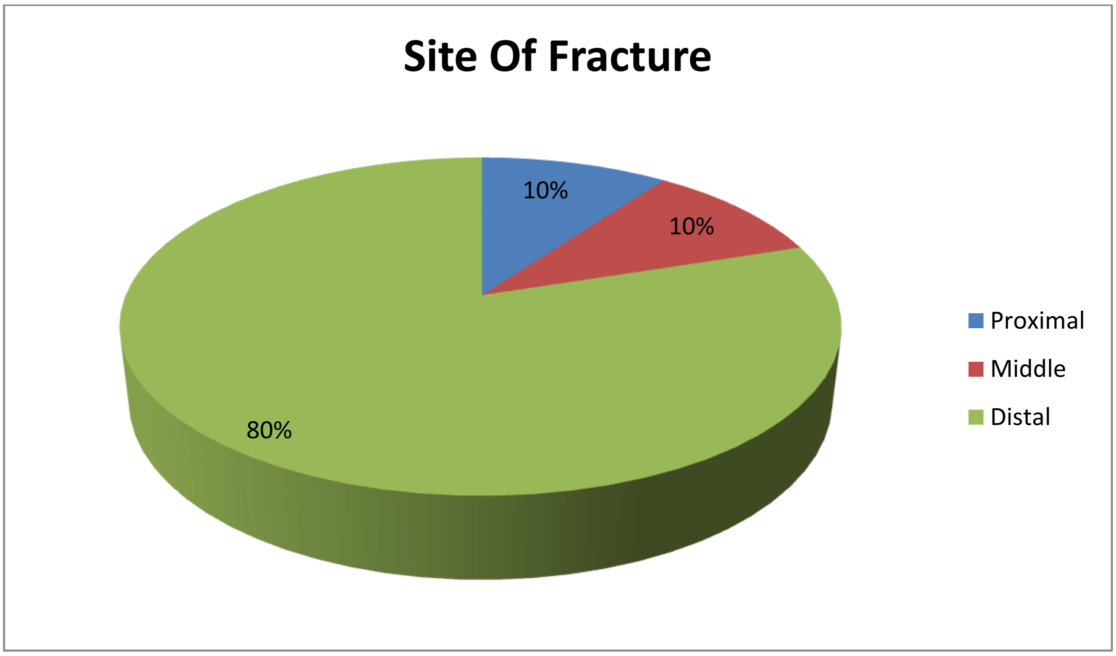

CHART NO.6 : PIE CHART SHOWING SITE OF FRACTURE AT TIBIA

ASSOCIATED COMORBIDITIES:

In present study, out of 30 patients, 16.7% had comorbidities among which 10% were hypertensive and 6.7% were diabetic. 83.3% patients had no comorbidities.

TABLE NO.13 : ASSOCIATED COMORBIDITIES

Comorbidity	No. of Patients	Percentage
Hypertension	3	10%
Diabetes Mellitus	2	6.7%
No comorbidities	25	83.3%
Total	30	100%

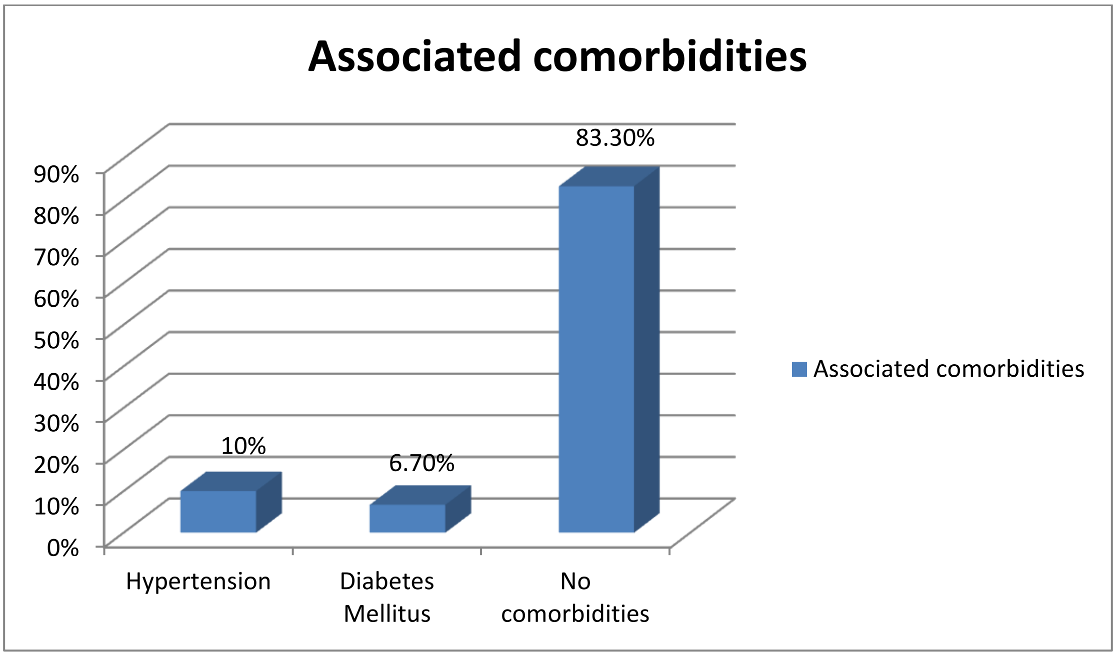

CHART NO.7 : BAR DIAGRAM SHOWING ASSOCIATED COMORBIDITIES

INJURY SURGERY INTERVAL:

In present study, out of 30 patients, injury surgery interval was within 24 hours in 3 patients, 24-48 hours in 21 patients and 48-72 hours in 6 patients.

TABLE NO.14 : INJURY SURGERY INTERVAL

Injury Surgery Interval	No. of Patients	Percentage
< 24 hrs	03	10%
24 - 48 hrs	21	70%
48-72 hrs	06	20%
Total	30	100 %

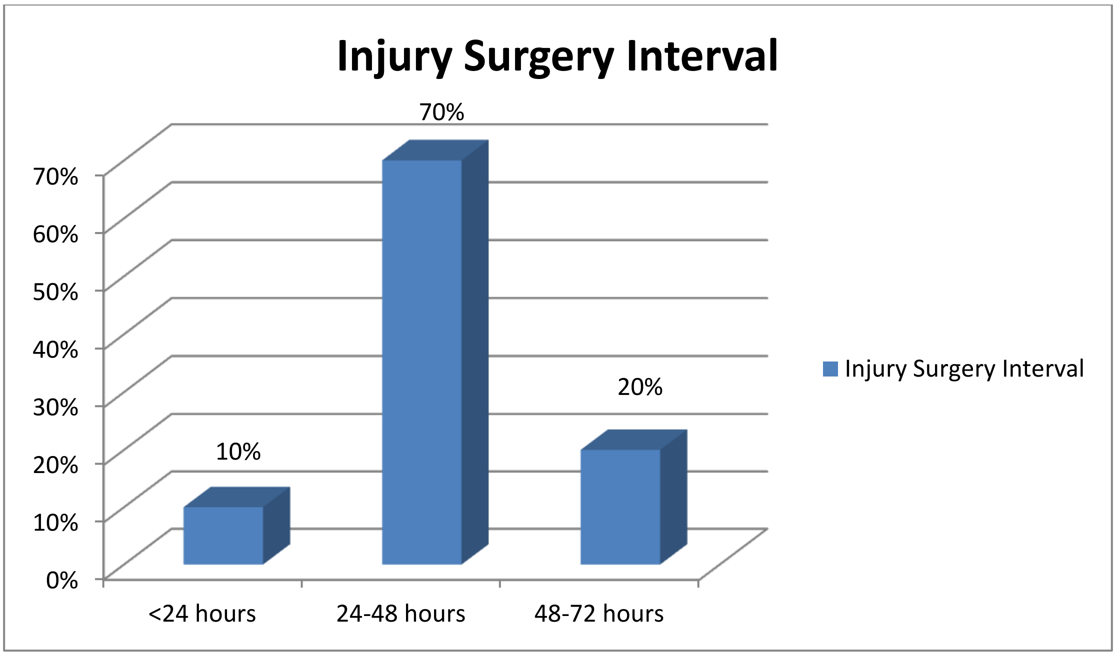

CHART NO.8 : BAR DIAGRAM SHOWING INJURY SURGERY INTERVAL

DURATION OF SURGERY :

In present study, out of 30 patients duration of surgery was 41-60, 61-80, 81-100 and 101-120 minutes for 10, 13, 4 and 3 patients respectively.

TABLE NO. 15 : DURATION OF SURGERY

Duration (Mins)	No.of cases	Percentage
41-60	10	33.33%
61-80	13	43.33%
81-100	4	13.33%
101-120	3	10%
Total	30	100%

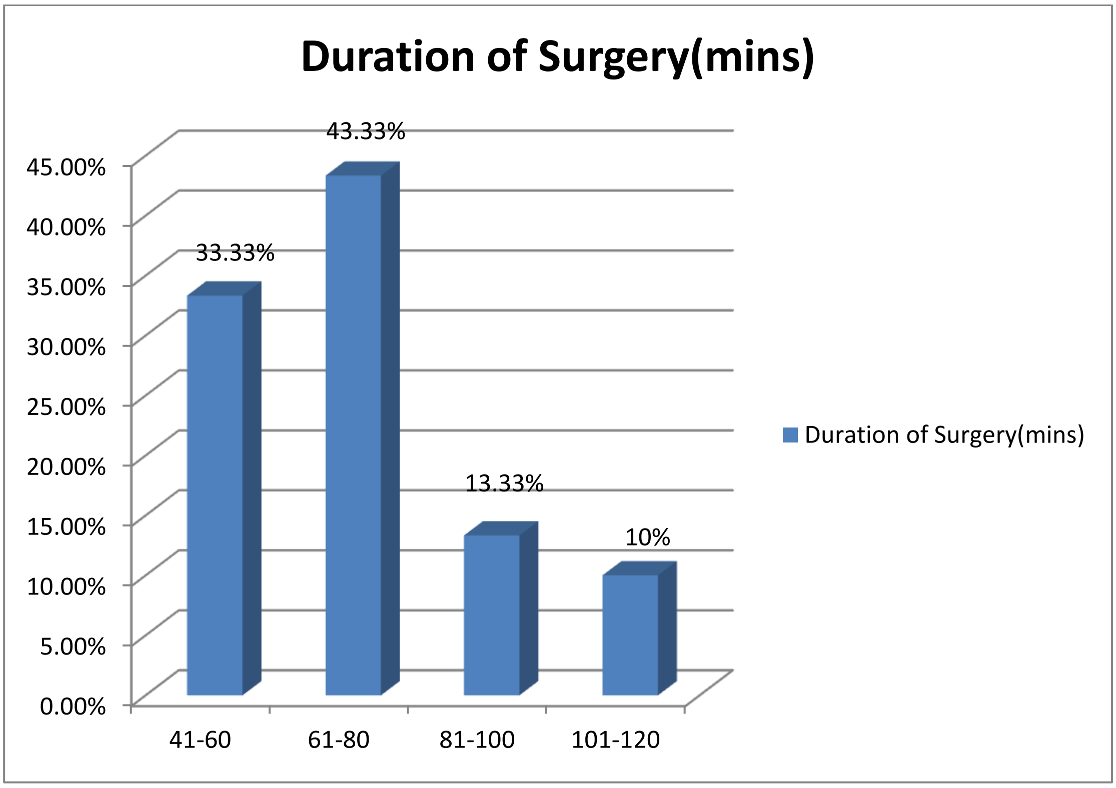

CHART NO.9 : BAR DIAGRAM SHOWING DURATION OF SURGERY

TIME OF FRACTURE UNION :

In present study, out of 30 patients fracture union time was 18 and 24 weeks in 13 patients each respectively. Nonunion was reported in 4 patients.

TABLE NO.16 : TIME OF FRACTURE UNION

Time (In Weeks)	No. of patients	Percentage
18	13	43.33%
24	13	43.33%
Nonunion	4	13.33%
Total	30	100%

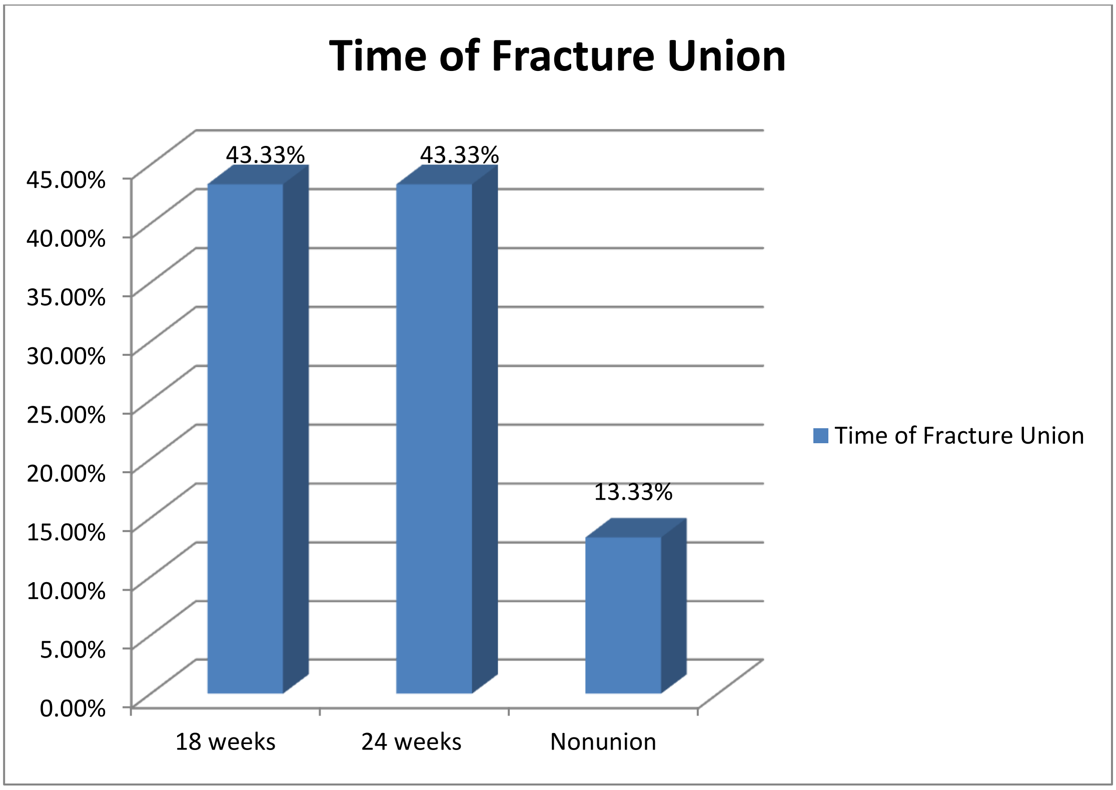

CHART NO.10 : BAR DIAGRAM SHOWING TIME OF FRACTURE UNION

IMPLANT INSITU TIME :

In present study, out of 30 patients implant insitu time was 22, 24, 28 weeks in 13, 4 and 13 patients respectively.

TABLE NO.17 : IMPLANT INSITU TIME

Time (weeks)	No. of patients	Percentage
22	13	43.33%
24	4	13.33%
28	13	43.33%
Total	30	100%

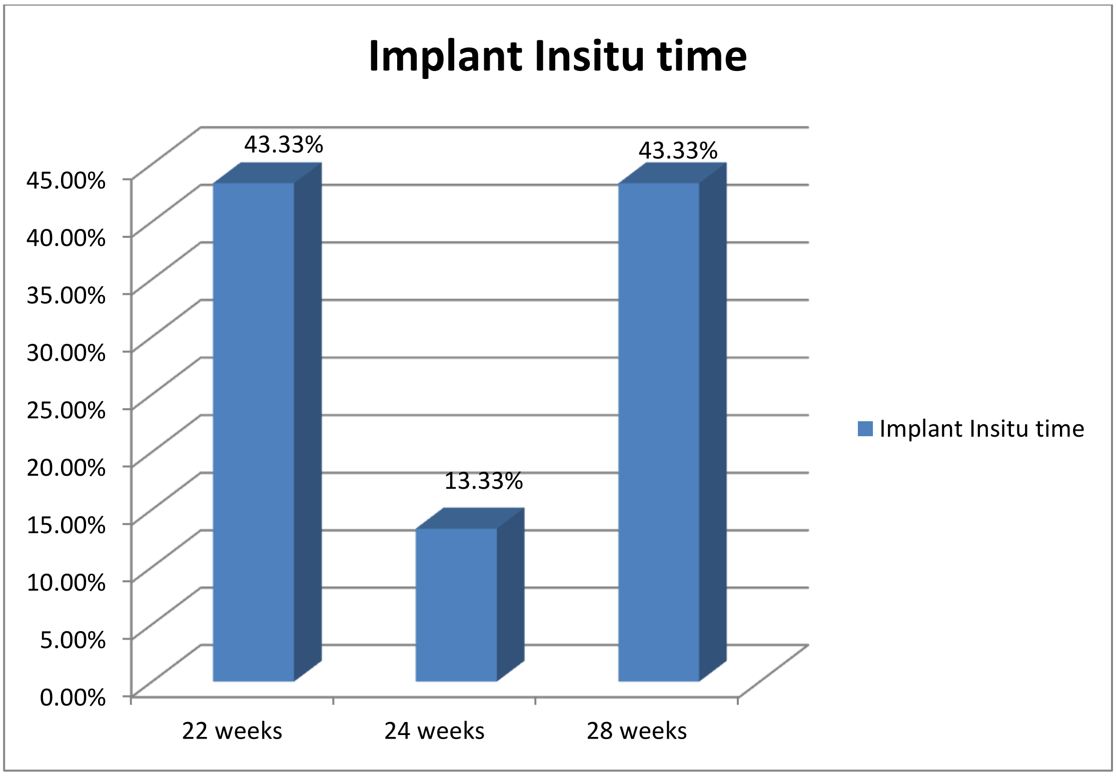

CHART NO.11 : BAR DIAGRAM SHOWING IMPLANT INSITU TIME

TIME FOR PLATE REMOVAL :

In present study, out of 30 patients, time for plate removal was 5-10, 11-15 and 16-20 minutes in 16, 12 and 2 patients respectively. In this study, all screws and plates of 30 patients were removed in clinic without difficulty with average time being 11 minutes.

TABLE NO. 18 : TIME FOR PLATE REMOVAL

Time (In mins)	No. of patients	Percentage
5-10	16	53.33%
11-15	12	40%
16-20	2	6.67%
Total	30	100%

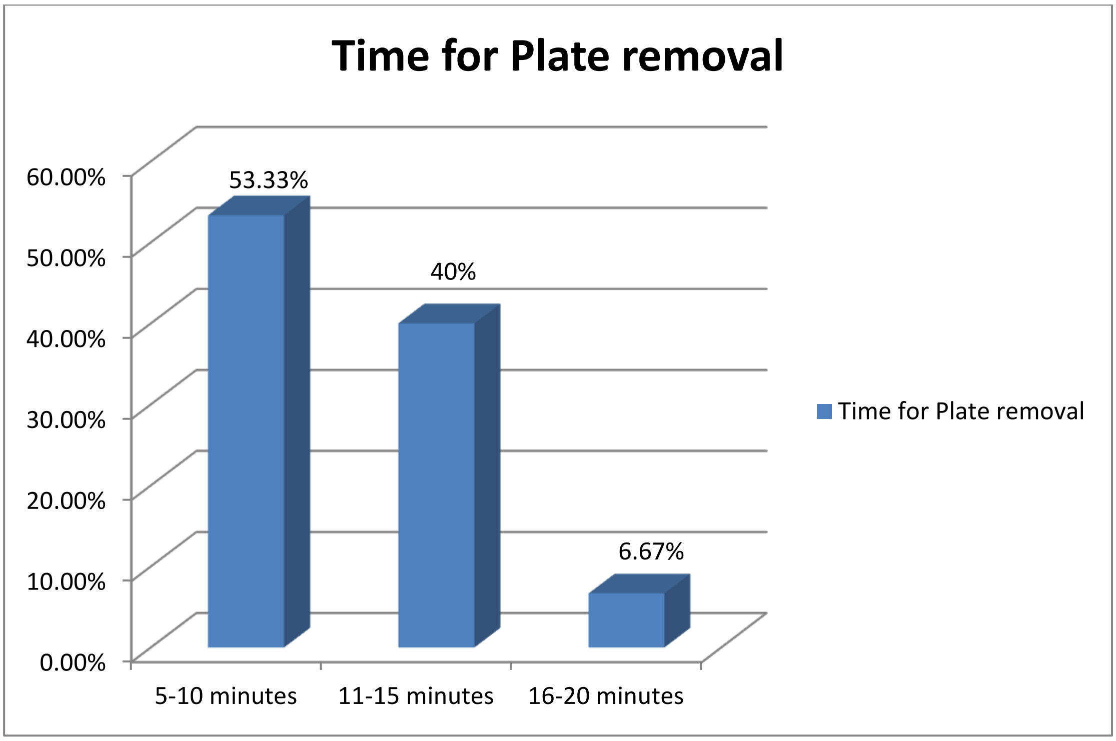

CHART NO. 12 : BAR DIAGRAM SHOWING TIME FOR PLATE REMOVAL

KNEE ROM :

In present study, out of 30 patients 16 patients had normal ROM, 11 patients had > 80% ROM, 2 patients had 75-80% ROM, 1 patient had <75% ROM. ROM quantified in percentage with respect to normal limb as per Johner & Wruh's criteria.

TABLE NO.19 : KNEE ROM

ROM	No. of patients	Percentage
Normal	16	53.33%
>80%	11	36.67%
75-80%	2	6.7%
<75%	1	3.3%
Total	30	100%

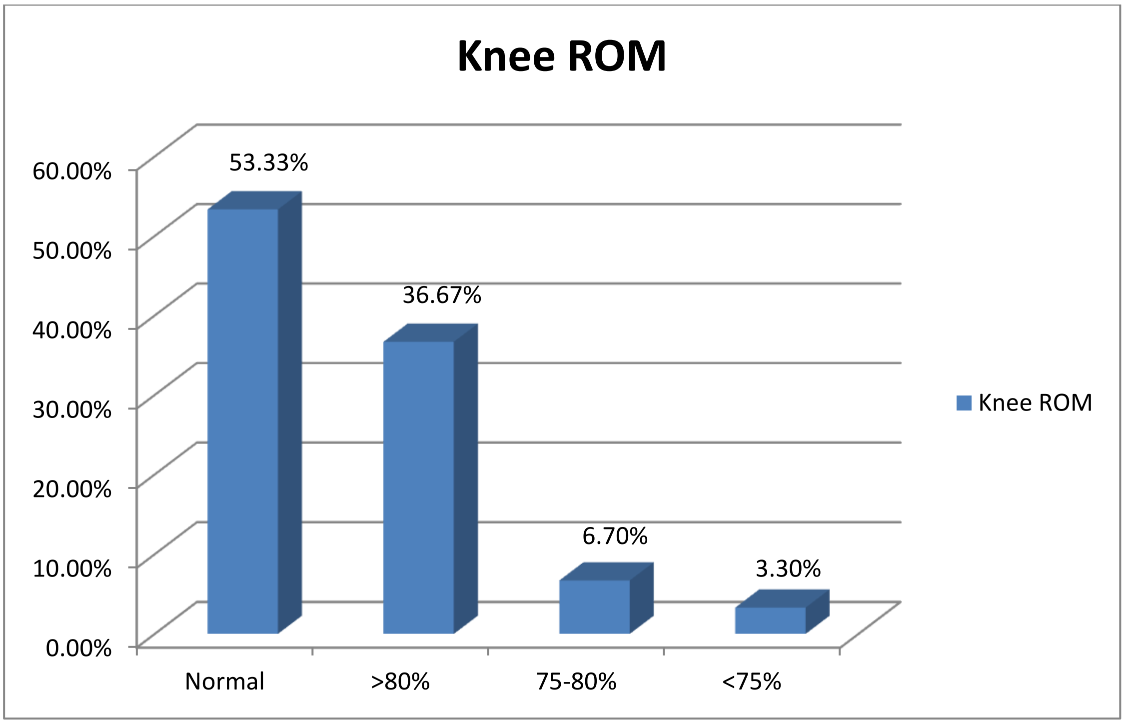

CHART NO.13 : BAR DIAGRAM SHOWING KNEE ROM

ANKLE ROM :

In present study, out of 30 patients 18 patients had normal ROM, 9 patients had > 75% ROM, 2 patients had 50-75% ROM, 1 patient had <50% ROM. ROM quantified in percentage with respect to normal limb as per Johner & Wruh's criteria.

TABLE NO.20 : ANKLE ROM

ROM	No. of patients	Percentage
Normal	18	60%
>75%	9	30%
50-75%	2	6.7%
<50%	1	3.3%
Total	30	100%

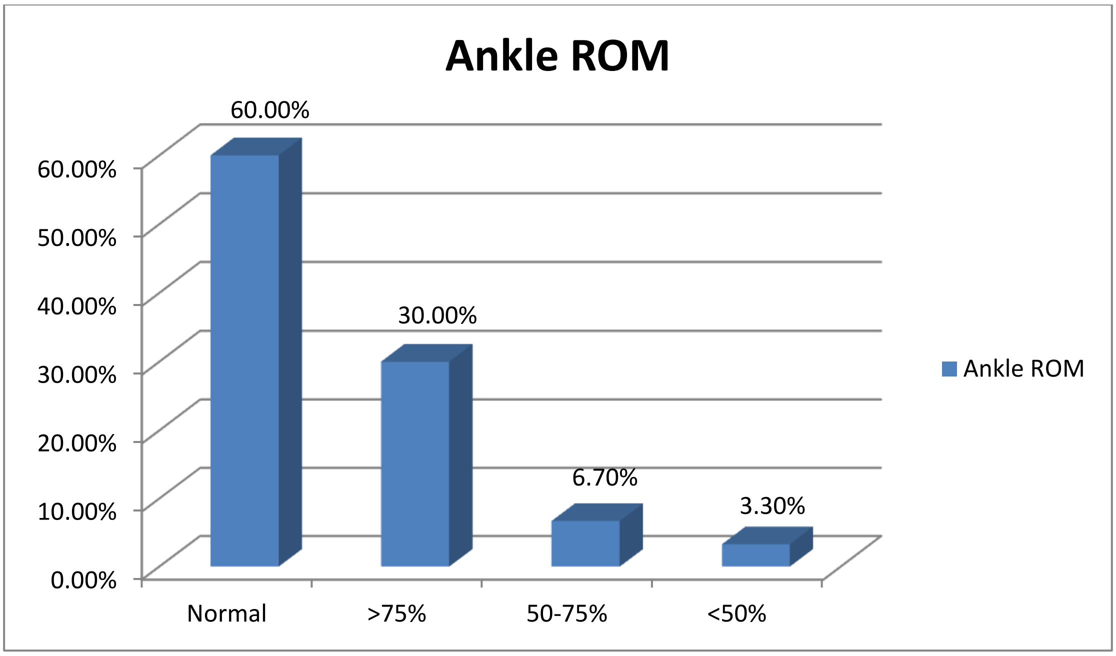

CHART NO.14 : BAR DIAGRAM SHOWING ANKLE ROM

COMPLICATIONS :

In present study, out of 30 patients 1 patient had infection and nonunion, 3 other patients developed nonunion. The patient with infection and nonunion was treated with debridement, antibiotic coated K nail with antibiotic coated beads. For remaining 3 patients who went for nonunion, were treated with intramedullary interlocking nail application.

TABLE NO.21 : COMPLICATIONS

Complications	No. of Patients	Percentage
Infection and nonunion	1	3.33%
Non Union	3	10%
No Complications	26	86.67%
Total	30	100%

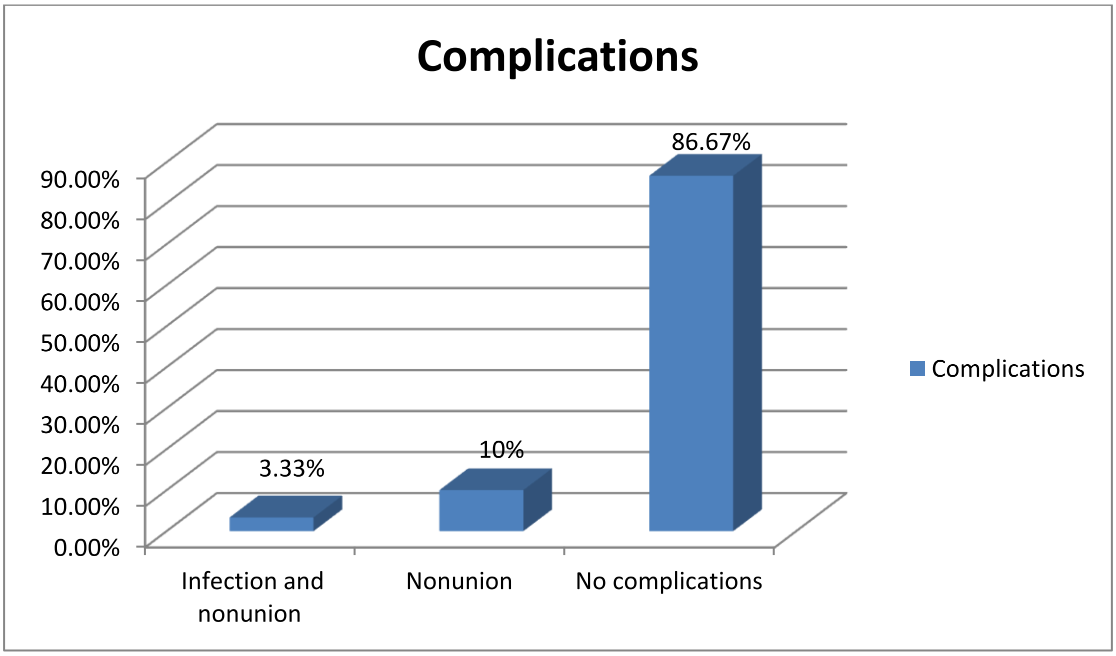

CHART NO.15 : BAR DIAGRAM SHOWING COMPLICATIONS

FUNCTIONAL OUTCOME AS PER JOHNER AND WRUH'S CRITERIA

In present study, out of 30 patients 53.33%, 26.67%, 6.7% and 13.3% patients had excellent, good, fair and poor outcome respectively.

TABLE NO.22 : FUNCTIONAL OUTCOME AS PER JOHNER AND WRUH'S CRITERIA

Functional Outcome	No. of Patients	Percentage
Excellent	16	53.33%
Good	8	26.67%
Fair	2	6.7%
Poor	4	13.3%
Total	30	100%

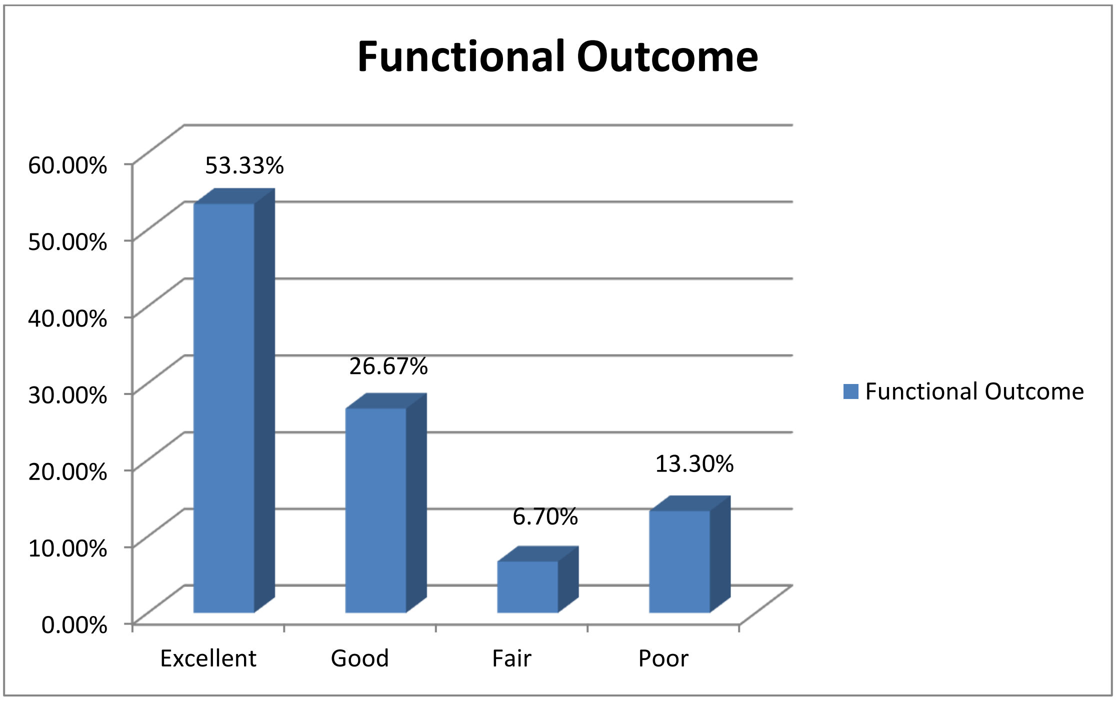

CHART NO.16 : BAR DIAGRAM SHOWING FUNCTIONAL OUTCOME AS PER JOHNER AND WRUH'S CRITERIA

CASE 1

Figure No.20 : Wound Picture

Figure No.21 : AP and Lateral radiograph of Left leg

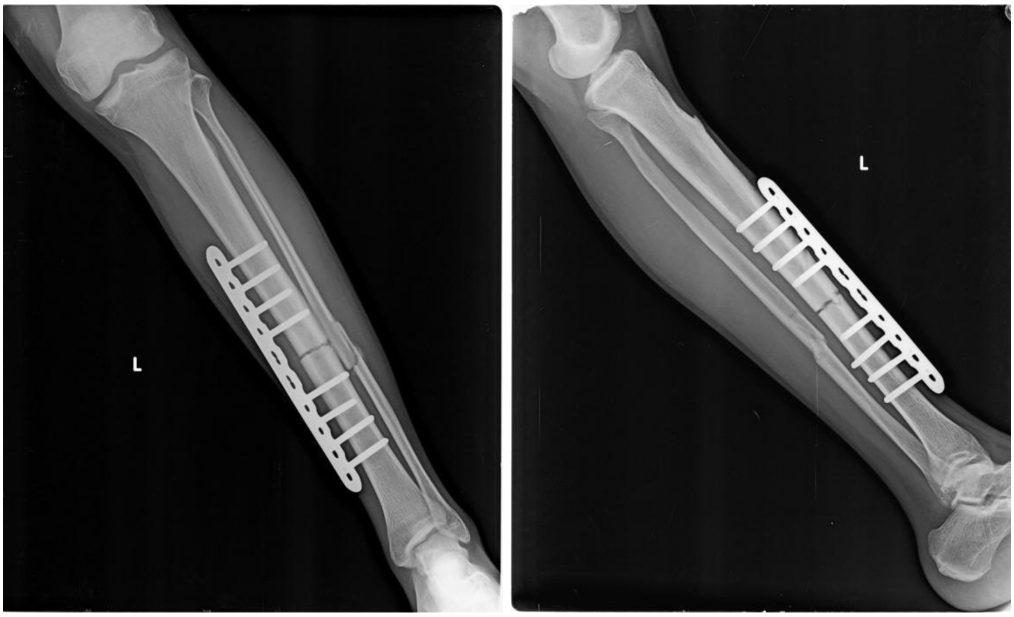

Figure No.22 : AP and Lateral radiograph of left leg at 6 weeks follow up

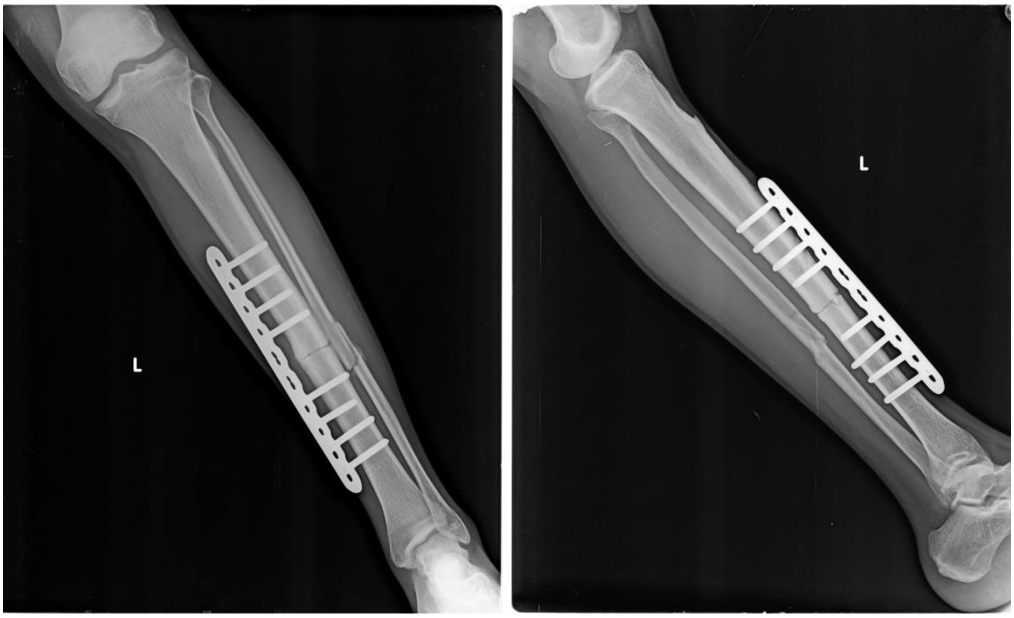

Figure No.23 : AP and Lateral radiograph of left leg at 18 weeks follow up

Figure No.24 : Left leg with supracutaneous LCP insitu

Figure No.25 : After Implant Removal

Figure No.26 : AP radiograph of left leg after implant removal

Figure No.27 : Lateral radiograph of left leg after implant removal

Figure No.28 : Knee extension and ankle plantar flexion

Figure No.29 : Knee extension and ankle dorsiflexion

Figure No.30 : Knee flexion and ankle dorsiflexion

Figure No.31 : Knee flexion

CASE 2

Figure No.32 : Wound Picture

Figure No.33 : AP and Lateral radiograph of Left leg

Figure No.34 : AP and Lateral radiograph of left leg at 6 weeks follow up

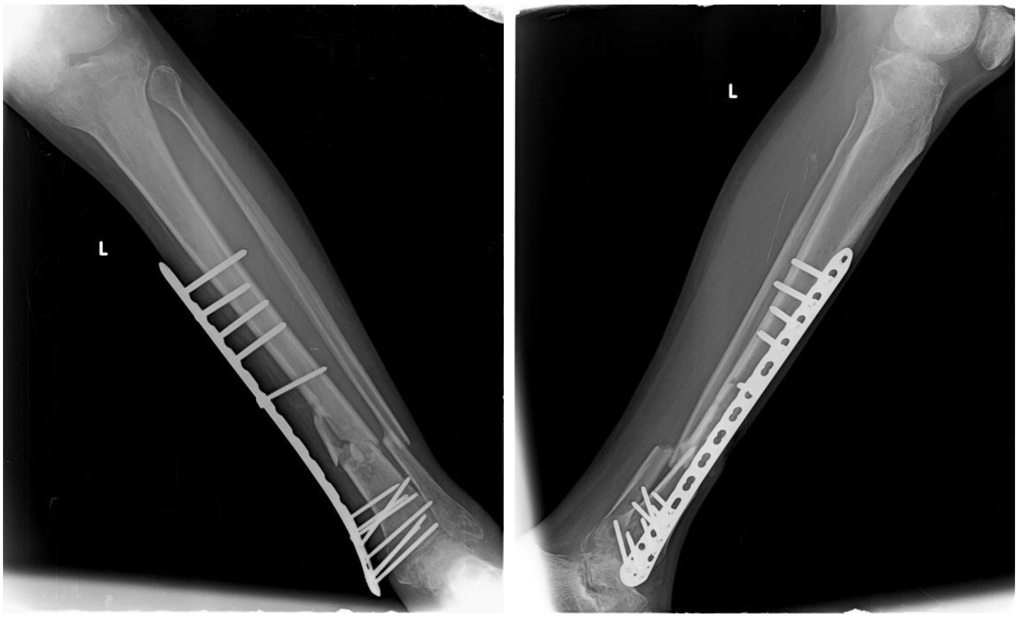

Figure No.35 : AP and Lateral radiograph of left leg at 18 weeks follow up

Figure No.36 : Left leg with supracutaneous LCP insitu

Figure No.37 : After Implant Removal

Figure No.38 : AP radiograph of left leg after implant removal

Figure No.39 : Lateral radiograph of left leg after implant removal

Figure No.40 : Knee extension and ankle dorsiflexion

Figure No.41 : Knee extension and ankle plantar flexion

Figure No.42 : Knee flexion and ankle dorsiflexion

Figure No.43 : Knee flexion

CASE 3

Figure No.44 : Wound Picture

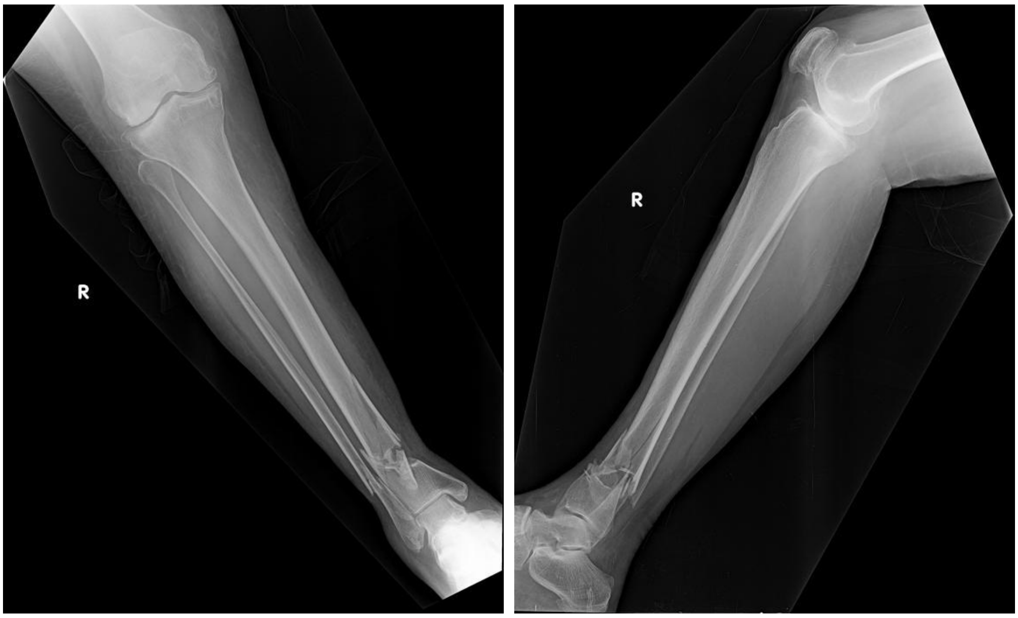

Figure No.45 : AP and Lateral radiograph of Right leg

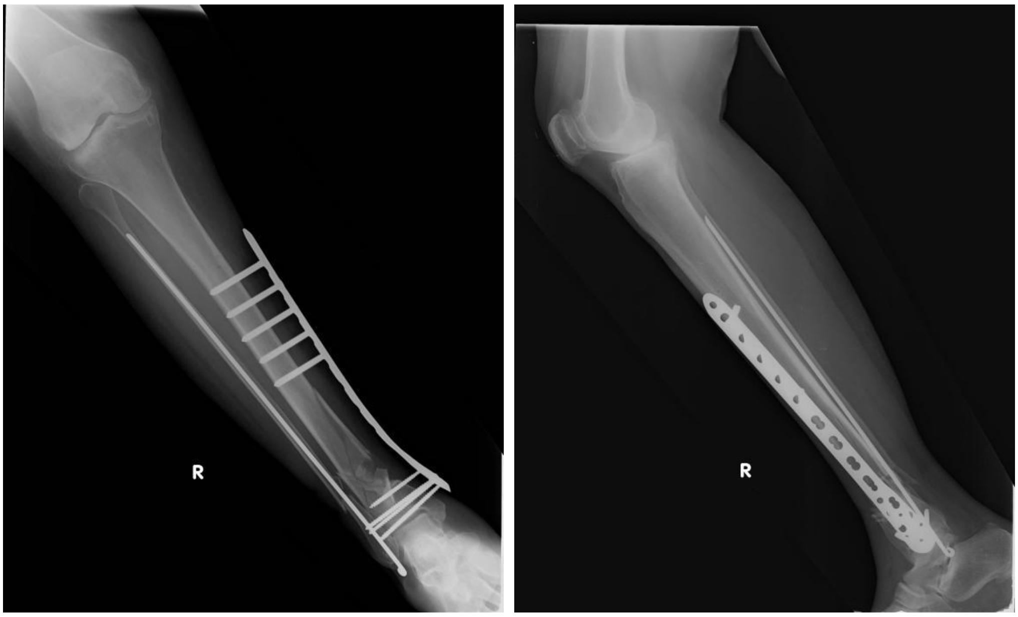

Figure No.46 : AP and Lateral radiograph of right leg at 6 weeks follow up

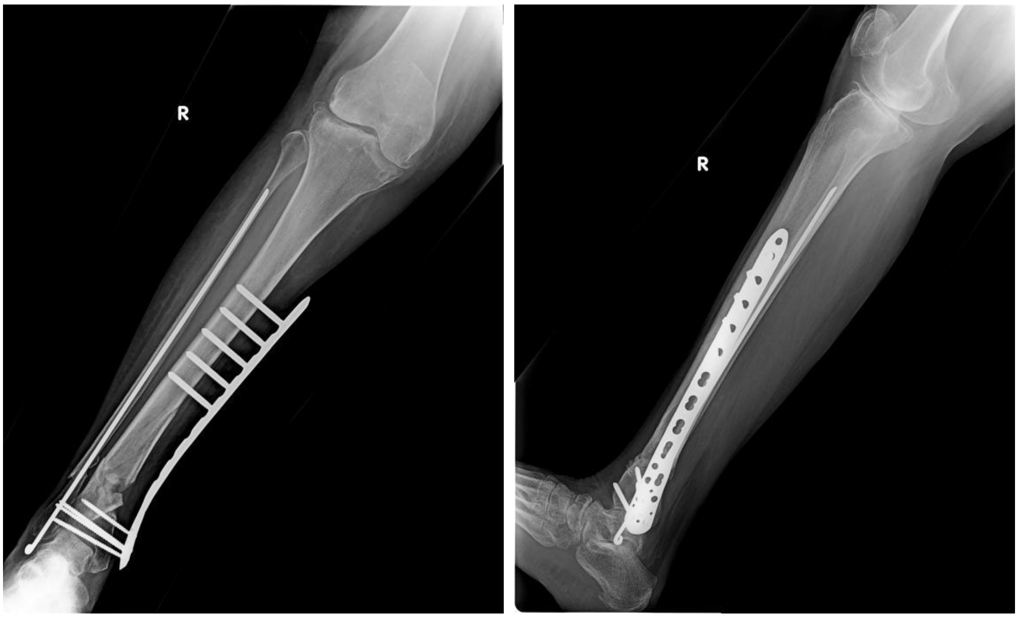

Figure No.47 : AP and Lateral radiograph of right leg at 18 weeks follow up

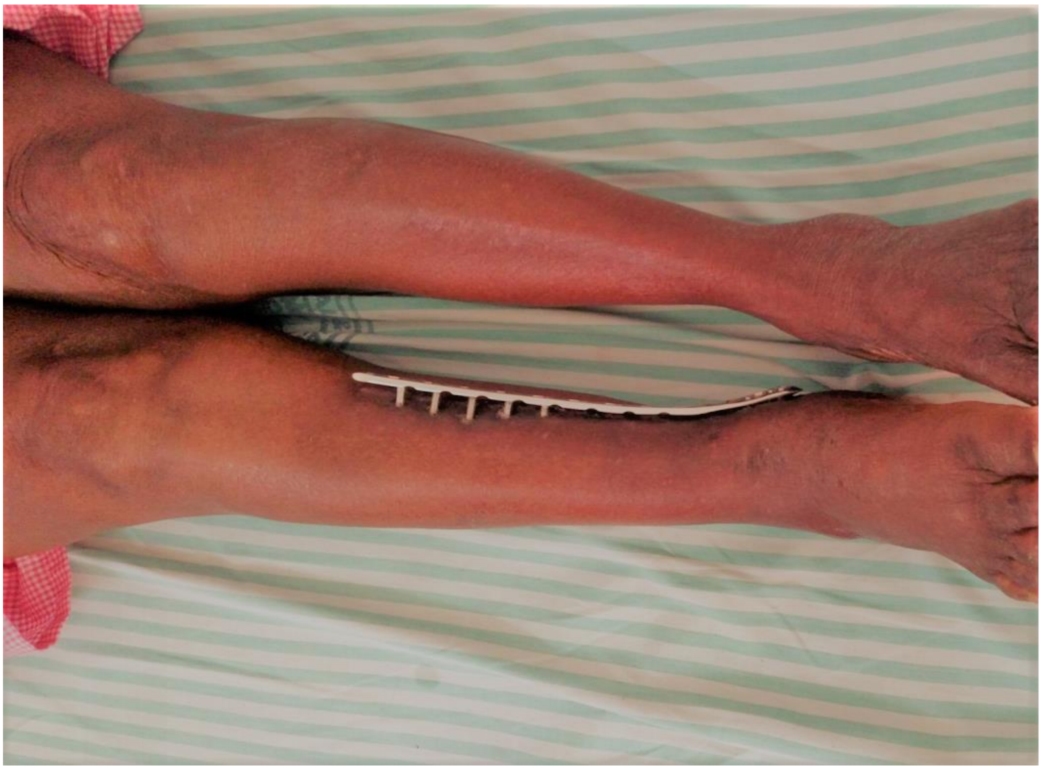

Figure No.48 : Right leg with supracutaneous LCP insitu

Figure No.49 : After Implant Removal

Figure No.50 : AP radiograph of right leg after implant removal.

Figure No.51 : Lateral radiograph of right leg after implant removal.

Figure No.52 : Knee extension and ankle plantar flexion

Figure No.53 : Knee extension and ankle dorsiflexion

Figure No.54 : Knee flexion

Figure No.55 : Knee extension and ankle plantar flexion

COMPLICATIONS

CASE 1

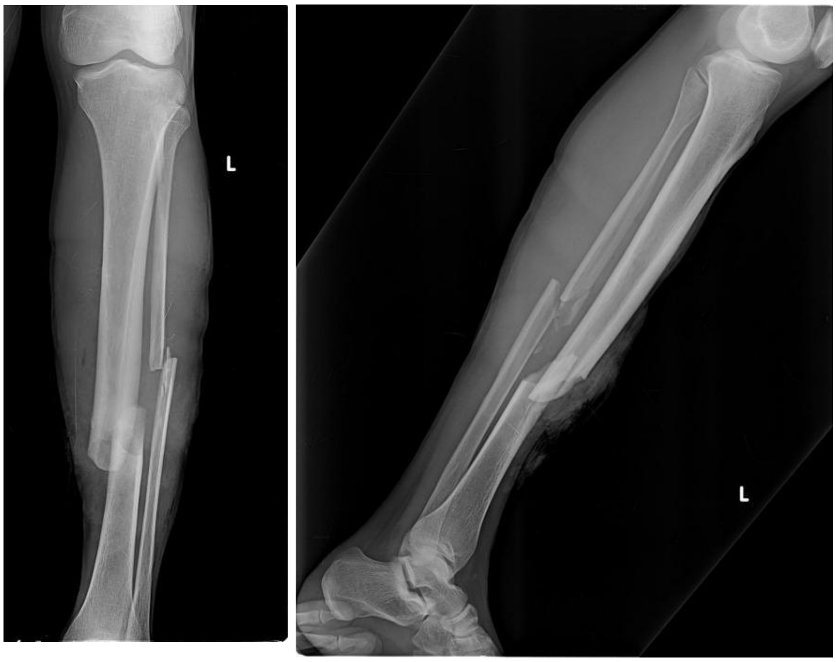

Figure No.56 : AP and Lateral radiograph of left leg

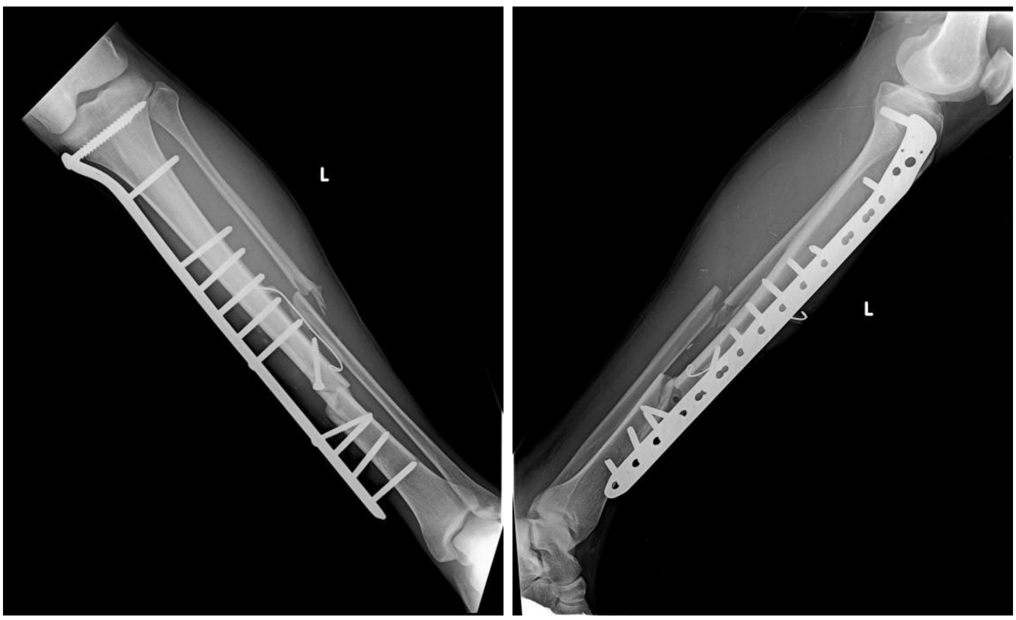

Figure No.57 : AP and Lateral radiograph of left leg at 6 weeks follow up

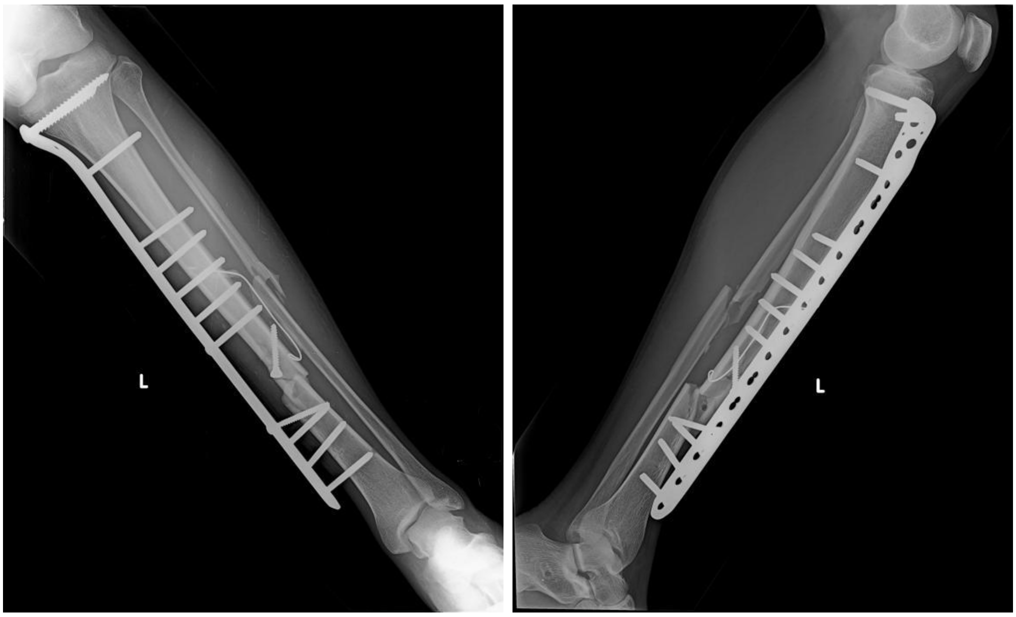

Figure No.58 : AP and Lateral radiograph of left leg at 18 weeks follow up

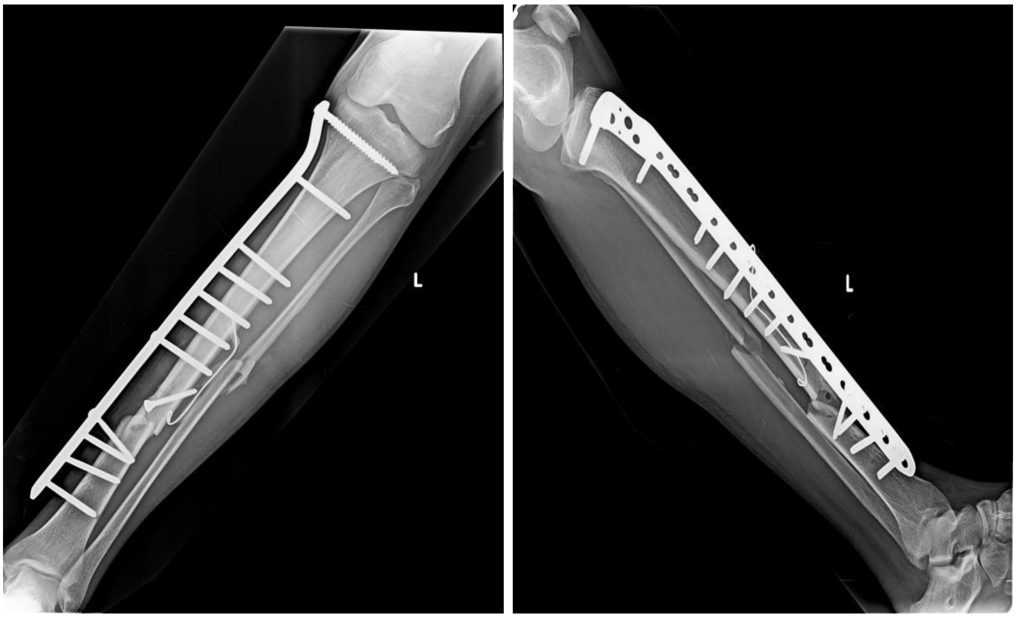

Figure No.59 : AP and Lateral radiograph of left leg at 24 weeks follow up

Figure No.60 : Clinical picture with infected wound

Figure No.61 : AP radiograph of left leg showing K nail, polar screw and antibiotic beads

Figure No.62 : Lateral radiograph of left leg showing K nail, polar screw and antibiotic beads

CASE 2

Figure No.63 : AP and Lateral radiograph of right leg

Figure No.64 : AP and Lateral radiograph of right leg at 6 weeks follow up

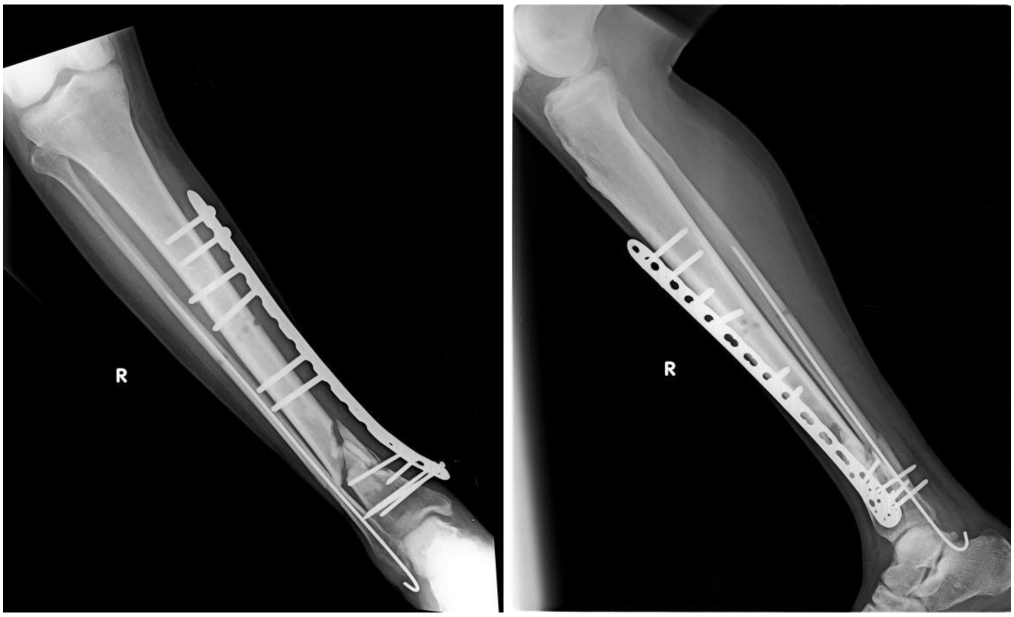

Figure No.65 : AP and Lateral radiograph of right leg at 18 weeks follow up

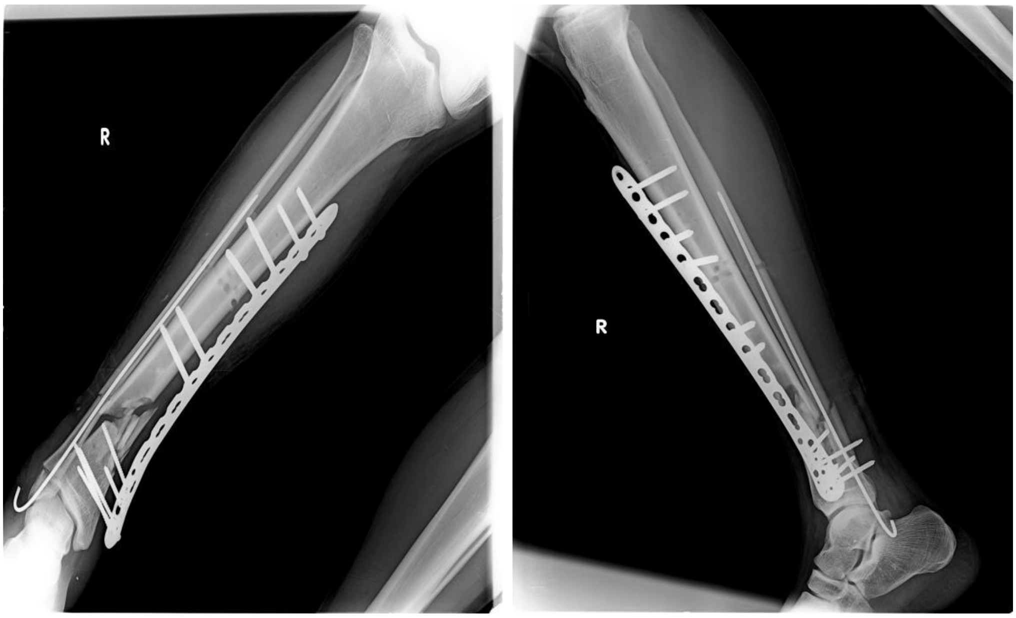

Figure No.66 : AP and Lateral radiograph of right leg at 24 weeks follow up

Figure No.67 : AP radiograph of right leg showing IMIL nail and polar screw

Figure No.68 : Lateral radiograph of right leg showing IMIL nail and polar screw

CASE 3

Figure No.69 : AP and Lateral radiograph of right leg

Figure No.70 : AP and Lateral radiograph of right leg at 6 weeks follow up

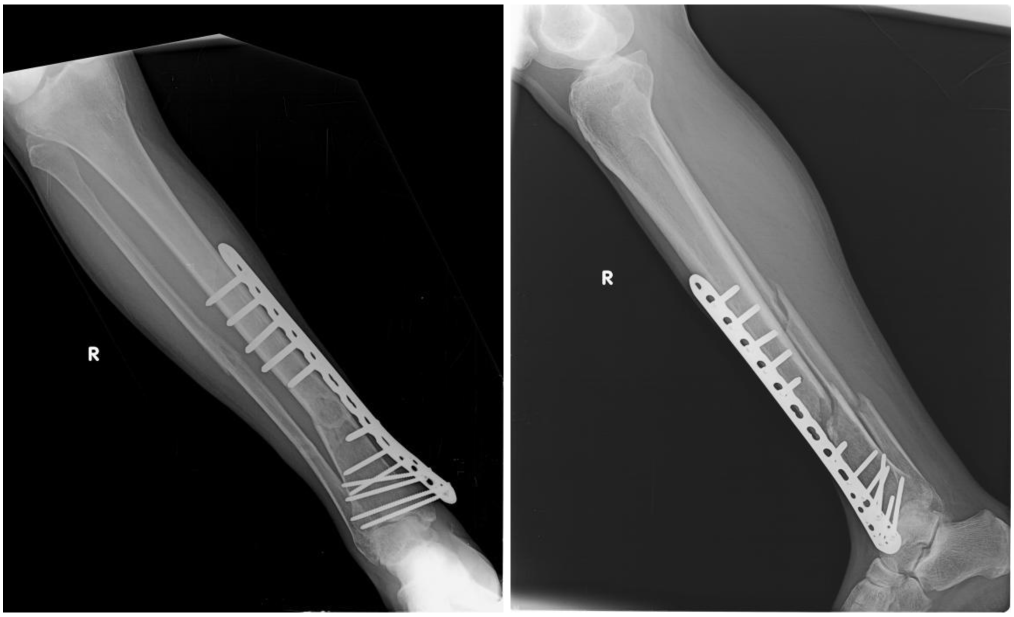

Figure No.71 : AP and Lateral radiograph of right leg at 18 weeks follow up

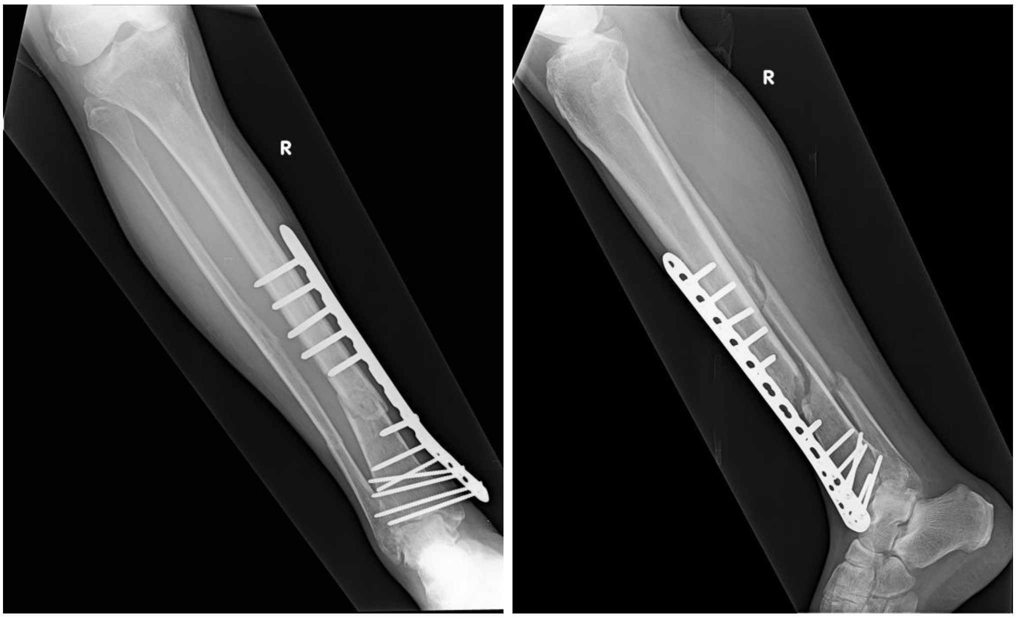

Figure No.72 : AP and Lateral radiograph of right leg at 24 weeks follow up

Figure No.73 : AP radiograph of right leg showing IMIL nail

Figure No.74 : Lateral radiograph of right leg showing IMIL nail

DISCUSSION

Open tibial fractures remain one of the most substantial therapeutic challenges that confront the orthopaedic traumatologist. The optimal treatment of open tibial fractures remains controversial, despite the variety of treatment options which have been suggested for these injuries including non-operative treatment, external fixation, intramedullary nailing and plate fixation. However, each of these treatment options has its own advantages and disadvantages.

Non-operative treatment may be complicated by loss of reduction and subsequent malunion; there is concern about the use of intramedullary nail in open tibial fractures in view of deep implant related infections; ORIF results in extensive soft tissue dissection and may be associated with wound complications and infections.

In recent years, numerous reports have argued that the supracutaneous LCP technique is a safe and worth-while method of managing such fractures, whilst avoiding the complications associated with conventional open plating methods.

We evaluated our results and compared them with those obtained by various other studies utilizing different modalities of treatment, our analysis is as follows:

For various variables like age, sex, mode of injury, average time for union, final functional and radiological outcomes our results are comparable to the previous studies done by different authors.

AGE DISTRIBUTION:

Our study revealed the average age of patients with such injuries to be 43 years (25-70 yrs). It is comparable with a study on similar fractures conducted by below authors. The age of the patient had no bearing on the time to union in our study.

TABLE NO. 23 : AGE DISTRIBUTION COMPARISON

Age Distribution	Minimum (yrs)	Average(yrs)	Maximum(yrs)
Jayakumar B et al[47]	45	52	60
Jing-Wei Zhang et al[62]	19	43	63
Gupta S K V et al[39]	28	36	42
Present study	25	43	70

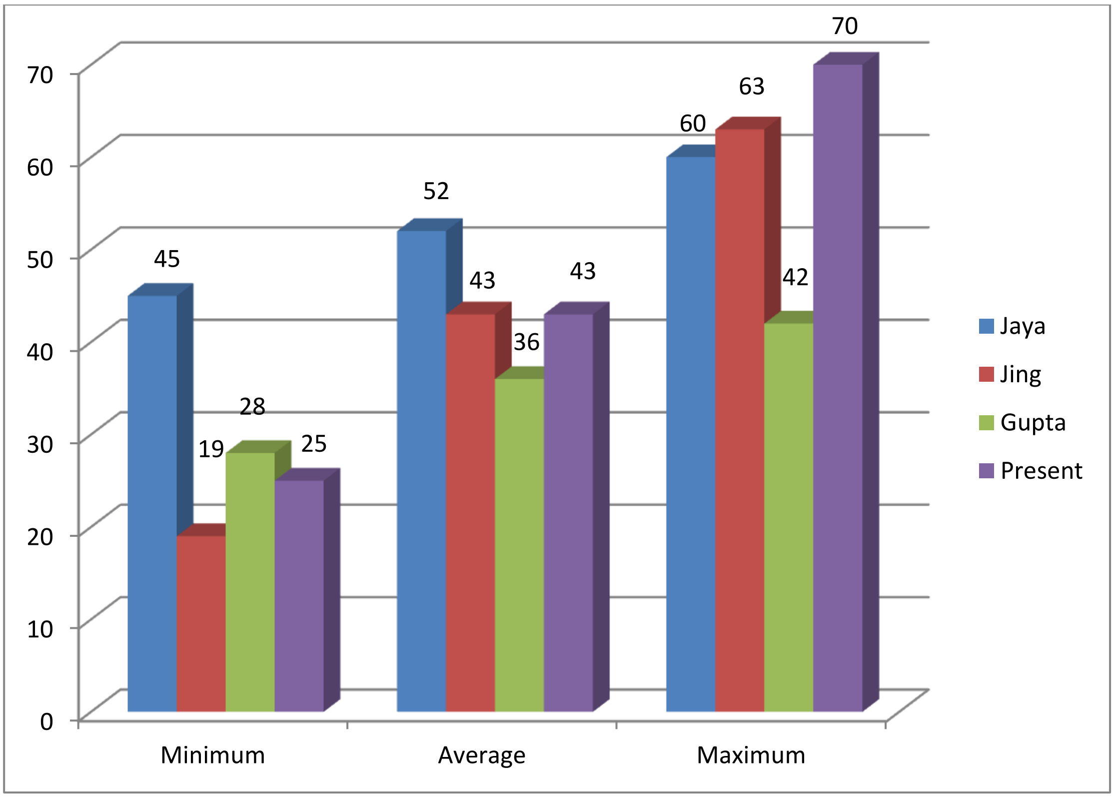

CHART NO.17 : BAR DIAGRAM COMPARING AGE DISTRIBUTION

GENDER DISTRIBUTION:

In our study, the male preponderance for such kind of injuries were high 87% compared to the study by B. Jayakumar et al, Jing-wei zhang et al and Gupta S V K et al which had 75%, 75%, 100% male patients respectively.

TABLE NO. 24 : GENDER DISTRIBUTION COMPARISON

	Male (%)	Female (%)	Total
B. Jayakumar et al[47]	75	25	100
Jing-Wei Zhang et al[62]	75	25	100
Gupta S K V et al[39]	100	0	100
Present study	87	13	100

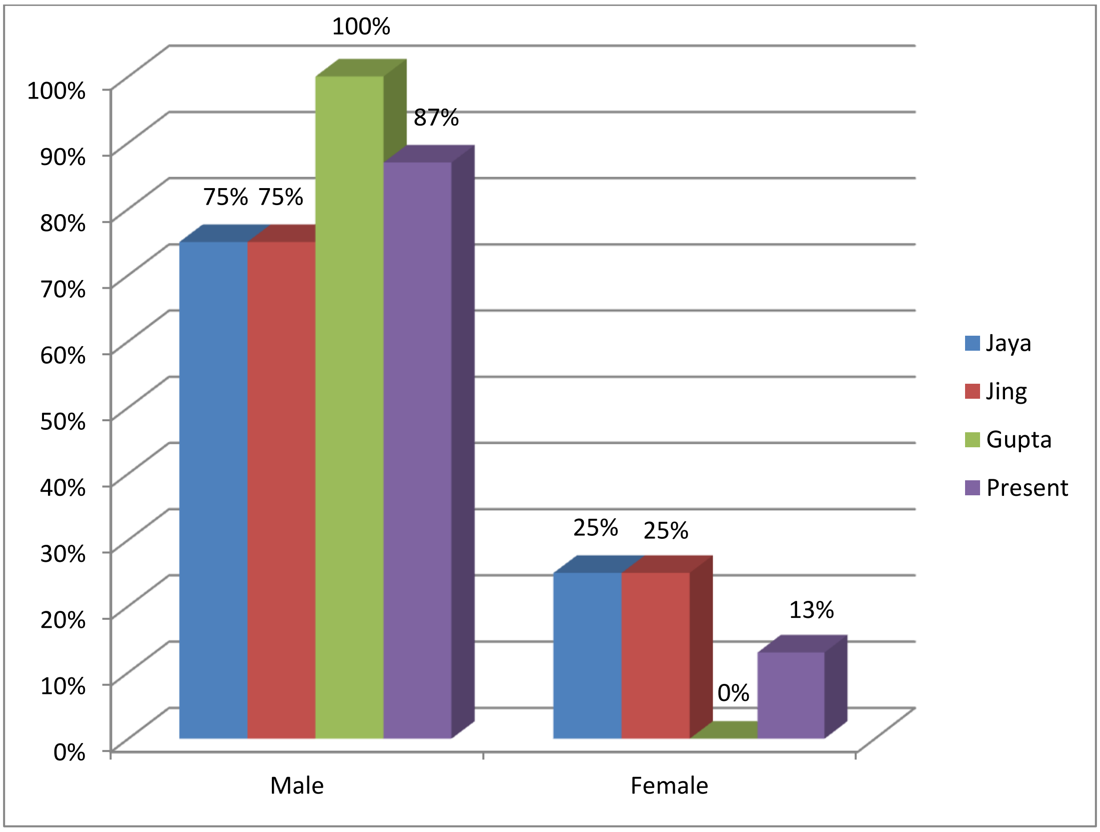

CHART NO.18 : BAR DIAGRAM COMPARING GENDER DISTRIBUTION

MODE OF INJURY :

Our present study had predominantly high energy injuries (83.3%) similar to studies done by B. Jayakumar et al, Jing-wei zhang et al and Gupta S V K et al where high energy trauma accounted for 100%, 66.7% and 100% of their cases respectively.

TABLE NO. 25 : MODE OF INJURY COMPARISON

	RTA	SELF FALL	TOTAL
B. Jayakumar et al[47]	100%	0	100%
Jing-Wei Zhang et al[62]	66.7%	33.3%	100%
Gupta et al[39]	100%	0	100%
Present study	83.3%	16.7%	100%

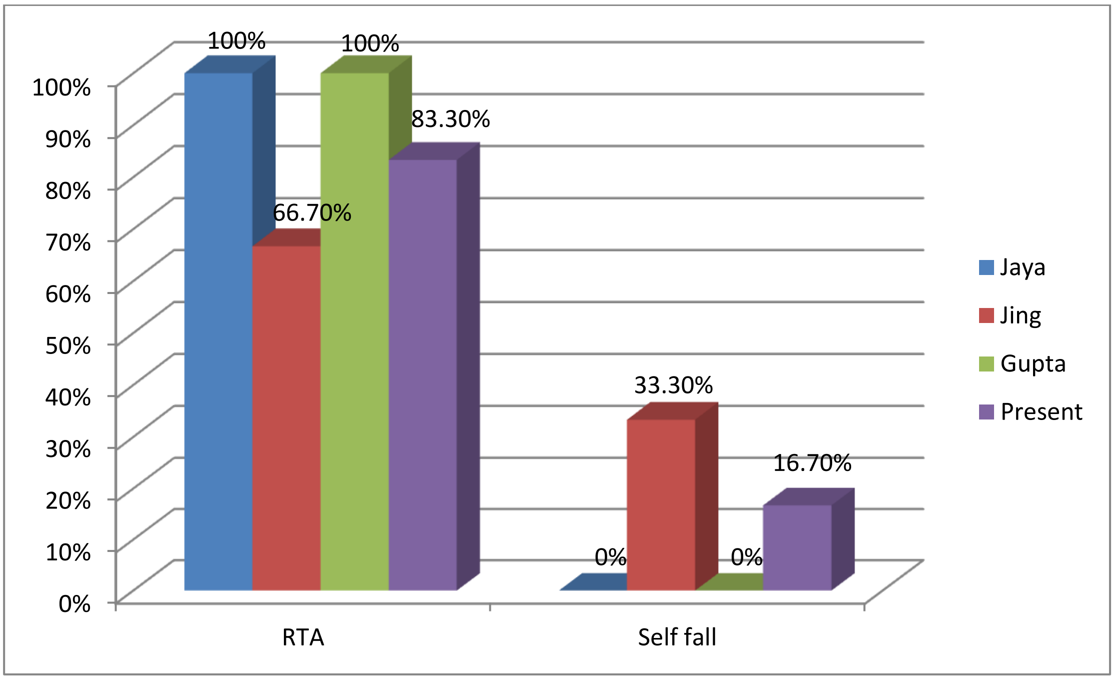

CHART NO. 19 : BAR DIAGRAM COMPARING MODE OF INJURY

AVERAGE FRACTURE UNION TIME :

The average fracture union time in our study was 21 weeks which is comparable with 20, 16.7 and 24 weeks of B. Jayakumar et al, Jing-Wei Zhang et al and Gupta S V K et al respectively.

TABLE NO. 26 : AVERAGE FRACTURE UNION TIME COMPARISON

	Average in weeks
B. Jayakumar et al[47]	20
Jing-Wei Zhang et al[62]	16.7
Gupta et al[39]	24
Present study	21

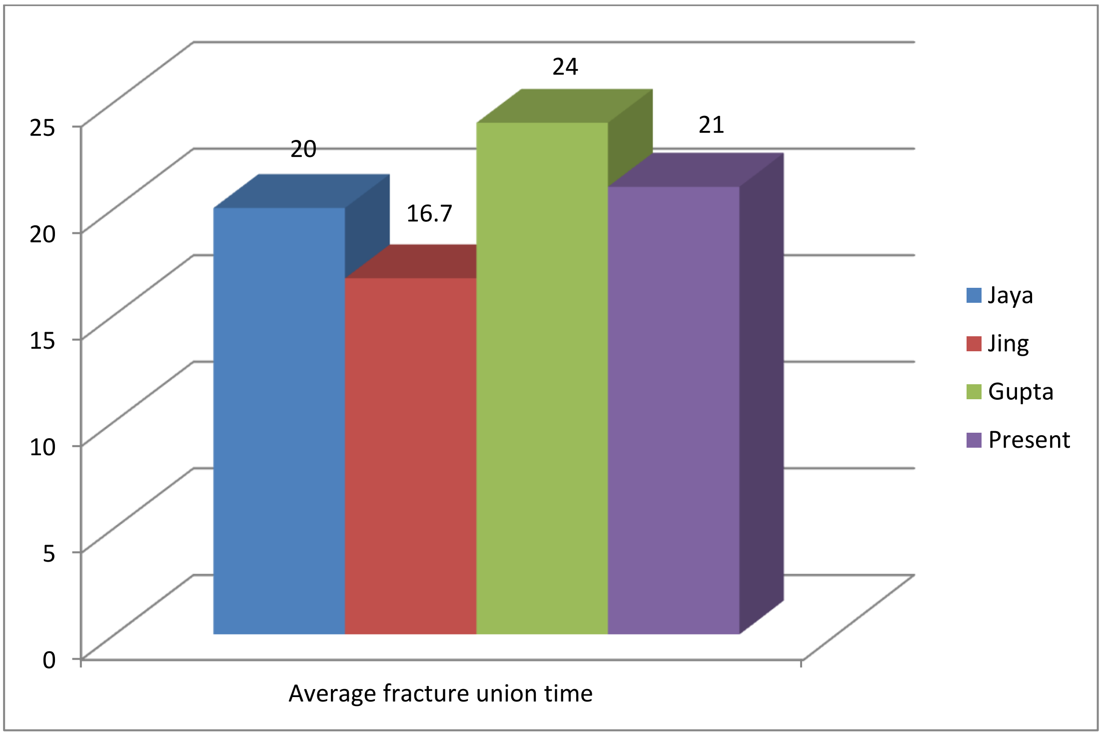

CHART NO. 20 : BAR DIAGRAM COMPARING AVERAGE FRACTURE UNION TIME

FUNCTIONAL OUTCOME :

In our study excellent and good outcomes accounted for 80 % patients similar to B.Jayakumar study while Jing-Wei Zhang and Gupta S V K et al accounted for 100% patients.

TABLE NO. 27 : FUNCTIONAL OUTCOME COMPARISON

	EXCELLENT + GOOD	FAIR + POOR
B Jayakumar[47]	80%	20%
Jing-Wei Zhang[62]	100 %	0%
Gupta S V K[39]	100%	0%
Present study	80%	20%

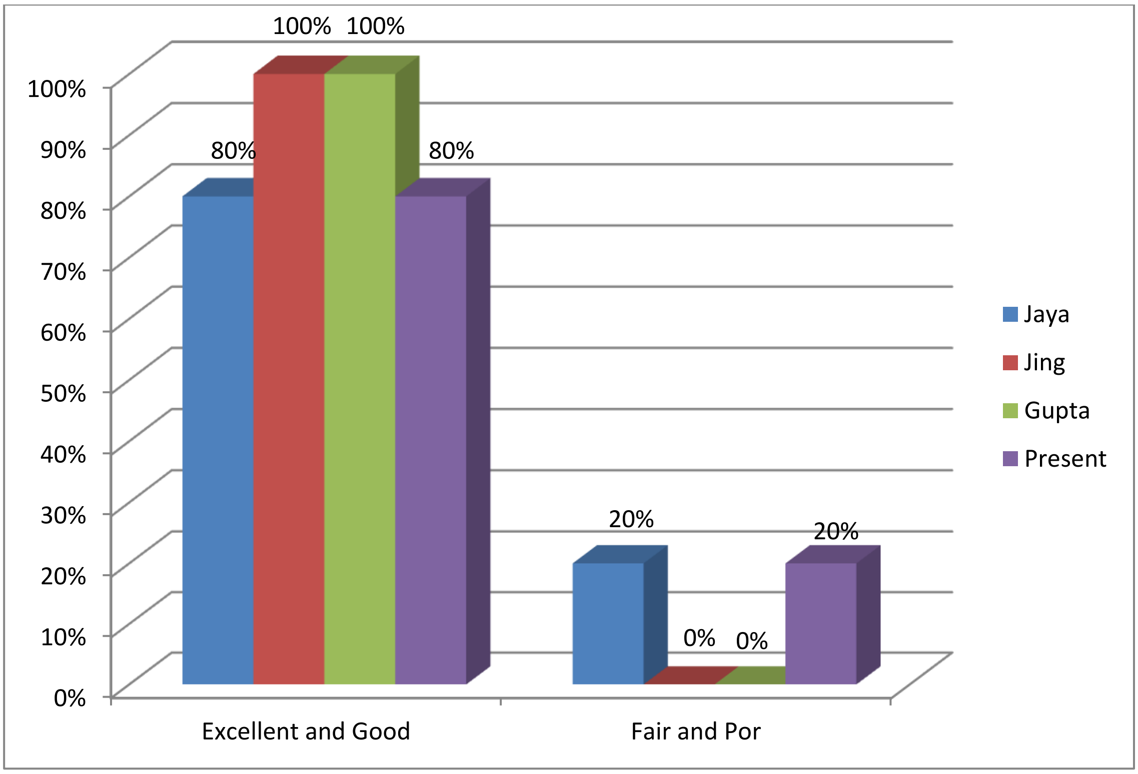

CHART NO. 21 : BAR DIAGRAM COMPARING FUNCTIONAL OUTCOME

TABLE NO. 28 : GENERAL DEMOGRAPHICS AND FUNCTIONAL ASSESMENT

	Jaya et al[47]	Jing et al[62]	Sven et al[38]	Gupta et al[39]	Present
Mean Age (yrs)	**52**	**43**	**43**	**36**	**43**
Male	**75%**	**75%**	**85%**	**100%**	**87%**
Female	**25%**	**25%**	**15%**	**0%**	**13%**
Right Side	**-**	**-**	**-**	**60%**	**40%**
Left side	**-**	**-**	**-**	**40%**	**60%**
RTA	**100%**	**66.7%**	**100%**	**100%**	**83.3%**
Self fall	**0%**	**33.3%**	**0%**	**0%**	**16.7%**
Avg. Fracture union time	**20 weeks**	**16.7 weeks**	**17.5 weeks**	**24 weeks**	**21 weeks**
Functional outcome	**E+G-80%** **F+P - 20%**	**E+G-100%**	**E+G-100%**	**E+G-100%**	**E+G-80%** **F+P-20%**

“-” parameter not available in the study

CONCLUSION

In the present study, 30 patients were treated with supracutaneous locking compression plate fixation for open tibial fractures and the following conclusions were drawn.

A. Young males are more prone to open tibial fractures due to high velocity trauma during RTA, attributed to their active lifestyle.

B. Road traffic accidents are the major cause of open tibial fractures in rural areas of Kolar district.

C. Co-morbidities should be taken into consideration and proper planning of the surgical procedure should be followed to avoid post surgical complications.

D. Locking compression plate as an external fixation is a relatively simple surgical procedure.

E. Reduction of fracture fragments peroperatively, is the most crucial step in using LCP as an external fixator.

F. Blood loss, soft tissue dissection, radiation exposure and anesthetic complications are all reduced owing to closed nature of surgery.

G. In cases of loss of reduction of fracture fragments, realignment of supracutaneous LCP can be done easily.

H. Removal of supracutaneous plate is a simple, cost effective and short procedure and can be done under local anaesthesia avoiding the need for surgery under spinal anaesthesia for implant removal. No recurrent fracture presented after plate removal. In contrast, the operation to remove an intramedullary nail or internal locking plate can be troublesome in some cases.

I. In fractures of the elderly, where mortality and morbidity is high, a closed reduction and external fixation surgery with supracutaneous LCP is associated with less morbidity.

J. Instead of two stage protocol for open tibial fractures, one stage definitive fixation in form of supracutaneous LCP avoids the need for second surgery, is comfortable and aesthetically acceptable for the patient, facilitates early mobilization and faster rehabilitation to pre-fracture life.

K. Traditional frames are often bulky and ambulating with a lower limb fixator frame insitu is awkward. Some patients are self-conscious of these fixators and find them less aesthetically acceptable, especially when more visible locations such as the femur and tibia are involved. Supracutaneous LCP offers better acceptability to patients as it can be well concealed under regular clothing. Additionally, tendency of the plate to strike the contralateral lower leg in the swing-through phase of either leg during ambulation is appreciably decreased.

L. It can be concluded that supracutaneous locking compression plate provides stability, strength, early mobility and excellent union rate of open tibial fractures.

SUMMARY

Aim of this study was to evaluate the outcome of open tibial fractures treated with supracutaneous plating as an external fixator.

Open tibial fractures are the price, humans are paying for fast transportation services. They are one of the most devastating injuries to bear and treat.

Though many other methods of treatment have been tried, from conservative methods to surgical methods using implants such as conventional external fixators, locking compresssion plate, intra medullary interlocking nail, complications like infection, non-union and delayed-union have haunted orthopedic surgeons for years.

Out of 30 patients, 26 were males and 4 females. Minimum age of patient included was 25 years and maximum of 70 years. Mean age of patients was 43 years. Right side was affected was 12 patients and left in 18 patients. Mode of injury was RTA in 25 patients and self-fall in 5 patients. 18 patients had Gustilo Anderson type II and 12 had type IIIA. Average fracture union time was 21 weeks .As per Johner and Wruh's criteria 80% patients had excellent and fair. In 4 patients secondary procedure in form of intramedullary interlocking locking nail was done in view of nonunion.

The consistent good outcome using this “supracutaneous technique” support our opinion of using Locking compression plate as external fixator in open tibial fractures which are very well tolerated by patients and address the challenging problems of compound wound healing, nonunion and osteomyelitis.

With experience and evidence of this study, we consider that supracutaneous locking compression plate is a reliable, easy, cost effective, efficient, aesthetically acceptable, safe mode of treatment in open tibial fractures.

LIMITATIONS OF THE STUDY

Though it is a prospective study, the study was done for a shorter duration of time and with limited sample size.

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PROFORMA

Name :   Case no :

Age :   Ip/op no :

Sex :   DOA :

Address :   DOS :

Occupation :   DOD :

Chief complaints :

History of presenting illness :

Mode of the injury- Road traffic accidents, fall, assault, sports injuries

Past history :

Family history:

Personal history:

General physical examination:

Vital signs	Systemic examination
BP	CVS
RR	RS
PR	CNS
Temperature	PA

Local examination:

Inspection - Attitude, swelling, deformity, wounds, others.

Palpation - Local rise of temperature, tenderness, abnormal mobility, crepitus

Measurements - Length of the leg Right Left

Movements - Knee flexion, extension Ankle – dorsiflexion , plantar flexion .

Distal neuro vascular status – Dorsalis pedis ,posterior tibial artery .

- Sensory disturbances
- Motor disturbances

Associated injuries

Diagnosis:

Investigations:

Blood: Haemoglobin TC

ESR DC

Blood grouping and typing

BT AND CT

RBS Blood urea

S.creatinine HIV

HbsAg Serum sodium

Serum potassium

ECG :

Radiography: x-ray leg full length with ankle and knee

Ap view

Lateral view

Chest xray ap view

Treatment:

Preoperative - Above knee plaster of paris slab or Thomas splint
Application
- Antibiotics
- Analgesics

Type of anaesthesia: spinal anaesthesia if needed can be converted to GA as per anaesthesiologist

Surgical procedure

-Duration of surgery

-External fixator

-Additional procedures

-Intra operative complications

Postoperative - Antibiotics

-Check x-rays

-Complications

-Revision procedures

-Secondary procedures

At 1 week – wound inspection and further wound skin care.

FOLLOW UP:

	Radiographs	Ankle movements (Dorsi and plantar flexion)	Knee movements (flexion and extension)
AT 6 WEEKS			
AT 18 WEEKS			
AT 24 WEEKS			

ಮಾಹಿತಿಯುಕ್ತ ಸಮ್ಮತಿ ಪತ್ರ

.... ಹೆಸರಿನ .... ವಯಸ್ಸಿನವನಾದ .... ಯ.ಹಚ್.ಐ.ಡಿ ಹೊಂದಿದ ನನಗೆ ಎಕ್ಸ್ ರೇ, ನಿಯತಕ್ರಮದ ಪರೀಕ್ಷೆಗಳನ್ನೊಳಗೊಂಡ " ತೆರೆದ ಕಾಲು ಮೂಳೆಯ ಮುರಿತವನ್ನು ಲಾಕಿ0ಗ್ ಕಂಪ್ರೆಶನ್ ಪ್ಲೇಟನ್ನು ಹೊರಭಾಗದಲ್ಲಿ ಜೋಡಿಸುವಂತೆ ಉಪಯೋಗಿಸಿ ಚಿಕಿತ್ಸೆ ನೀಡಿದಾಗ ಆಗುವ ಕ್ರಿಯಾತ್ಮಕ ಫಲಿತಾಂಶ " ಕುರಿತು ಅಧ್ಯಯನದ ಕಾರ್ಯ ವಿಧಾನಗಳು ಮತ್ತು ಅಹಿತಕರ ಪರಿಣಾಮಗಳಾದ ಸೋಂಕು, ತಡವಾಗಿ ಕೂಡುವುದು, ಮೂಳೆ ಕೂಡದಿರುವುದು ಗಳ ಬಗ್ಗೆ ಕನ್ನಡದಲ್ಲಿ ವಿವರಿಸಿರುತ್ತಾರೆ.

ನನಗೆ ಕಾಲಿನ ಮೂಳೆಯ ತೆರೆದ ಮುರಿತ ತೊಂದರೆ ಇರುವುದಾಗಿ ತಿಳಿಸಿದ್ದು, ಅದಕ್ಕೆ ಲಭ್ಯವಿರುವ ಎಲ್ಲಾ ಚಿಕಿತ್ಸಾ ವಿಧಾನಗಳ ಆಗು ಹೋಗುಗಳ ಬಗ್ಗೆ ಕನ್ನಡದಲ್ಲಿ ವಿವರಿಸಿರುತ್ತಾರೆ.

ಈ ಅಧ್ಯಯನದ ವಿವಿಧ ಅಂಶಗಳ ಬಗ್ಗೆ ಪ್ರಶ್ನೆಗಳನ್ನು ಕೇಳುವ ಅವಕಾಶವನ್ನು ನನಗೆ ನೀಡಲಾಗಿದೆ ಮತ್ತು ನನ್ನ ಪ್ರಶ್ನೆಗಳಿಗೆ ತೃಪ್ತಿಕರವಾದ ಉತ್ತರಗಳು ದೊರೆತಿರುತ್ತವೆ

ಮೇಲೆ ತಿಳಿಸಿರುವ ಅಧ್ಯಯನದ ಕಾರ್ಯ ವಿಧಾನಗಳು ಮತ್ತು ಅಹಿತಕರ ಪರಿಣಾಮಗಳನ್ನು ಅರಿತು ಮುಚ್ಚುಮರೆ ಇಲ್ಲದೆ ನನ್ನ ಪರಿಪೂರ್ಣ ವಿವೇಚನೆಯಲ್ಲಿ ಅಧ್ಯಯನದಲ್ಲಿ ಭಗವಹಿಸಲು ಹಾಗು ನನ್ನ ಹೆಸರು ಮತ್ತು ಪರೀಕ್ಷಾ ವರದಿಗಳನ್ನು ಸಂಶೋಧನೆಯಲ್ಲಿ ಬಳಸಿಕೊಳ್ಳಲು ಒಪ್ಪಿಗೆ ನೀಡುತಿದ್ದೇನೆ.

ಈ ಅಧ್ಯಯನದಿಂದ ಯಾವುದೇ ಸಂದರ್ಭದಲ್ಲಿ ಹಿಂದೆ ಸರಿಯುವ ಸ್ವಾತಂತ್ರ್ಯ ನನಗಿದೆ ಎಂಬುದನ್ನು, ಈ ಅಧ್ಯಯನದಲ್ಲಿ ಪಾಲ್ಗೊಳ್ಳುವುದರಿಂದ ನನಗೆ ಯಾವುದೇ ಹೆಚ್ಚುವರಿ ವೆಚ್ಚ ತಗಲುವುದಿಲ್ಲವೆಂಬುದನ್ನು ತಿಳಿದಿರುತ್ತೇನೆ.

ಮೆಲೆ ತಿಳಿಸಿರುವ ಅಧ್ಯಯನದ ಯಾವುದೇ ಅಹಿತಕರ ಪರಿಣಾಮಗಳಿಗೆ ಚಿಕಿತ್ಸೆ ನೀಡುತ್ತಿರುವ ವೈದ್ಯರು,ಶುಶ್ರೂಷಾ ಸಿಬ್ಬಂದಿ ಹಾಗೂ ಆಸ್ಪತ್ರೆಯ ವ್ಯವಸ್ಥಾಪಕರನ್ನು ಹೊಣೆಗಾರರನ್ನಾಗಿ ಮಾಡುವುದಿಲ್ಲವೆಂದು ತಿಳಿಸುತ್ತಾ ಅಧ್ಯಯನದಲ್ಲಿ ಭಾಗವಹಿಸಲು ಒಪ್ಪಿರುತ್ತೇನೆ.

ಪರೀಕ್ಷಾರ್ಥಿ: ಸಹಿ - .... ಹೆಸರು - ....

ಸಾಕ್ಷಿ : 1) ಸಹಿ - .... ಹೆಸರು - ....

2) ಸಹಿ - .... ಹೆಸರು - ....

ಸಹಿ ತೆಗೆದುಕೊಂಡ ದಿನಾಂಕ: ....

ಸಂದರ್ಶಕರ ಸಹಿ: ಪ್ರಧಾನ ಪರೀಕ್ಷಕರ ಸಹಿ:

ದಿನಾಂಕ: ದಿನಾಂಕ:

STUDY TITLE: STUDY OF THE FUNCTIONAL OUTCOME OF OPEN TIBIAL FRACTURES TREATED USING A LOCKING COMPRESSION PLATE AS AN EXTERNAL FIXATOR

CHIEF RESEARCHER/ PG GUIDE'S NAME : Dr. D. SATYARUP

PRINCIPAL INVESTIGATOR : Dr. ABHISHEK YADAV

NAME OF THE SUBJECT :

AGE :

GENDER :

I have been informed in my own language that this study involves pre and post operative X-ray, blood & urine investigations, surgical treatment, pre & post operative hospital stay and regular follow up. I have been explained thoroughly and understand its complication and possible side effects.

I understand that the medical information produced by this study will become part of institutional record and will be kept confidential by the said institute.

I understand that my participation is voluntary and may refuse to participate or may withdraw my consent and discontinue participation at any time without prejudice to my present or future care at this institution.

I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s).

I confirm that Dr. D. Satyarup/ Dr. Abhishek Yadav(chief researcher/ name of PG guide and principal investigator) has explained to me the purpose of research and the study procedure that I will undergo and the possible risks and discomforts that I may experience, in my own language. I hereby agree to give valid consent to participate as a subject in this research project.

Participant's signature/thumb impression

Signature of the witness: Date:

1)

2)

I have explained to ____ (patient) the purpose of the research, the possible risk and benefits to the best of my ability.

Chief Researcher/ Guide signature Date:

ರೋಗಿಯ ಮಾಹಿತಿ ಹಾಳೆ

ಅಧ್ಯಯನ ಶೀರ್ಷಿಕೆ : ತೆರೆದ ಕಾಲು ಮೂಳೆಯ ಮುರಿತವನ್ನು ಲಾಕಿ0ಗ್ ಕಂಪ್ರೆಶನ್ ಪ್ಲೇಟನ್ನು ಹೊರಭಾಗದಲ್ಲಿ ಜೋಡಿಸುವಂತೆ ಉಪಯೋಗಿಸಿ ಚಿಕಿತ್ಸೆ ನೀಡಿದಾಗ ಆಗುವ ಕ್ರಿಯಾತ್ಮಕ ಫಲಿತಾಂಶ ಕುರಿತು ಅಧ್ಯಯನ.

ಅಧ್ಯಯನ ಸಂಸ್ಥೆ : ಆರ್ ಎಲ್ ಜಾಲಪ್ಪ ಆಸ್ಪತ್ರೆ, ತಮಕ, ಕೋಲಾರ

ಉದ್ದೇಶ: ತೆರೆದ ಕಾಲು ಮೂಳೆಯ ಮುರಿತವನ್ನು ಲಾಕಿ0ಗ್ ಕಂಪ್ರೆಶನ್ ಪ್ಲೇಟನ್ನು ಹೊರಭಾಗದಲ್ಲಿ ಜೋಡಿಸುವಂತೆ ಉಪಯೋಗಿಸಿ ಚಿಕಿತ್ಸೆ ನೀಡಿದಾಗ ಆಗುವ ಕ್ರಿಯಾತ್ಮಕ ಮತ್ತು ರೇಡಿಯೋಲಾಜಿಕಲ್ ಪರಿಣಾಮಗಳನ್ನು ಜೋಹನ್ನೆರ್ ಮತ್ತು ಹ್ರುನ ಕ್ರೈಟೇರಿಯ ಉಪಯೋಗಿಸಿ ತಿಳಿದುಕೊಳ್ಳಲಾಗುವುದು

ತೆರೆದ ಕಾಲು ಮೂಳೆಯ ಮುರಿತದಿಂದ ಬಳಲುತ್ತಿರುವ ರೋಗಿಗಳನ್ನು ತಪಾಸಣೆ ಮಾಡಿ ತನಿಖೆ ಮಾಡಲಾಗುತ್ತದೆ. ರೋಗಿಗೆ ಮೂಳೆ ಮುರಿತವನ್ನು ಲಾಕಿ0ಗ್ ಕಂಪ್ರೆಶನ್ ಪ್ಲೇಟನ್ನು ಹೊರಭಾಗದಲ್ಲಿ ಜೋಡಿಸುವಂತೆ ಉಪಯೋಗಿಸಿ ಬಳಸಿ ಜೋಡಿಸಲಾಗುವುದು. ನಂತರ ರೋಗಿಯನ್ನು ಒಂದು, ಮೂರು ಹಾಗು ಆರು ತಿಂಗಳಲ್ಲಿ ಕರೆಸಿ ಪರೀಕ್ಷೆ ಮಾಡಲಾಗುತ್ತದೆ.ಈ ಮಾಹಿತಿಯನ್ನು ಉದ್ದೇಶಪೂರ್ವಕವಾಗಿ ನಿಮಗೆ ಇದರ ಮೂಲ ಹಿನ್ನಲೆಯನ್ನು ತಿಳಿದುಕೊಳ್ಳುವುದಕ್ಕಾಗಿ ನೀಡಲಾಗಿದೆ. ದಯವಿಟ್ಟು ತಾವು ಈ ಮೇಲಿನ ಮಾಹಿತಿ ಓದಿ ನಿಮ್ಮ ಕುಟುಂಬದವರೊಂದಿಗೆ ಚರ್ಚಿಸಿಕೊಳ್ಳಬೇಕಾಗಿದೆ. ನೀವು ಇದರಲ್ಲಿ ಭಾಗವಹಿಸಲು ಆಸಕ್ತಿ ತೋರಿಸಿದಲ್ಲಿ, ನಾವು ನಿಮ್ಮ ಮತ್ತು ನಿಮ್ಮ ಜವಾಬ್ದಾರಿಯನ್ನು ಹೊತ್ತ ವ್ಯಕ್ತಿಯ ಬಗ್ಗೆಯ ಮಾಹಿತಿಯನ್ನು ಪಡೆದುಕೊಳ್ಳಲಾಗುವುದು. ಈ ಮಾಹಿತಿಯನ್ನು ಪಡೆದು ಪ್ರೌಢಬಂದಕ್ಕೆ ಮತ್ತು ಪ್ರಕಾಶನಕ್ಕೆ ಬಳಸಿಕೊಳ್ಳಾಗುವುದು.

ಯಾವ ಮಾಹಿತಿಯನ್ನು ನಿಮ್ಮ ಹತ್ತಿರ ಪಡೆದಿರುತ್ತೇವೆಯೋ, ಆ ಮಾಹಿತಿಯನ್ನು ಗೌಪ್ಯವಾಗಿ ಇರಿಸಿಕೊಳ್ಳಲಾಗುವುದು, ಮತ್ತು ಮೂರನೇ ವ್ಯಕ್ತಿಗೆ ತಿಳಿಸುವುದಿಲ್ಲ. ನಿಮ್ಮ ಹೆಸರನ್ನು ಬಯಲು ಮಾಡಲಾಗುವುದಿಲ್ಲ. ನೀವು ಇದರಲ್ಲಿ ಕಡ್ಡಾಯವಾಗಿ ಭಾಗವಹಿಸಬೇಕೆಂದೇನು ಇಲ್ಲ ಹಾಗು ನೀವು ಭಾಗವಹಿಸಲು ಇಷ್ಟಪಡದಿದ್ದಲ್ಲಿ, ನಿಮಗೆ ಸಿಗುವ ಆರೈಕೆಯಲ್ಲಿ ಯಾವುದೇ ಬದಲಾವಣೆಗಳಿರುವುದಿಲ್ಲ. ನೀವು ಈ ಅಧ್ಯಯನದಲ್ಲಿ ಭಾಗವಹಿಸಲು ಸ್ವಯಂಪ್ರರಿತವಾಗಿ ಆಸಕ್ತಿ ತೋರಿದಲ್ಲಿ ಮಾತ್ರವೇ ಸಹಿ/ ಹೆಬ್ಬೆಟ್ಟಿನ ಗುರುತು ಮಾಡಬೇಕಾಗುವುದು.

ಯಾವುದೇ ತರಹದ ಸ್ಪಷ್ಟಿಕರಣಕ್ಕಾಗಿ ನೀವು ಈ ಕೆಳಕಂಡ ಅಧ್ಯಯನ ತನಿಖಾಧಿಕಾರಿಯನ್ನು ಸಂಪರ್ಕಿಸಬಹುದು:

ಡಾ. ಅಭಿಷೇಕ್ ಯಾದವ್

ಮೊಬೈಲ್ ಸಂಖ್ಯೆ: 9468462065

ಈ ಮೇಲ್ : abhishek.kims@gmail.com

PATIENT INFORMATION SHEET

STUDY TITLE

STUDY OF THE FUNCTIONAL OUTCOME OF OPEN TIBIAL FRACTURES TREATED USING A LOCKING COMPRESSION PLATE AS AN EXTERNAL FIXATOR

STUDY SITE:

R.L Jalappa hospital, Tamaka, Kolar.

AIM:

To evaluate the functional and radiological outcome of open tibial fractures treated using locking compression plate as external fixator using Johner and Wruh's criteria.

Please read the following information and discuss with your family members. You can ask any question regarding the study. If you agree to participate in this study we will collect information (as per proforma) from you. Routine and Relevant blood investigations, radiological investigation will be carried out if required. This information collected will be used for dissertation and publication only.

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.
For any further clarification you can contact the study investigator:

Dr. ABHISHEK YADAV
Mobile no: 9468462065
E-mail id: abhishek.kims@gmail.com

Johner and wruh's criteria will be used for evaluation of final results and results will be graded as excellent, good, fair or poor.

Johner & Wruh's Criteria for Evaluation of Final Results

Sl. No.	Criteria	Excellent (Left=Right)	Good	Fair	Poor
1.	Non-unions, ostetitis, amputation	None	Non	None	Yes
2.	Neurovascular disturbances	None	Minimal	Moderate	Severe
3.	Deformity				
	Varus/ Valgus	None	2-5°	6-10°	>10°
	Anteversion/ Recurvation	0-5°	6-10°	11-20°	>20°
	Rotation	0-5°	6-10°	11-20°	>20°
4.	Shortening	0-5mm	6-10mm	11-20mm	>20 mm
5.	Mobility				
	Knee	Normal	>80%	>75%	<75%
	Ankle	Normal	>75%	>50%	<50%
	Subtalar	>75%	>50%	<50%	--
6.	Pain	None	Occasional	Moderate	Severe
7.	Gait	Normal	Normal	Insignificant limp	Significant limp
8.	Strenuous activities	Possible	Limited	Severely limited	Impossible
9.	Radiological union	Consolidated	Consolidated	Union	Not consolidated

KEY TO MASTER CHART

S.No	-	Serial Number
Sex		
M	-	Male
F	-	Female
AC	-	Associated co morbidities
HTN	-	Hypertension
DM	-	Diabetes Mellitus
UHID	-	Universal Hospital Identification Number
MOI	-	Mode Of Injury
RTA	-	Road Traffic Accident
# Type	-	Fracture type based on Gustillo Anderson classification
Site	-	Fracture site at Tibia
HS	-	Hospital Stay in days
ISI	-	Injury Surgery Interval in days
ST	-	Surgery Time in minutes
BL	-	Blood Loss in millilitres
TOU	-	Time of radiological union in weeks
IIS	-	Implant Insitu in weeks
TPR	-	Time for Plate Removal in minutes
COMPL	-	Complications
1 to 9	-	Johner and Wruh's criteria for evaluation of final results at 6 months follow up
1	-	Non union, osteitis, amputation
No	-	None

Y	-	Yes
2	-	Neurovascular disturbances
3	-	Deformity
3A	-	Varus/Valgus
3Aa	-	None
3Ab	-	2-5^{o}
3Ac	-	6-10^{o}
3Ad	-	> 10^{o}
3B	-	Anteversion/Recurvation
3Ba	-	0-5^{o}
3Bb	-	6-10^{o}
3Bc	-	11-20^{o}
3Bd	-	> 20^{o}
3C	-	Rotation
3Ca	-	0-5^{o}
3Cb	-	6-10^{o}
3Cc	-	11-20^{o}
3Cd	-	> 20
4	-	Shortening
4a	-	0-5 mm
4b	-	6-10 mm
4c	-	11-20 mm
4d	-	> 20 mm

5	-	Mobility
5A	-	Knee
5Aa	-	Normal
5Ab	-	> 80%
5Ac	-	75 - 80 %
5Ad	-	< 75 %
5B	-	Ankle
5Ba	-	Normal
5Bb	-	> 75 %
5Bc	-	50 - 75 %
5Bd	-	< 50 %
5C	-	Subtalar
5Ca	-	> 75%
5Cb	-	50 - 75 %
5Cc	-	< 50 %
6	-	Pain
No	-	None
O	-	Occasional
M	-	Moderate
7	-	Gait
N	-	Normal
IL	-	Insignificant Limp
Sl	-	Significant Limp

8		- Strenous Activity
	P	- Possible
	L	- Limited
	Im	- Impossible
9		- Radiological Union
	C	- Consolidated
	NC	- Not Consolidated

S.No	UHID	Age	Sex	AC	Side	MOI	# Type	Site	HS	ISI	ST	TOU	IIS	TPR	COMPL	1	2	3A	3B	3C	4	5A	5B	5C	6	7	8	9	FO
1	263298	30	M		Right	RTA	Type IIIA	Proximal third	16	1	60	18	22	9		No	No	3Aa	3Ba	3Ca	4a	5Ab	5Ba	5Ca	No	N	P	C	Good
2	271260	60	M		Left	RTA	Type II	Distal third	15	1	50	18	22	10		No	No	3Aa	3Ba	3Ca	4a	5Aa	5Ba	5Ca	No	N	L	C	Excellent
3	294175	70	M	HTN	Right	RTA	Type II	Distal third	7	1	70	24	28	10		No	No	3Aa	3Ba	3Ca	4a	5Aa	5Ba	5Cb	No	N	P	C	Good
4	353504	31	M		Left	RTA	Type IIIA	Distal third	14	2	80	24	28	11		No	No	3Aa	3Ba	3Ca	4a	5Aa	5Bb	5Ca	No	N	P	C	Good
5	355462	60	M	HTN	Right	RTA	Type II	Distal third	25	1	100	Non union	24	12	Non union	Y	No	3Aa	3Ba	3Ca	4b	5Ac	5Bd	5Ca	M	Sl	Im	NC	Poor
6	384787	38	F		Left	RTA	Type IIIA	Distal third	14	1	70	24	28	10		No	No	3Aa	3Ba	3Ca	4a	5Aa	5Ba	5Ca	No	N	L	C	Excellent
7	384824	46	F		Right	RTA	Type II	Distal third	14	1	60	24	28	9		No	No	3Aa	3Ba	3Ca	4a	5Ab	5Bb	5Cb	No	IL	L	C	Fair
8	384913	52	M	DM	Left	Self fall	Type IIIA	Distal third	15	2	65	24	28	10		No	No	3Aa	3Ba	3Ca	4a	5Aa	5Ba	5Ca	No	N	P	C	Excellent
9	393395	48	M		Left	RTA	Type IIIA	Distal third	14	1	75	24	28	11		No	No	3Aa	3Ba	3Ca	4a	5Aa	5Ba	5Ca	No	N	P	C	Excellent
10	393493	36	M		Right	Self fall	Type II	Distal third	12	1	55	18	22	16		No	No	3Aa	3Ba	3Ca	4a	5Aa	5Bb	5Cb	No	N	P	C	Good
11	405449	48	M		Left	RTA	Type II	Proximal third	15	1	90	18	22	10		No	No	3Aa	3Ba	3Ca	4a	5Ab	5Ba	5Ca	No	N	L	C	Good
12	412303	37	M		Left	RTA	Type IIIA	Distal third	15	1	80	24	28	12		No	No	3Aa	3Ba	3Ca	4a	5Ab	5Bb	5Ca	No	N	L	C	Good
13	428249	50	M		Right	RTA	Type II	Proximal third	14	1	60	18	22	10		No	No	3Ab	3Ba	3Cb	4a	5Ab	5Ba	5Ca	No	N	P	C	Good
14	461342	25	M		Left	RTA	Type II	Middle third	15	0	70	24	28	12		No	No	3Aa	3Ba	3Ca	4a	5Aa	5Ba	5Cb	No	N	L	C	Excellent
15	506795	62	M	DM	Left	RTA	Type II	Distal third	15	1	50	18	22	11		No	No	3Aa	3Ba	3Ca	4a	5Aa	5Bb	5Ca	No	N	P	C	Excellent
16	509880	25	M		Left	RTA	Type II	Distal third	40	1	90	18	22	10		No	No	3Aa	3Ba	3Ca	4a	5Ab	5Ba	5Ca	No	N	L	C	Good
17	510627	42	M		Right	RTA	Type II	Distal third	15	2	60	24	28	9		No	No	3Aa	3Ba	3Ca	4a	5Aa	5Bb	5Cb	No	N	P	C	Excellent
18	510674	38	M		Left	RTA	Type II	Distal third	14	0	70	18	22	10		No	No	3Aa	3Ba	3Ca	4a	5Ab	5Ba	5Ca	No	N	P	C	Excellent
19	519498	27	M		Right	Self fall	Type II	Distal third	13	1	110	Non union	24	12	Non union	Y	No	3Aa	3Ba	3Ca	4b	5Ac	5Bc	5Ca	M	Sl	Im	NC	Poor
20	525730	29	M		Left	RTA	Type IIIA	Distal third	15	2	80	18	22	10		No	No	3Aa	3Ba	3Ca	4a	5Aa	5Ba	5Ca	No	N	L	C	Excellent
21	525815	35	M		Right	RTA	Type IIIA	Distal third	14	1	60	24	28	11		No	No	3Aa	3Ba	3Ca	4a	5Aa	5Ba	5Ca	No	N	P	C	Excellent
22	538200	45	M		Left	RTA	Type IIIA	Distal third	9	1	85	24	28	17		No	No	3Aa	3Ba	3Ca	4a	5Ab	5Ba	5Ca	No	N	P	C	Excellent
23	539523	45	M		Right	RTA	Type II	Distal third	15	2	70	18	22	9		No	No	3Aa	3Ba	3Ca	4a	5Ab	5Bb	5Ca	No	IL	L	C	Fair
24	539576	41	F		Left	RTA	Type IIIA	Middle third	14	1	105	Non union	24	10	Non union	Y	No	3Aa	3Ba	3Ca	4b	5Ab	5Bc	5Ca	O	Sl	Im	NC	Poor
25	539632	51	M		Left	Self fall	Type IIIA	Distal third	15	0	50	24	28	12		No	No	3Aa	3Ba	3Ca	4a	5Aa	5Ba	5Ca	No	N	P	C	Excellent
26	543850	65	F	HTN	Right	RTA	Type II	Distal third	14	1	80	18	22	11		No	No	3Aa	3Ba	3Ca	4a	5Aa	5Ba	5Ca	No	N	L	C	Excellent
27	543937	40	M		Left	RTA	Type II	Distal third	15	1	70	18	22	10		No	No	3Aa	3Ba	3Ca	4a	5Aa	5Bb	5Ca	No	N	L	C	Excellent
28	547903	38	M		Left	RTA	Type II	Middle third	15	1	110	Non union	24	11	Non union, infection	Y	No	3Ab	3Ba	3Cb	4a	5Ad	5Bb	5Ca	O	Sl	Im	NC	Poor
29	563913	40	M		Right	Self fall	Type II	Distal third	15	2	65	18	22	12		No	No	3Aa	3Ba	3Ca	4a	5Aa	5Ba	5Ca	No	N	P	C	Excellent
30	578258	45	M		Left	RTA	Type IIIA	Distal third	14	1	60	24	28	10		No	No	3Aa	3Ba	3Ca	4a	5Ab	5Ba	5Ca	No	N	P	C	Excellent