FUNCTIONAL OUTCOME IN MANAGEMENT OF OPEN TIBIAL DIAPHYSEAL FRACTURES BY LIMB RECONSTRUCTION SYSTEM AS PRIMARY AND DEFINITIVE TOOL - A PROSPECTIVE STUDY

By

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LIST OF ABBREVIATIONS

LRS	LIMB RECONSTRUCTION SYSTEM
AO	ARBEISGEMEINSCHAFT OSTEOSYNTHETICSEFRAGEN
OTA	ORTHOPEDIC TRAUMA ASSOCIATION
CD	COMPRESSION DISTRACTION
CNS	CENTRAL NERVOUS SYSTEM
IV	INTRAVENOUS
BP	BLOOD PRESSURE
ASIF	ASSOCIATION FOR STUDY OF INTERNAL FIXATION
OT	OPERATION THEATRE

ABSTRACT

INTRODUCTION:

One of the most frequent long bone fractures that most orthopaedic surgeons see is a tibial diaphyseal fracture. The tibia has more open fractures than any other major long bone because it is covered by skin for the majority of its length. The best course of therapy is still up for debate due to the high occurrence of comorbidities linked to these fractures, which makes care challenging in many cases.

AIMS AND OBJECTIVES:

The aim of the study is to assess the functional outcome in management of open tibial diaphyseal fractures by limb reconstruction system

MATERIALS AND METHODS:

In this prospective study, 30 patients who met the inclusion criteria were admitted in Department of Orthopaedics in BLDEU (Deemed to be University), Shri B. M. Patil Medical College Hospital and Research Centre, Vijayapura. Procedure was explained and informed consent taken. The period of study was from Jan 2022 to May 2022. The patients were followed up for a period of 6 months.

RESULTS:

In our study, there were 26 male and 4 female patients. Most common mode of injury was road traffic accident. The functional outcomes obtained were good results in 73.3% , moderate results in 16.7%, fair results and poor result in 10% of the study population. Pin tract infections and shortening were the most frequent complications

CONCLUSION:

It was concluded that, early stabilisation of an open tibial fracture using LRS and immediate soft tissue covering led to excellent fracture union and low rates of complications when compared to other treatment techniques. With a short duration of hospital stay and an early return to work, it is economically beneficial. Overall morbidity is reduced, and overall patient satisfaction is noted.

KEY WORDS: Limb reconstruction system, open tibial fracture.

INTRODUCTION

Current day injuries and fractures are so regular, with the primary cause being increased population, increased vehicular traffic congestion, urbanization and mechanization.

Fractures have different causes depending on the age group, with younger people typically suffering from high-energy trauma from incidents involving vehicles and falls from great heights. Unlike in the elderly, it is the result of trivial trauma that is secondary to osteoporosis.

The tibia is long bone which is most frequently fractured and the cost of providing orthopaedic care around the world is greatly influenced by how these fractures are managed. The most frequent causes of tibial diaphyseal fractures, according to epidemiological studies, are motor vehicle accidents, followed by sports-related injuries.

High-energy trauma transmits greater kinetic form energy, resulting in fractures that are mostly severe and are associated with soft tissue injuries.

Type of fracture, age group, condition of the soft tissues, and associated complications, treatment options vary for tibial fractures. For stable closed fractures, conservative treatments like casting or bracing are employed. These conservative techniques are less effective because of associated soft tissue injuries due to improper anatomical alignment.

External fixation, intramedullary nailing, and fixation with plates and screws are the operative procedures.

Unstable type I and type II of open tibial fractures are fixed with intramedullary interlocking nails. Compound fractures of types IIIA, IIIB, and IIIC, severely contaminated fractures, open periarticular fractures, open tibial fractures treated late, and polytraumatised patients should all be treated with external fixators[1].

Because of its location, the tibia is frequently injured[1]. The tibia has open fractures more frequently than any other major bone (long) as one-third of its surface is subcutaneous along the major portion of its length. Additionally, the vascular supply of tibia is less secure than that to bones surrounded with heavy muscles, particularly in the lower 1/3rd of tibia covered by tendons.[1]

Due to its subcutaneous location and thin soft tissue coverings, the leg is particularly susceptible to trauma. As a result, even a little soft tissue injury can result in serious issues like osteomyelitis, ulceration, and skin sloughing and loss. Soft tissues are thin and unhealthy in old age, suggesting venous stasis and the effects of ageing. While in young patients, open tibial wounds are frequent because of their increased level of intense exercise, and their thin soft tissue coverage. The risk of infection and non-union of fracture is considerably increased by reduced blood supply to bone due to stripping of associated soft tissues, as well as by the risk of contamination. The blood supply to the bone is relatively inadequate at the intersection of the middle third and lower thirds of the tibia. Thus, it is less likely that these fractures will heal within the allotted period.

Compound tibia fractures have been managed using a variety of techniques, all of which have produced varied degrees of success. The adoption of an external fixator has revolutionised how compound tibia fractures are managed and avoided the amputation of several limbs.

The external fixator has experienced a "sea of change," evolving from a simple frame to one with increasing complexity pin arrangements. It is a relief and a crucial weapon in the arsenal of the orthopaedic surgeon. Fragmented pieces are fixed using an external fixator. The phrase "external fixation" is misleading because it actually involves joining protruding pins to rigid framework that has many various designs outside the limb by anchoring the fragments of bone at an angle to the bone's long axis. This external scaffold is what gives the approach its name.

Fragment realignment, compression, or distraction are possible with external fixation without having to expose the fracture site.

The capacity to stabilise bone tissue and soft tissues away from surgical/damage focus is special feature of external fixators.

When used properly, they offer unhindered access to the important skeletal and soft tissue tissue structures for both initial assessment and any secondary interventions required to reestablish bone continuity and a functional soft tissue sleeve.[2]

External fixation causes far less vascular stress to the bone and soft tissues after application, which lowers infection risks than internal fixation methods.

An external fixator that is more stiff enables the patient to move virtually immediately. There are numerous external fixators with different levels of functionality and complexity available. The orthopaedic surgeon must decide what is best for his requirements and level of adaptation to the particular fixator.

Any external fixator must be used with a pre planned approach. The roentgenogram is essential. There should be a full set of instruments available.

“Limb Reconstruction System, a unilateral frame with half pins” was employed in our study (LRS). This technique is very efficient and provides access to soft tissue care together with hard stabilisation of fracture pieces. Though initially costly, these fixators end up being inexpensive because they may be used again without compromising quality.

Because the majority of our patients come from rural areas, using an external fixator that is so simple and efficient is essential to minimising costs and maximising benefits.

OBJECTIVES

1. Study of functional outcome in management of open tibial diaphyseal fractures by limb reconstruction system.
2. To study incidence of infection.

REVIEW OF LITERATURE

In 1985, Court CM Brown and SP Hughes in their study presented the findings of a prospective trial of Hughes unilateral external fixator use in the treatment of 48 tibial diaphyseal fractures. Grade II and Grade III fractures saw successful outcomes. It was discovered that successful outcomes depended on how well the initial decrease was done. [3]

In 1988, Charles C. Edwards managed 202 Gustilo Grade III open tibial fractures with primary external fixation and serial wound debridement. For 176 patients who had survived multiple injuries, staged reconstruction of soft tissue and bone was carried out (skin grafts in 57% of cases, muscle flaps in 32% of cases, and bone grafts in 28% of cases). 15% of patients had an infection, and 7% had an amputation.The removal of all necrotic bone before covering the wound contributed significantly to the infection rate dropping to 9% in the second half of the series. Early posterolateral grafting and progressive fracture loading in the fixator both helped to reduce angulation (>10%) and delayed union in 9% of cases. The fractures united in 93% of the cases. Fixator removal typically takes 87 days. The results of 89% of patients were successful, indicating that staged reconstruction is now an option for Grade III open tibial fractures.[4]

In 1987, Robert J. Caudle and P J. Stern Gustilo's did a study on on "severe open tibial fracture" ,Grade IIIa and IIIb open tibial fractures were included. They discovered that early healing of the injured soft tissue by local flaps or free tissue transfer had shown positive effects in those fractures.[5]

In 1990, Marsh JL and Nepola JV evaluated the outcomes of 35 cases of open tibial fractures treated with dynamic axial fixators. 33 patients were effectively managed with external fixator until healing in. They concluded that an early callus response is encouraged by early weight bearing and axial fracture site movements.[6]

In 1991, Anand J. Thakur and Joy Patankar investigated the management of 79 open tibial fractures, with early bone grafting and uniplanar external fixation, Weight bearing was made possible by exceptional stability. It took 11 to 40 weeks for bones to recover (mean 20 weeks). According to the study, a good strategy is the combination of external fixation and early grafting.[7]

In 1992, Korovessis P et al. in their study contrasted a group of patients who had only internal fixation with a group that received external fixation at first and then a "Sarmiento walking plaster" subsequently. Internal fixation was found to be ineffective for treating open Grade II and Grade III tibial shaft fractures; the latter technique was proven to be an acceptable substitute. [8]

In 1994, Paul Tornetta's treated Grade IIIB open tibial fractures with external fixation or interlocking intramedullary nail. The same initial care, soft tissue surgery, and early bone grafting were used in both groups of patients under. Out of 29 cases, 14 were managed with an IM nail and 15 with external fixators. They were all together, however the patients in the nailing group had improved motion and the less angulation.[9]

In 1995, Checketts RG, Moran CG, and Jenings AG assessed the outcomes of 134 patients of tibial shaft fractures treated with dynamic axial fixators and were examined. Open fractures were seen in 48 patients. The extent of the soft tissue damage was correlated with the union time. For Grade II and Grade III open fractures, respectively, the average union time was 5 and 6 months, respectively. The study's findings led them to the conclusion that the Dynamic Axial Fixator is a trustworthy and safe tool for treating tibial fractures. [10]

In 1997, Carlos Puento-Alanso, Pedro Antich-Adrover, David Martin-Garin, Juan Murias-Alvares, and Carlos Antich-Adrover conducted study on open tibial fractures with external fixation initially and subsequent intramedullary nailing. They came to the conclusion that the best method with minimal complications for treating open tibial fractures is external fixation followed by intramedullary nailing. [11]

In 1998, Henley MB, Chapman JR, et al. did a prospective study on the treatment of II, IIIA, and IIIB types of open tibial shaft fractures by Interlocking intramedullary nails that aren't reamed and half-pin external fixators, especially in terms of maintaining limb alignment. They concluded that the degree of soft tissue damage appears to be the main factor controlling how quickly bones heal and how frequently infection occurs at the injury site, not the type of implant used. [12]

In 2001, Bhandari M, Gugatt GH, Swiout Kowski MF, and Schemitsch EH reviewed t he impact of various open fracture stabilisation techniques on reoperation rates was reviewed by. In this research they found that, compared to fixation with plates, the use of an external fixator greatly reduced the need for re-operation. [13]

In 2001, a research was conducted by Sultan S. and Shah AA on treating open tibial fractures. In

32 open Grade III tibial fractures, the treatment and results were reviewed. With an AO external fixator, the patient was treated. All of them got standardised wound care that included surgical debridement and delayed wound closure. Once the fracture had healed and the soft tissue damage had healed, the external frame was taken down and a patella tendon-bearing cast was put on. In 31 cases, union took place in 32 weeks. The rates of deep infections were 13% and pin tract infections were 10%. [14]

In2001, Hans P. Granhed and Abbas H. Karladani conducted study on "bone debridement and limb lengthening in type III open tibial fractures". The median follow-up duration following bone resection was 27 months in the study of 9 patients treated with distraction and bone excision for open tibial shaft fractures with extensive soft tissue damage.. Of these patients, 4 had type III B fractures and 5 had type III C fractures. After removing dead bone and devitalized soft tissue, proximal corticotomy and lengthening were done to restore limb length. Repairing soft tissue damage with free vascular and local flap techniques. The median union time for the fracture was 7 months following the time of bone resection and 8 months following the injury. There were no subsequent amputations, non-unions, or deep infections.[15]

In 2002, a prospective trial was done by Ong CT, Choon DS, Cabrera NP, and Maffulli N. on "use of a Novel external fixator for the treatment of open tibial fractures and tibial non-union." According to their findings, acute patients performed more functionally than chronic ones. Although the inductors for using Novel Fixator are quite particular, they claimed that it is safe and adaptable. [16]

In 2003, CG Zalavras and MJ Patzakis developed methods for managing open fractures. Treatment objectives include function restoration, fracture union, and infection control. According to the form of fracture, any accompanying soft tissue damage, and any bacterial contamination present, all open fractures must be categorised. The urgent administration of intravenous antibiotics and tetanus prevention is required. Debriding the wound completely is required. Large-scale soft tissue injury may need for the healing of a local or free muscle flap. The anatomical location of the fracture and the kind of damage determine the stabilisation procedures. [17]

In 2004, Kesemenli CC, Kapukaya A, Subali M, Arsalan H, Neemioglu S, and Kayikei C in a study of early prophylactic autogenous bone grafting in type III open tibial fractures, found that primary prophylactic bone grafting done concurrently decreases the rate of delayed union, shortens the time to union, and does not increase the rate of infection. [18]

In 2005, Milenkovic S, Mitkovic M, and Radenkovic M.in their study on external skeletal fixation of tibial shaft fractures, came to the conclusion that early mobilisation, weight bearing, and rehabilitation are all made possible by the simple and efficient approach of external fixation of tibial shaft fractures. There was a chance of compression and distraction as well as unilateral fixation of tibial shaft fractures using convergent pin placement. External fixation had excellent or good results in 94.07% of instances, and unsatisfactory results in 5.08% of cases. [19]

In 2006, Kazuhiko Yokoyama, Moritoshi Itoman, Koushin Nakamura, Masataka, Tatsuro Tsukamoto, and Takashi Suzuki evaluated Six patients who had primary shortening and limb lengthening for Gustilo Type IIIB open tibial fractures, long-term functional results, and quality of life. One patient experienced a refracture at the healed docking site, one had a deep infection at the site of the initial corticotomy, and one had a superficial infection at the initial corticotomy. Two cases had serious wire breakage in the exterior frames, while two more involved severe equinovarus deformities. Three patients had high functional outcomes, two had acceptable functional outcomes, and one had poor functional outcomes.From their research, they came to the conclusion that primary shortening and limb lengthening (PSLL) was regarded as a practical treatment option for severe open tibia fractures with bone defect. [20]

In 2007, Reuss BL and Cole JD studied Open tibial shaft fractures and retrospectively analysed the impact of treatment time on infection and non-union rates. The end results revealed that when sufficient wound care, prompt antibiotic administration, and standardised and complete debridement were implemented in the operating room, the infection and non-union rates were not adversely influenced by prolonged time to surgical therapy (up to 48 hours). [21]

In 2008, Said Saghieh, Elie Ghanem, Bernard Sagherian, Maria Karam, Nadim Afeiche studied on distraction osteogenesis in a segmental tibial delayed union. In their study initially fractures were stabilized with a monolateral bridging external fixator with no evidence of callus formation 6 weeks later. The proximal fracture was used as “an osteotomy” for bone transport after a period of 6 weeks of compression. The successful outcome in this patient, confirms that distraction of a delayed union even when it is mobile, can lead to bone formation and healing of the delayed union.[22]

In 2010, Vijay C, Mahendra Kumar K L, Manjappa C N conducted a study where initial wound debridement and fracture stabilisation with an LRS external fixator were used to treat 45 cases of type IIIA and IIIB compound tibia fractures out of 157 total patients. Overall, 90% of the fractures had full healing. Only 18% and 10% of the cases had moderate and bad results respectively, whereas 28 instances, or 72% of the cases, had good to extraordinary results. The method of management using the LRS external fixator was found to be simple and effective for stabilising fractures, lessening the financial burden and those patients who are unwilling to undergo multiple procedures. These benefits include easy access to soft tissue care, enabling fracture union, and enabling an early return to function.[23]

In 2015, Ali Çağrı Tekin, Mehmet Selçuk Saygılı, Müjdat Adaş studied 62 patients who were operated on between 2011 and 2014 for open tibial diaphyseal fractures resulting from high-energy trauma, 50 tibias from 49 patients (males: 32, females: 17) were classified as type 3 according to the Gustilo-Anderson open fracture classification, and definitive treatment was applied with the LRS. Of the 50 tibias, full union was achieved with the LRS in 48 (96%). The mean time to union was 20.4 ± 4 weeks (range: 16–24). In this study, for the definitive treatment of open tibia diaphyseal fractures, the LRS was an optimal and safe choice that offered single-stage surgery.[24]

In 2016, Mahantesh Yellangouda Patil, Srinath Myadam Gupta conducted a study in which, LRS was used to treat 54 individuals out of 412 compound tibia fractures with Modified Gustilo-Anderson Type IIIA and IIIB during a 26-month period.. Bony and functional assessment was done by Association for the Study and Application of the Methods of Illizarov (ASAMI) criteria. Bony outcomes according to the ASAMI score have been excellent in 36 patients, good in 14, fair in 2, and poor in 2. Functional outcomes were excellent in 43 cases, good in 7 cases, and fair in 4 cases. The average duration to heal a fracture was 8 months. When compared to multiple staged surgery, the average hospital stay was 7 days, and the cost burden was reduced by 40%. LRS is a simple and effective surgical treatment which allows full-weight-bearing walking. It decreases hospital stays, is economical, and has very high patient compliance.[25]

In 2017, Sandeep Pangavane and Gaurav Kapadnis Studied 10 cases of compound tibia IIIa and 10 cases 0f IIIb as classified by Gustello -Anderson open wound criteria ,comorbidies were noted ,additional procedure if any were noted. Average age of patient was 37.9 year. Results showed total 100% fracture united. Average time tibial union was 10.2 month . Average time for tibial LRS in situ was 10.6 month. Average lengthening was 2.5 cm in 7 no cases (1.5-5 cm range). Average knee rom is 100 degree of flexion(range90-130).[26]

In 2018, Dr. Rajesh Kapila, Dr. Kamal Kumar Arora, Dr. Ranbir Singh a research was done for evaluating effectiveness of LRS in management of open fractures of long bones of the lower limb with significant bone loss. 25 people of either sex who were healthy and between the ages of 11 and 70 were included in the study. Using modified Anderson and Hutchin's criteria, they found that 19 patients had good outcomes, 4 had intermediate results, and 2 had poor results. Their study led them to the conclusion that LRS is an alternative to the conformist technique of fixation in the first treatment of open fractures of long bones with significant bone loss. It is also more patient-friendly, less burdensome, and expensive for the patient. Thus, it is a reliable, single-stage process.[27]

SURGICAL ANATOMY

The tibia's anatomical location, which renders it more susceptible to damage from direct impact, also makes surgical access simpler. Although the tibia and fibula are almost the same length, their structure and abilities are distinct. The fibula is small and essential for maintaining ankle stability, whereas the tibia is broad and transfers the majority of walking-related stress.[28]

1. Anterior or extensor compartment

The compartment is the region between deep fascia and interosseous membrane, limited laterally by anterior intermuscular septum and the fibula's extensor surface, and medially by the tibia's extensor surface.[29]

“The deep peroneal nerve, anterior tibial vessels, and the muscles tibialis anterior, extensor hallucis longus, extensor digitorum longus, and peroneus tertius are all contained inside it. It is a small space, thus any further accumulation of its contents, such as a haematoma or muscle oedema, might result in compression and ischaemia of the compartment's neurovascular and muscular components (compartment syndrome)”.[29]

“The superior extensor retinaculum, which is connected to the anterior margins of the tibia and fibula, is formed when the deep fascia is enlarged in its lower length. The tibialis anterior, extensor hallucis longus, extensor digitorum longus, and peroneus tertius tendons run medially to laterally in front of the lower end of the tibia, deep to the retinaculum”.[29]

“Deep to the retinaculum, between the extensor hallucis longus and the extensor digitorum longus, are the anterior tibial vessels, which are medial to the deep peroneal nerve”. [29]

Deep peroneal nerve:

At the point where the common and deep peroneal nerves split, the deep peroneal nerve emerges into the peroneus longus and crosses the fibula's neck. Between the extensor digitorum longus and tibialis anterior, it sits on the interosseus membrane after spiralling around the fibula's neck. Between the tibialis anterior and the extensor hallucis longus, in the interosseus membrane, is the neurovascular bundle in the centre of the leg. The extensor hallucis muscle lies on its medial side and crosses the bundle from the front. All four of the muscles in the anterior compartment of the leg are supplied by the deep peroneal nerve. [29]

Anterior tibial artery:

The anterior tibial artery, which is formed from the popliteal artery's bifurcation in the calf, travels forward through the top interosseous membrane close to the fibula's neck, with a companion vein on either side. The dorsalis pedis artery then continues distally as it descends over interosseous membrane and passes in front of ankle joint between malleoli. It nourishes the extensor compartment muscles and gives both malleoli malleolar branches as well as an anterior recurrent branch that anastomosis around the top end of the tibia. The deep peroneal nerve is present beside the artery.[29]

TIBIOFIBULAR JOINTS

A synovial joint between the lateral tibial condyle and the fibular head is called the superior tibiofibular joint. The surfaces that articulate the joints are almost flat. The anterior and posterior ligaments support the capsule.

The inferior tibiofibular joint is a fibrous connection (syndesmosis) between the concave fibular notch of the distal tibia and the convex medial surface of the distal end of the fibula. The interosseous tibiofibular ligament and anterior and posterior tibiofibular ligaments serve as strong anchors for the bones. The tibiofibular joints barely move at all; during ankle dorsiflexion, the fibula rotates a little laterally.[29]

LATERAL COMPARTMENT OF THE LEG

The anterior and posterior intermuscular septa border the front and back of this muscular compartment, which is located between the peroneal surface of the fibula and the deep fascia of the leg.[29]

The superficial peroneal nerve and the peroneous longus and brevis muscles are located there. It receives blood from peroneal artery branches that puncture the posterior intermuscular septum and the flexor hallucis longus. Most of its vein drains into the little saphenous vein. A branch of the common peroneal nerve called the superficial peroneal nerve arises at the anterior border of the peroneus longus muscle, beyond the anterior intermuscular septum. It starts in the peroneus longus substance. It penetrates the deep fascia between the middle and lower third of the leg, supplies both peronei, and divides into medial and lateral branches. It provides the skin across the lower leg's anterolateral side.[29]

POSTERIOR COMPARTMENT OF LEG

This is often referred as calf. The terminal of the posterior femoral cutaneous nerve supplies to the top of the calf's skin. The lateral side of the calf and the back of the leg are supplied by the tibial and common peroneal nerves below this level, while the medial side is supplied by the saphenous nerve.

The sural nerve is located behind the lateral malleolus, with **short saphenous vein**, It drains the dorsal venous arch's lateral side as well as the lateral border of the foot. It passes upward through the subcutaneous fat to the midline of the calf after penetrating the deep fascia midway between midcalf and the popliteal fossa's roof. It enters the popliteal vein after passing through the deep fascia. The flexor retinaculum, a thickening of the deep fascia that connects the deep flexor tendons and neurovascular bundle, between the medial process of the calcaneus and the medial malleolus.

Between the superficial and deep muscle groups that make up the calf, the posterior compartment of the leg, is where the deep transverse fascia of the leg is located. The tendocalcaneus or Achillis tendon, which is a thick tendon in the back of the heel, is where the gastronemius, plantaris, and soleus superficial muscles come together. They serve as the ankle joint's primary plantar flexors. 40 Popliteus, flexor digitorum longus, flexor hallucis longus, and tibialis posterior are all members of the deep group, extending deep to the flexor retinaculum in plantar aspect of foot.

The sciatic nerve's tibial portion serves as the posterior compartment's nerve, the compartment's arteries are the posterior tibial and its peroneal branch.

POSTERIOR TIBIAL ARTERY:

Occurs where the popliteal artery splits into the anterior and posterior tibial branches at the lower margin of the popliteus. It descends on the tibialis posterior, between the flexor digitorum longus and the flexor hallucis longus, passing beneath the fibrous arch in the origin of the soleus. It splits into the medial and lateral plantar arteries as it exits behind the flexor retinaculum. It is joined by two venae comitantes that are in communication with one another and surround the artery. 2.5 cm in front of the medial border of the tendo calcaneus, behind the medial malleolus, the artery's pulses may be felt.[28]

BRANCHES:

(a) 2.5 cm distal to the popliteus is where the **peroneal artery** starts. It provides branches to the calf muscles as well as branches that supply the peroneus longus and brevis. It travels distally in a fibrous canal between flexor hallucis longus muscle and the tibialis posterior muscle. It provides the fibula with a nutrition artery. It splits off at the end into a perforating branch that enters the extensor compartment through the interosseous membrane and a lateral calcaneal branch that exits to the side of the heel.

(b) **Circumflex fibular artery**, the arterial anastomosis around the knee is joined as it passes laterally across the fibular neck. It enters the tibia just distal to the soleal line and provides the soleus and deep flexors with a nutritional artery.. Flexor retinaculum is penetrated by medial calcanean branches, which also feed the medial side of the heel.

The tibial nerve extends from the soleus deep to the midline of the calf. Initially on its lateral side, the posterior tibial artery eventually passes in front of it and descends on its medial side. It nerve splits into medial and lateral plantar nerves halfway between the medial malleolus and the tendo calcaneus, where it exits under the centre of the flexor retinaculum.

It is the flexor compartment nerve that supplies the soleus, flexor digitorum longus muscle, hallucis longus muscle, and tibialis posterior muscles through branches. It provides the medial calcanean nerves necessary to nourish the skin of the heel, particularly the weight-bearing surface, through the flexor retinaculum.

The interosseous membrane, a thick sheet of fibrous tissue, fills the gap between the tibia and fibula except for a small hole at its top end that allows the anterior tibial vessels to pass through. [39] In fractures, it stops the bone from separating until it has been severely damaged. The interosseous membrane distributes indirect force exerted on the tibia to the fibula since the bulk of its fibres flow downward and outward.

TIBIA

Medial to the fibula is the tibia. Its shaft features broadened ends and a triangular cross shape. The smaller distal end has a robust medial malleolus that protrudes distally. Sharp and sloping medially in the direction of the medial malleolus is the anterior boundary. It has three borders and three bony surfaces. **Proximal end**: Body weight is transferred via the femur and is supported by the enlarged proximal end. It has a tibial tuberosity, medial and lateral condyles, and an intercondylar region. **Condyles**: The proximal posterior side of the shaft is overhung by the tibial condyles. Both have irregular intercondylar region separating their proximal articular surfaces. The lateral condyle stands out more. In the fossae surrounding the patellar tendon in the passively flexed knee, the anterior edges of the condyles are palpable.

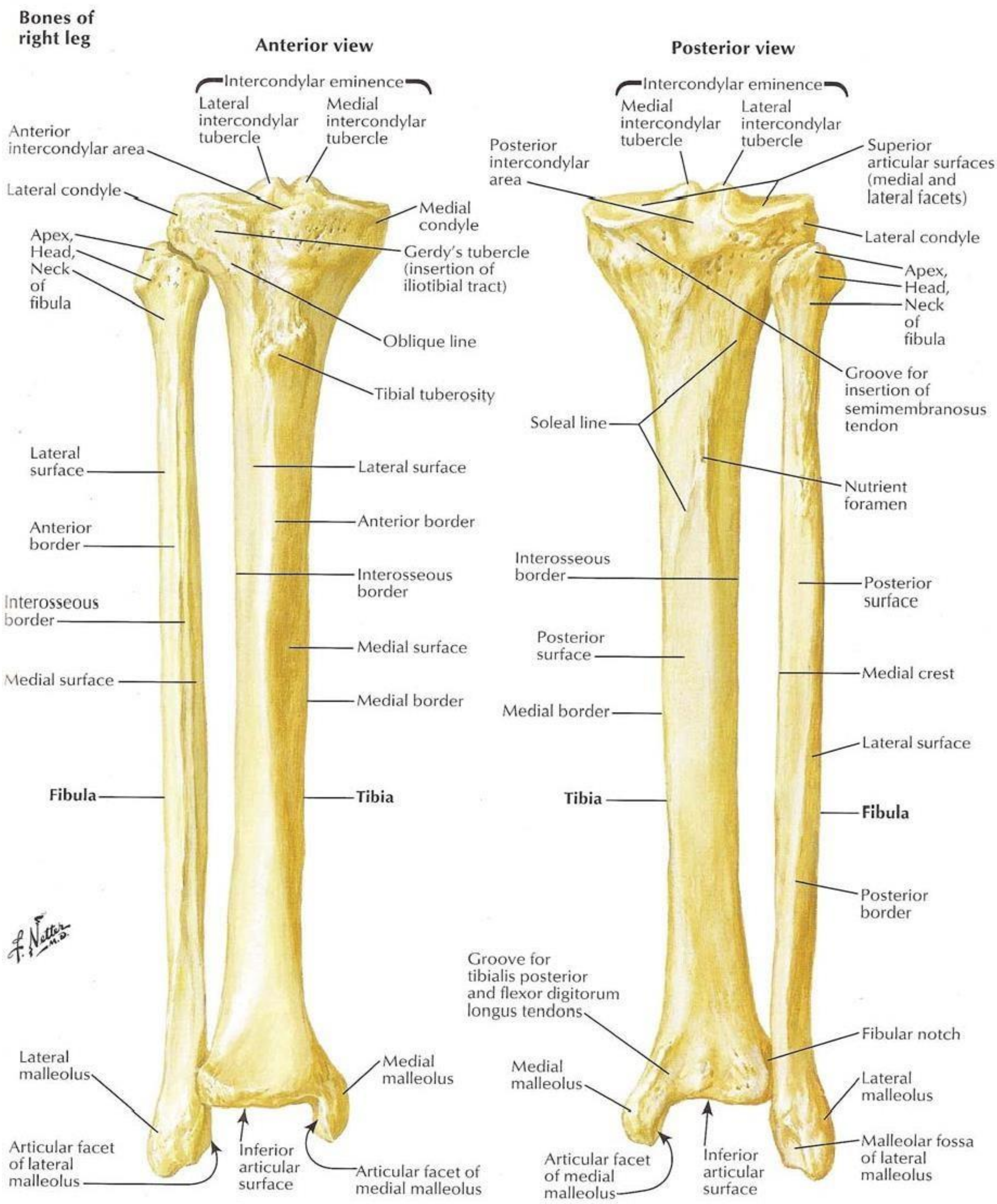


Fig. 1: Osteology of tibia and fibula

The lateral condyle's fibular facet faces distally and posterolaterally. Superior tibiofibular joint inclination varies, however it can be either horizontal or oblique. The lateral surface of the shaft and the anterolateral side of the condyle are divided by a sharp boundary that permits the attachment of deep fascia. On its anterior side, the iliotibial tract's distal connection leaves a flat yet distinct imprint. Gerdy's tubercle, which is typically palpable, is this. The lateral edge is a sharp ridge between the lateral condyle and lateral surface of the shaft, and the distal end of the large triangular portion, which is created by the tibial tuberosity, lies at the distal end of the continuous anterior condylar surfaces.[28]

Tibial tuberosity: The triangular region where the anterior condylar surfaces converge is the truncated apex of th**e** tibial tuberosity. It has a little projection and is separated into a smooth proximal zone and a rough distal section. The subcutaneous infrapatellar bursa separates the distal portion from the skin, which is palpable. The distal limit of the proximal tibial growth plate is indicated by a line that runs across the tibial tuberosity. The superficial fibres of the patellar tendon extend to the rough region distal to the line from where it is linked to the smooth bone nearby.[28]

Shaft: The medial, lateral, and posterior sides of the triangular-shaped shaft are separated from their other by anterior, lateral (interosseous), and medial boundaries. It is narrowest and spreads to both ends at the junction of the middle and distal thirds. The anterior border is entirely subcutaneous and descends to the medial malleolus's anterior border from the tuberosity. Its distal fourth cannot be distinguished. It has a sinuous, acute crest, and a distal fourth medial turn. The fibular facet is distal and anterior to the interosseous border, which begins distally and descends to the anterior margin of the fibular notch. Most of its length is covered by the interosseous membrane that joins the tibia and fibula.

The medial border descends to the medial malleolus's posterior boundary from the medial condyle's anterior end of the groove. It is indistinct both proximally and distally, yet sharp in the middle. Between the anterior and medial boundaries, the anteromedial surface is large, smooth, and totally subcutaneous. In the proximal three-fourths, the lateral surfaces face laterally and are transversely concave. Because of the medial deviation of the anterior and distal interosseous boundaries, its distal fourth swerves anteriorly. It has a convex shape. Between the interosseous and medial borders, over the posterior surface, an uneven, oblique soleal line may be seen that is largest above. The deep fascia and medial end of the superior extensor retinaculum are attached to the anterior border.

The tibialis anterior tendon, extensor hallucis longus, anterior tibial vessels, deep peroneal nerve, extensor digitorum longus, and peroneous tertius cross it in mediolateral order at its distal end. Near the soleal line, the popliteus is linked to the posterior surface in a triangle. The deep transverse fascia, soleus, and its fascia, as well as the popliteal aponeurosis, all attach to the soleal line. The tibial nerve and posterior tibial vessels descend on the tibialis posterior laterally to the tubercle. The tubercle for the medial end of the tendinous soleal arch is located on the soleal line. A vertical line distal to the soleal line separates the posterior attachments of the flexor digitorum longus and tibialis muscles.[28]

Distal end: Anterior, medial, posterior, lateral, and distal surfaces may be seen on the tibia's somewhat broadened distal end. As the medial malleolus, it projects inferomedially. Tibia's distal end is laterally rotated in relation to its proximal end. In Caucasians and Asians, tibial torsion is 30, but it is substantially higher in persons of

African descent. The smooth anterior surface continues onto the lateral side of the shaft when a thin groove divides it from the distal surface.[28]

An anterior groove close to the articular surface is where the ankle joint's capsule is linked. The malleolus and the shaft's medial surfaces are continuous with the smooth medial surface above and below. It is both subcutaneous and obvious. It is smooth and continues with the shaft's rear surface in other places. Tibialis posterior tendon is located in the groove at the back. the flexor digitorum longus often disengages from the bone. The posterior tibial vessels, nerve, and flexor hallucis longus come into touch with this area further laterally.[28]

The lateral surface is composed of the triangular fibular notch, the anterior and posterior borders of which protrude and merge at the interosseous border. A significant interosseous ligament roughens the notch's floor at its proximal end, although it is smooth distally. The borders of the notch are where the anterior and posterior tibiofibular ligaments are joined.

Medial malleolus: The smooth lateral side of the short, thick medial malleolus articulates with the medial talar surface through a crescentic facet. Its back continues the groove that runs along the posterior aspect of the shaft for the tibialis posterior tendon, and its anterior side is rough.

The distal border provides connection to the deltoid ligament and is pointed anteriorly and posteriorly depressed. The medial malleolus ends just before the lateral malleolus, which is also more posterior. The proximal medial border and the anterior surface of the ankle joint capsule are joined, respectively.[28]

Vascular flow: The metaphyseal arteries from the genicular arterial anastomosis supply the proximal end of the tibia. The branch of the posterior tibial artery travels through the nutritional foramen, which is located close to the soleal line.When it first enters the bone, it produces more ascending than descending branches. The anterior tibial artery and its muscle branches furnish the periosteal supply to the shaft. The anastomosis surrounding the ankle supplies the distal metaphysis with branches.

Innervation: The proximal and distal ends of the tibia are innervated by branch nerves from the nerves that supply the knee joint and ankle joint. Branching nerves that innervate the muscles connected to the tibia supply the periosteum of the shaft.

Ossification: Three ossification centres are present in tibia. One in each epiphysis and one in the shaft. Midshaft ossification starts during the sixth intrauterine week.[28]

In most cases, the proximal epiphyseal centre is present from birth. The smooth portion of the tibial tuberosity is then formed by a narrow anterior process that descends from the centre about the age of 10. Around the twelfth year, a distinct tuberosity centre may emerge; this centre quickly unites with the epiphysis. The proximal epiphysis merges in the eighth year in both males and females. Early in the first year, the distal epiphyseal centre develops, and it meets the shaft in around the fifteenth year for females and the seventeenth year for men. The medial malleolus, which is an outgrowth of the distal epiphysis, starts to ossify in the seventh year.

FIBULA:

Since it is significantly thinner than the tibia, the fibula does not directly contribute to the transfer of weight. It features a long shaft, a distal lateral malleolus, a proximal head, and a small neck.[28]

Head: The fibula's head protrudes forward, backward, and laterally. A circular facet on the proximomedial side of the lateral tibial condyle articulates with a facet on the infero lateral surface. Skull's apex is perceptible 2 cm distal to the knee joint and faces proximally from the posterolateral side of the head. In front of apex, fibular collateral ligament is connected. Edges of articular facet are where tibiofibular capsular ligament is joined. The common peroneal nerve might rub on bone where it crosses posterolaterally to the neck.[28]

Shaft: Three surfaces and three edges surround the shaft. Apex of an extended triangular area that is continuous with lateral malleolar surface serves as the anterior border, which rises proximally to the anterior aspect of the fibular head. Lateral malleolus's posterior border continues with medial boundary of posterior groove and is rounded in proximal half, generally distinct distally. Interosseous boundary is often more posterior and is medial to anterior border. The lateral surface faces laterally in its distal third between the anterior and posterior limits. The distal quarter spirals to become continuous with the posterior groove of the lateral malleolus, and the lateral side of the distal quarter is attached to the peroneal muscles. Between the anterior and interosseous boundaries, the anteromedial surface often faces anteriorly. It is connected to the extensor muscles. It has a large distal portion, a narrow proximal portion, and simply become a ridge. Posterior surface is biggest, which is connected to the flexor muscles, is found between the interosseous and posterior borders. A longitudinal medial crest divides its proximal two thirds.

The medial aspect is curved by the distal half of the posterior surface. Distally, this region is located in the tibia's fibular notch. Subcutaneous tissue covers the triangular region immediately adjacent to lateral malleolus, while muscles covers remaining portion of shaft.

A triangular subcutaneous surface is enclosed by two ridges that split the anterior border distally. To its proximal three-fourths is linked the anterior intermuscular septum. The superior extensor retinaculum is distally joined at the lateral end of the triangular region's anterior border. The posterior border of the triangle is linked distally to the lateral end of the superior peroneal retinaculum. The interosseous border terminates at the proximal limit of the rough region for the interosseous ligament. The peroneal artery is connected to the medial crest of the posterior border. A layer of deep fascia that is connected to the medial crest divides the flexor hallucis longus muscle and flexor digitonum longus muscle from the tendons of tibialis posterior muscle.[28]

Lateral malleolus: The lateral malleolus, which extends distally and posteriorly, is formed by the distal end of the fibula[39]. Its posterior face features a deep groove with a distinct lateral boundary, whereas its lateral aspect is subcutaneous. Its anterior side is smooth, rounded, and continuous with the tibia's inferior border. On the medial surface, there is a triangle-shaped articular facet that is vertically convex, has a distant apex, and articulates with the lateral talar surface. A rough malleolar fossa with vascular foramina pits is located behind this facet. The posterior tibiofibular and posterior talofibular ligaments attach in the posterior fossa. Anterior talofibular ligament attaches to the lateral malleolus on its anterior side. Prior to its peak, notch is connected to calcaneofibular ligament. The superior peroneal retinaculum is covered by the tendons of the peroneus brevis and longus, which groove the area's posterior edge.

Vascular supply: A nutritional foramen located distally in the centre of the posterior surface of the fibular shaft receives a branch of the peroneal artery. Metaphyseal vessels are received from the genicular and ankle arterial anastomosis, respectively, at the proximal and distal ends.

Innervation: The proximal and distal ends of the bone are supplied by branches of nerves that supply the knee and superior tibiofibular joint, as well as the ankle and inferior tibiofibular joint, respectively. Branches from nerves innervates muscles linked to the fibula supply the periosteum of the shaft.

Ossification: The three centres, one for the shaft and two for the extremities, are where the fibula ossifies. The process starts in the shaft around the eighth intrauterine week, moves to the distal end in the first year, the proximal end in the third year for females, and the fourth year for men. Around the fifteenth year in females and the seventeenth year in men, the distal epiphysis merges with the shaft. In contrast, the proximal epiphysis does not combine until a male's or a female's 17th or 19th year.

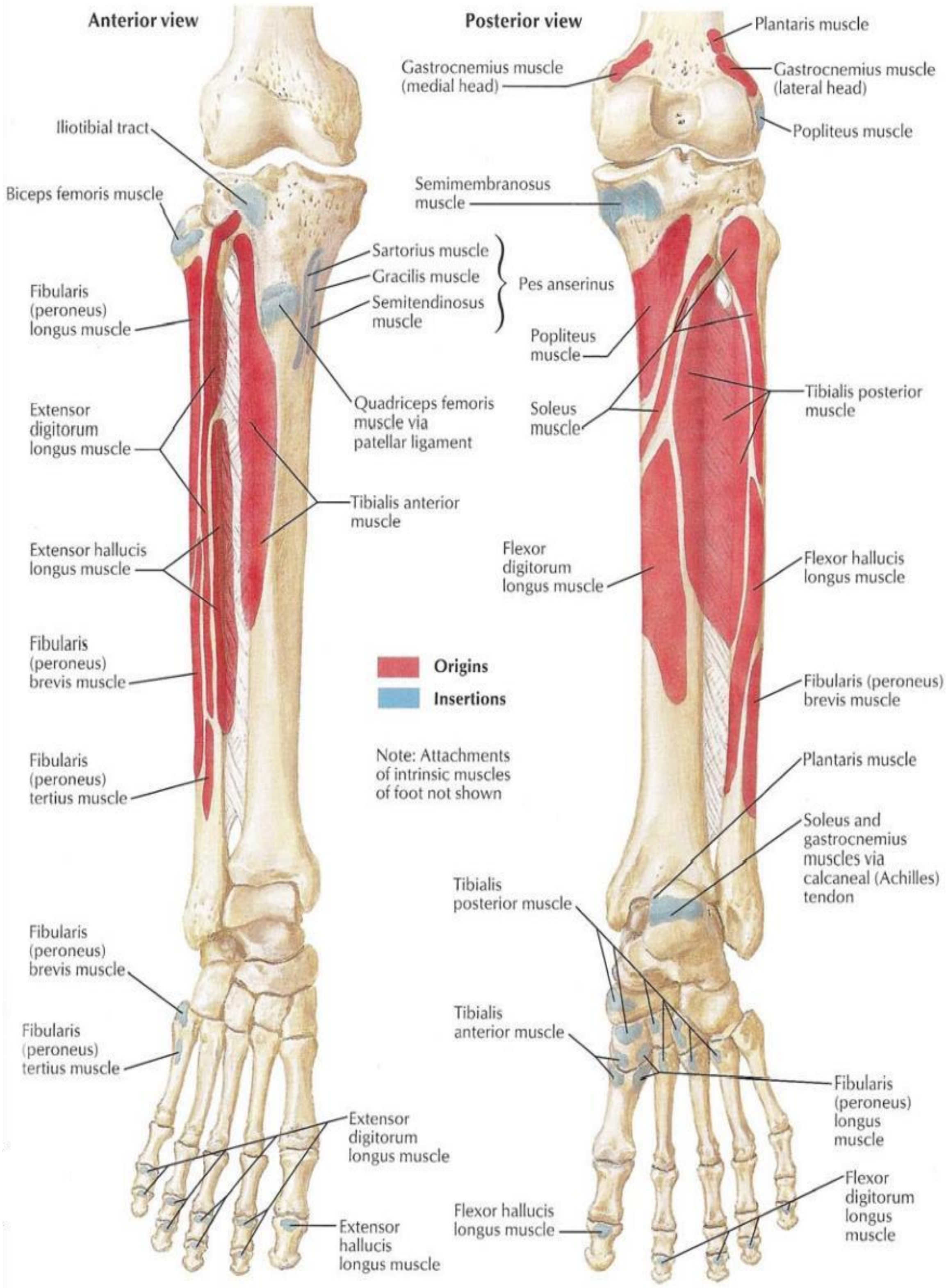


Fig. 2: Attachments of muscles of leg

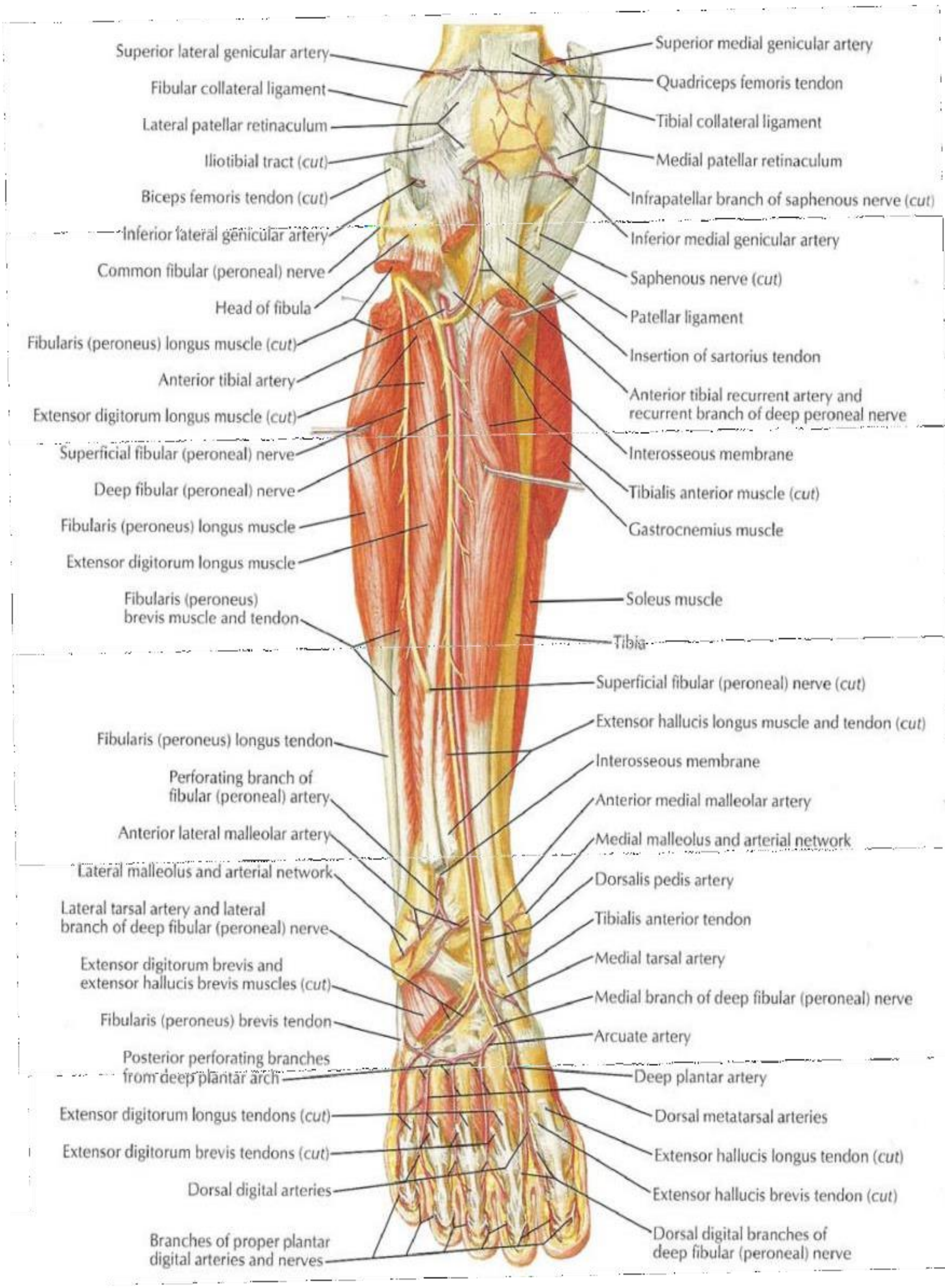


Fig. 3: Muscles of leg (Deep Dissection): Anterior view

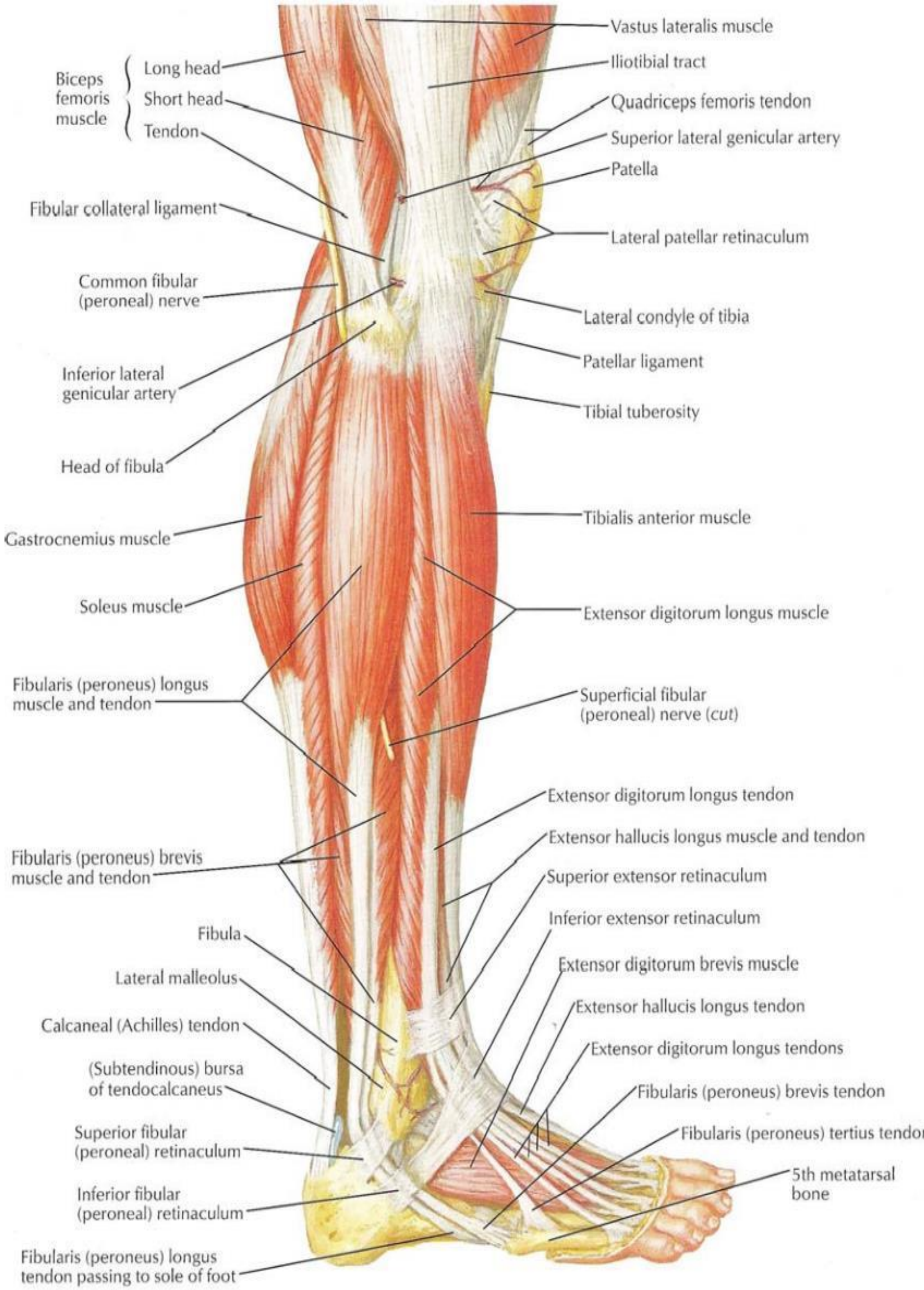


Figure 4: Muscles of leg: Lateral view

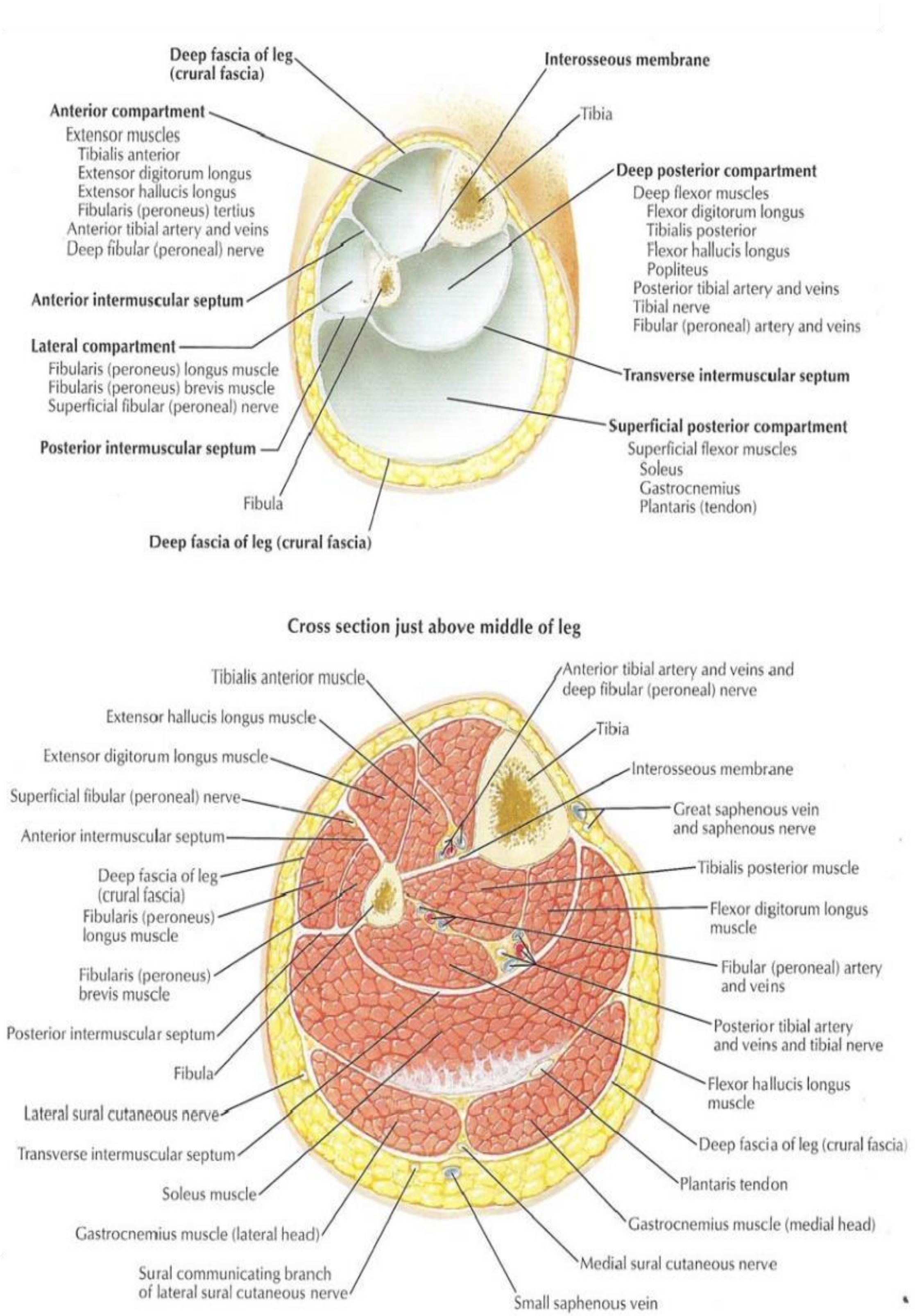


Fig. 5: Leg: Cross sections and fascial compartments

MUSCLES OF LEG

Muscles of lateral compartment of leg[28,29]

Sl. No.	Name of the muscle	Origin	Insertion	Action	Nerve supply	Test to function
1	Peroneus longus	Head and the upper 2/3rd of the peroneal surface of the fibula and from the intermuscular septa.	Lateral side of the base of the first metatarsal and the adjoining part of the medial cuneiform.	Evertor and weakly plantar flexor of the foot. Peroneus longus is a factor in maintaining the lateral longitudinal arch and transverse arches of the foot.	Superficial peroneal nerve (L_5, S_1)	Foot is everted. The tendons are seen and felt below the lateral malleolus.
2	Peroneus brevis	Lower 2/3rd of the fibula in front of the origin of peroneus longus.	The tendon passes above the peroneal trochlea to be inserted into the tubercle at the base of the fifth metatarsal bone.	Everts and plantar flex the foot.	Superficial peroneal nerve.	The tendon can be seen and felt below the lateral malleolus when foot is everted.

Muscles of extensor compartment[28.29]

Sl. No.	Name of the muscle	Origin	Insertion	Action	Nerve supply	Test to function
1	Tibialis anterior	Upper 2/3rd of the extensor surface of the tibia, from the interosseous membrane, and from deep fascia overlying it.	Medial and inferior surfaces of the medial cuneiform and adjacent part of the first metatarsal bone.	Combined dorsiflexion of the ankle joint and inversion of the foot.	Deep peroneal and recurrent genicular nerves (L_4).	Dorsiflex the foot against resistance.
2	Extensor hallucis longus	Middle half of the fibula and the adjacent interosseous membrane.	Base of the terminal phalanx of the great toe.	Dorsiflex the great toe and also it is a dorsiflexor of the ankle.	Deep peroneal nerve (L_5).	Big toe is dorsiflexed against resistance.
3	Extensor digitorum longus	Upper three quarters of the extensor surface of the fibula, a small area on the lateral condyle of the tibia, and the interosseous membrane.	Divides into four slings and inserted into the lateral four toes. Dorsal extensor expansion over the proximal phalanx divides into three slips, the central slip being inserted into the base of the middle phalanx, two side, slips reunite after joining with tendons of interossei and lumbricals and inserted into base of distal phalanx.	To dorsiflex the lateral four toes.	Deep peroneal nerve (L_5, S_1)	Lateral four toes can be dorsiflexed against resistance.
4	Peroneus tertius	Lower third of the fibula.	Dorsum of the base of fifth metatarsal bone.	To dorsiflex and evert the foot.	Deep peroneal nerve (L_5, S_1)	Dorsiflex the foot against resistance.

Posterior compartment of leg – Superficial muscles of the calf[28,29]

Sl. No.	Name of the muscle	Origin	Insertion	Action	Nerve supply	Test to function
1	Flexor digitorum longus	Arises from the posterior surface of the tibia below the soleal line.	Are inserted into the bases of distal phalanges of the lateral four toes.	Action is to plantar flex the lateral four toes. Secondarily to plantar flex the ankle joint. It helps in maintaining the longitudinal arch of the foot.	Tibial nerve (S_1, S_2)	Terminal phalanges of the other toes (lateral four) are flexed against resistance.
2	Flexor hallucis longus	It arises from the interosseous membrane and adjoining posterior surface of the both tibia and fibula below the soleal line.	Inserted mainly into the tuberosity of the navicular. Tendinous slips also pass to the sultentaculum tali, all three cuneiforms, cuboid, second, third, fourth metatarsals.	To invert, adduct the fore foot, and also to plantar flex the foot. It contributed to maintaining the medial longitudinal arch of the foot.	Tibial nerve (L_4)	With the foot in slight plantar flexion, it is inverted against resistance, the tendon can be felt behind the medial malleolus.

Deep muscles of the posterior compartment of the leg[28,29]

Sl. No.	Name of the muscle	Origin	Insertion	Action	Nerve supply	Test to function
1	Gastrocneumius	Lateral head of the gastrocneumius arises on the lateral surface of the lateral femoral condyle from a smooth pit above that of popliteus. Medial head of gastrocneumius arises from the back of the medial condyle and popliteal surface of the shaft of femur.	Two head converge to lie side by side. Broad bellies of the muscle insert into a dense aponeurosis on their anterior surfaces, bearing on the soleus muscle. The aponeurosis blends with that of soleus to form tendocalcaneus, which is inserted into a smooth area on the middle 1/3rd of posterior surface of calcaneus.	Plantar flexor of the foot. This is also a flexor of the knee.	Tibial nerve ($S_{1,2}$). Each head of gastrocneumius receives a branch from the nerve in the popliteal fossa.	The foot is plantar flexed against resistance. The contracting muscle can be seen and felt.
2	Plantaris	Arises from the lower part of the lateral supracondylar line of the femur.	It is slender tendon runs distally deep to medial head of gastrocneumius and continues along the medial border of tendocalcaneus with which it fuses.	Plantar flexion of foot.	Tibial nerve ($S_{1,2}$) branch to lateral head of gastrocneumius supplies plantaris as well.	Plantar flex the foot against resistance.
3	Soleus	The muscle arises from the upper quarter of the back of the fibula, including the head of the fibula; soleal line of the tibia, middle third of the posterior border of the tibia.	The muscle has a dense aponeurosis upon either surface. Muscle fibres slope downwards from the anterior to posterior lamella. The posterior lamella is continued at its lower end into tendocalcaneus, it along with gastrocneumius inserted into a smooth transverse area on the middle third of the posterior surface of the calcaneum.	Chief plantar flexors of the foot. Soleus is an antigravity muscle is a slow plantar flexor of the foot.	Tibial nerve (S1,2) it receives two branches one from above the muscle in the popliteal fossa and one on its deep surface in the calf.	Plantar flex the foot against resistance. TA and muscle can be seen and palpated while contracting.

MECHANISM OF INJURIES[32,33]

A substantial amount of energy must be supplied to the tibial shaft fracture. Bone is strongest in compression and weakest in tension, which explains why it fractures in particular patterns. As a result, the part of a loaded bone that experiences failure first when a force causes tensile stresses is that area. A lengthy bone that underwent pure bending developed a transverse fracture. The failure (marked by a fracture) starts on the upper, convex surfaces because they experience the greatest elongation and thus, the maximum tensile strains. After then, the material is penetrated transversely by the fracture. The layer immediately under the outer layer also experienced significant tensile, causing them to break. The fracture continues to spread transversely across the bone in this manner until it collapses.

Since the concave surface is compressed, the fracture does not start there. the crack or fracture line that appears when an axial or torsional twist is applied to a bone. That results in a spiral fracture.

Depending on the direction of the twist, one diagonal of the rectangle lengthens while the other shortens as the bone twists. Spiral fractures happen when a crack develops parallel to the lengthening diagonal and travels around the outside of the bone. Since it allows for the most twist, the area with the lowest diameter often exhibits the highest distortion.This explains why the tibia's small distal portion of the shaft frequently experiences torsional fractures.

As bone is weaker in shear than during compression, a compressive stress causes cortical bone to fail through shear, which is seen by sliding along the diagonal. Shear stresses are internal stresses that are 45 percent of the compressive force. In this instance, compression forces the bone's surface to glide along an oblique surface at a 45° angle to the applied stress.

Bone can also be crushed or ground down under extremely high stresses, such as during impact fractures, especially weaker at metaphyseal ends of bones. Diaphyseal cortical bone is stronger in shear than the metaphyseal ends' trabecular bone is in compression.As a result, it is improbable that the diaphysis would experience shearing failure as a result of only compressive stresses.

The butterfly fractures are the consequence of both compression and bending. As a result of the bending strain, the fracture first fails in tension, resulting in a transverse crack.

Tibial diaphyseal fractures have five main causes: falls, sports-related injuries, attacks or direct blows to the body, vehicle accidents, and gunshot wounds. Simple falls, in which the patient falls from a height, descends steps or a slope, or falls from a height, are a subset of falls.

Motorcyclists, pedestrians, or car occupants are often the ones that suffer injuries from motor vehicles. Additionally, the sort of gun used affects the injuries caused by gunshots. Land mines and other explosives are additional causes of tibial diaphyseal fractures, but these kinds of injuries are not common.

The many types of tibial fractures that are treated in hospitals across the world vary and are typically influenced by how the country's health system is set up.Patients with severe injuries are frequently transported to major teaching hospitals in nations with sophisticated trauma systems, whereas patients with less serious fractures are treated in peripheral hospitals.

The patient who presents with a gunshot tibial fracture is often young, or homeless, or soon to enter criminal justice system.

There is a dearth of knowledge regarding these fractures.

The muzzle velocity of the firearm affects the fracture morphology and soft tissue injury brought on by bullets to the tibia.

Military weapons create high velocity injuries, while low velocity injuries are more frequently found in civilian practise and are linked with a muzzle velocity < 2,000 feet/sec. Gunshot wounds are not very prevalent in most nations.

Simple falls, falls down the stairs, sports related injuries, and direct blows to the tibia frequently cause tibial fractures with simple fracture patterns. However, there is a substantially greater incidence of OTA type B and C fractures in motor vehicle accidents and falls from heights.[33]

CLASSIFICATION OF TIBIAL FRACTURES

There have been several attempts to categorise tibial fractures in the last 25 years, according to the literature. Ellis divided fractures into three fundamental categories:

1. Minor severity

A fracture with a minor degree of communition or a minor open wound is considered to be of minor severity.

2. Moderate severity

Total displacement or angulation with little comminution or a modest open wound are considered moderately severe injuries.

3. Major severity

Here, the fracture pieces are completely displaced along with significant degrees of comminution or a significant open incision.

Description of the fracture

(a) When characterising the X-ray, the fracture is categorised as being in proximal, middle, or distal third of the bone, depending on its anatomical position.

Radiographically, a fracture might be transverse, oblique, spiral, comminuted, or segmental. Both the lateral and anterior-posterior views are used to quantify angulation. The fragmented pieces' apex is the direction in which the angulation is measured. As a result, the angulation is anterior or posterior, and in anteroposterior view, it is varus and valgus.

To be observed are shortening, overlapping, and distracting. Rotation must be assessed clinically because it is challenging to determine on X-rays.

According to the Gustilo-Anderson method of categorization, compound fractures are categorised as follows:[34]

TypeI : Open fracture: less than one centimeter-long wound. A bone spike has often punctured the skin with a reasonably clean puncture. Little soft tissue damage or injury exists, and no symptoms of a crushing injury exist. Typically, there is little comminution and fracture is simple transverse or short oblique.

TypeII: Significant soft tissue injury, a flap or avulsion, and the laceration is longer than one centimetre is seen. Tissues are slightly or moderately crushed, there is moderate comminution, and there is moderate contamination.

TypeIII: It is associated with significant contamination levels and substantial soft tissue injury, especially to muscles, skin, and neurovascular systems. High velocity trauma frequently results in the fracture, which causes significant comminution and instability.

Type IIIa : Despite severe laceration or high energy trauma, soft tissue covering of the fractured bone is sufficient. Regardless of the extent of the lesion, this category comprises segmental or highly comminuted fractures after high energy trauma.

Type IIIb : is linked to severe fracture comminution from high energy trauma and widespread damage with soft tissue loss, periosteal striping, and exposure of bone to enormous contaminants.

A fragment of bone is left exposed after debridement and drainage of the wound, necessitating the use of a local free flap to cover it.

TypeIIIc : No matter the severity of the soft tissue damage, it covers any open fractures connected to a neurovascular injury.

Gustilo-Anderson's Classification System [34]

Type	Wound	Level of contamination	Soft tissue injury	Bony injury
I	< 1 cm long	Clean	Minimal	Minimal comminution
II	> 1 cm long	Moderate	Moderate, some muscle damage	Moderate comminution
IIIa	> 10 cm long	High	Severe with crushing	Includes segmental comminuted fractures. Soft tissue coverage of bone possible.
IIIb	> 10 cm	High	Extensive soft tissue injury with periosteal striping	Bone exposed, soft tissue reconstruction required
IIIc	Regardless of size	High	Extensive soft tissue injury with vascular injury	Vascular and soft tissue reconstruction / repair required.

Automatically classified as a Type III open fracture include segmental fractures, shotgun injuries, and high velocity gunshot injuries that occur in contaminated environments.

This categorization scheme is important for prognosis.

Classification by Byrd

Byrd classed as follows because he considered vascular condition to be the most significant character:

TypeI : Skin laceration of less than 2 cm caused by low energy forces, spiral or oblique fracture pattern, and generally clean wound.

Type II : A moderate energy force that results in a comminuted or displaced fracture pattern, a 2 cm or longer skin laceration, a moderate nearby skin and muscle contusion, but no devitalized soft tissue.

Type III : High energy forces resulting in a considerably displaced fracture pattern, severe comminution, a segmental fracture, or bone defect, together with considerable skin loss and tissue devitalization.

Type IV: similar to Type III fracture pattern, but with extremely high energy stresses, such in a high-velocity gunshot. a history of vascular damage that has to be repaired due to a crush accident or degloving injury.

Classification by Swartz and Mears

In order to offer more specific recommendations for free tissue transfer in the lower extremities, Swartz and Mears developed a categorization.

TypeI Soft tissue injury

(a) Clean (b) Infected

TypeII Soft tissue and bony injury less than 8cms

(a)Clean (b) Infected

TypeIII Massive soft tissue and bone injury more than 8cms

(a)Clean (b) Infected

Type IV Bone only

(a)Clean (b) Infected

Hannover open fracture score

		Points
A	**Fracture Type (AO / OTA)**	
	Type A	1
	Type B	2
	Type C	3
	Bone loss	
	< 2 cm	1
	> 2 cm	2
B	**Soft tissue**	
	Skin (wound, contusion, abrasion)	
	None	0
	< ¼ circumference at level of injury	1
	¼ - ½	2
	½ - ¾	3
	> ¾	4
	Skin loss	
	None	0
	< ¼ circumference at injury level	1
	¼ - ½	2
	½ - ¾	3
	> ¾	4
	Deep soft tissue injury (e.g. muscles, ligaments)	
	None	0
	< ¼ circumference at level of injury	1
	¼ - ½	2
	½ - ¾	3
	> ¾	4
	Amputation	
	None	0
	Subtotal guillotine	20
	Subtotal crush	30

		Points
C	**Ischaemia**	
	None	0
	Incomplete (compartment syndrome)	10
	Complete > 4 hours	15
	Complete 4-8 hours	20
	Complete > 8 hours	25
D	**Nerves**	
	Palmar – Plantar sensation (sensory)	
	Yes	0
	No	8
	Finger toes movement (motor)	
	Yes	0
	No	8
E	**Contamination**	
	Foreign bodies / Particulate material	
	None	0
	Single	1
	Multiple	2
	Massive	10
F	**Bacteriology (initial post debridement culture)**	
	Aerobe 1 organism	2
	Aerobe > 1 organism	3
	Anaerobe	2
	Aerobe and Anaerobe	4
G	**Onset of treatment** (only if soft tissue score > 2)	
	< 6 hours	0
	6-12 hours	1
	> 12 hours	3
	Total score I to IV	

A score for open fractures that considers the AO/ASIF fracture classification, loss of bone, loss of soft tissue, skin, muscle, neurovascular damage, compartment syndrome, foreign body exposure, final bacteriological testing, and the interval between the injury and the start of management was developed by Tscherne[35] and the trauma department of Hannover, Germany. There are four grade levels from I through IV in this score.

Grade I	:	2-3 points
Grade II	:	4-19 points
Grade III	:	20-60 points
Grade IV	:	> 70points

AO Classification of open fractures[36]

AO group classified separately for skin, musculotendons, neurovascular injury.

Skin injury classification

IO_1 - Skin breakage from insideout.

IO_2 - Skin breakage from outside in < 5 cm contusededges.

IO_3 - Skin breakage > 5 cm, increased contusion, devitalized edges.

IO_4 - Considerable, full thickness contusion, abrasion, skinloss.

IO_5 - Extensive degloving of skin.

This classification of skin wounds adds a fourth grade for particularly severe skin damage while still fitting in with the three-grading system for open fractures.

Muscle-tendon injury

A classification of the level of muscle tissue and tendon involvement is deemed crucial due to the possibility of significant harm to the muscular envelope and, on rare occasions, the tendons in open fractures.

MT_1 - No muscle injury

MT_2 - Circumscribed muscle injury, one compartment only

MT_3 - Considerable muscle injury, two compartments

MT_4 - Muscle defect, tendon laceration, extensive muscle contusion

MT_5 - Compartment syndrome (crush syndrome with wide injury zone)

Neurovascularinjury

NV_1 - No neurovascular injury

NV_2 - Isolated nerve injury

NV_3 - Localized vascularinjury

NV_4 - Extensive segmental vascular injury

NV_5 - Combined neurovascular injury including subtotal or even total amputation.

MANGLED EXTREMITY SEVERITY SCORE (MESS)

This aids surgeons in choosing between early amputation and limb salvage attempts.

Type	Injuries	Points
Skeletal and soft tissue group		
1. Low energy	Stab wounds, simple closed fractures, small caliber gunshots	1
2. Medium energy	Open or multiple level fractures, dislocations, moderate crush injuries	2
3. High energy	Shotgun blast (short range), high velocity gunshot wounds	3
4. Massive crush	Logging, rail road, oil rig accidents	4
Shock group		
1. Normotensive	Blood pressure stable in field and in operating room	0
2. Transiently hypotensive	BP unstable in field but responsive to IV fluids	1
3. Prolonged hypotension	Systolic blood pressure less than 90 mmHg in field and responsive to IV fluids only in operating room	2
Ischaemia group		
1. None	A pulsatile limb without signs of ischaemia	0
2. Mild	Diminished pulses without signs of ischaemia	1
3. Moderate	No pulse by Doppler, sluggish capillary refill, paraesthesia, diminished motor activity	2
4. Advanced	Pulseless, cool, paralyzed and numb without capillary refill	3
Age group		
1. < 30 years		0
2. 30-50 years		1
3. > 50 years		2

Limbs having scores between 7 and 12 ultimately required amputation.

Limbs with scores between 3 and 6 were salvageable.

MATERIALS AND METHODS

1. SOURCE OF DATA:

The material for the present study was obtained from the patients admitted in B.L.D.E.A.S' Shri B.M.Patil Medical college hospital and research centre, Department of Orthopaedics with diagnosis of open tibial diaphyseal fracture from January 2021 to May 2022.

A minimum of 30 cases were taken and the patients were informed about the study in all respects and informed consent was obtained from each patient.

METHOD OF COLLECTION OF DATA

- By interview
- By clinical examination
- By History taking.

By Radiological examination – X-ray

Clinical follow-up will be done at 6wks, 3months, 6months intervals and will be assessed with reference to Anderson's and Hutchin's criteria.

Radiological follow up at 6wks, 3months, 6months intervals.

INCLUSION CRITERIA:

1. Age above 18yrs
2. Patient with open tibial type II, IIIA and IIIB diaphyseal fractures as classified by Gustilo-Anderson classification.

EXCLUSION CRITERIA:

1. Patients with closed fractures
2. Patients with open type IIIC fractures and segmental fractures of tibia.
3. Tibial fracture with intra-articular extension
4. Open tibial fractures associated with ipsilateral fracture femur (floating knee)

METHODOLOGY

A collection of clamps (often 2/3) can be connected by compression distraction devices and move on a solid rail makes up LRS fixation framework. The rail fixation system can be used to treat non-union and malunion, repair fractures, adjust diaphyseal and metaphyseal abnormalities with or without shortening, correct bony or soft tissue deformities, extend limbs, and apply bone transfer.

The rail fixation system may be utilised to achieve maximal stability in cases of non-union or mal-union, with or without some degrees of osteoporosis, in comminuted fractures with bone loss, Because of how the device is built, depending on the length of the rail being utilised, the clamp locations for the bone screw may be adjusted throughout the whole length of the bone.

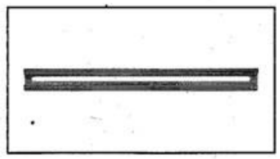
Surgery on multiple levels: The rail fixation method is primarily intended for divisional surgery. Here are the three primary justifications for doing so:

- Bone loss with or without shortening,
- deformity with shortening, and
- extreme shortening are among the options.

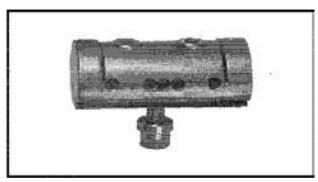
Through the use of the procedures of bone translocation, compression distraction, and bifocal lengthening, the system offers repair in these circumstances.

Components and their use:

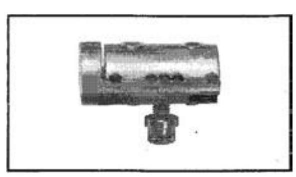
1. Rails: Rails come in three sizes: 240 mm, 300 mm, and 400 mm. Clamps may slide down the rail and can be joined at either end. The 300 mm rail will be more suitable for tiny females and children over the age of 12 than the 400 mm rail, which is typically used for adults. 240 mm rail intended for usage by kids younger than 12 years old.



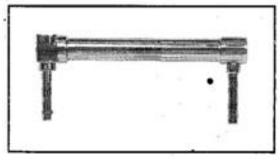
2. Central clamp: The central clamp is slidable via the rail. The locking bolt is offered to secure each clamp to the rail. There are five screw seats on the clamp. furthermore have holes on either side for mounting the compression-distraction unit (CD-unit) on both ends.



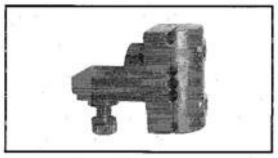
3. End clamp: The clamp has a rail-sliding opening. The locking bolt is offered to secure each clamp to the rail. There are five screw seats on the clamp. It just has one hole for mounting the CD player on one end. As needed, the clamp can be applied at either the proximal or distal end.



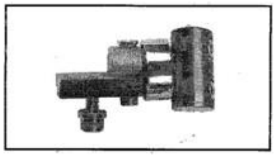
4. CD-unit: There are three different sizes of compression-distraction units: 40 mm, 80 mm, and 100 mm. The device may be installed on different clamps and is used for distraction or compression.



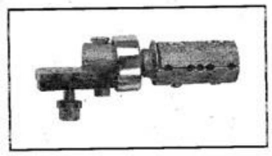
5. T-clamp: Although it is not free to glide along the rail, this may be fastened to either end of it. It is a fixed clamp that forms a T-shape with the rail's ends. A straight clamp could not have been used to insert the centre of a tiny bone fragment or a metaphyseal osteotomy in enough room for purchase to be made.



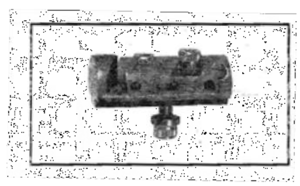
6. T-ball and socket clamp: This can be fastened to the rail's ends, but it cannot glide along the rail at all. When unlocked, the ball joints provide unrestricted movement of the clamp up to a certain degree of angulation in all planes. Once the required adjustment has been made, an Allen key may be used to lock this ball-joint.



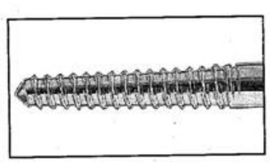
7. **The ball and socket clamp standard**: .Ball joints allow the clamp to freely rotate up to 35 degrees when freed. This module cannot glide along the rail since it is fastened to both ends of the rail.



8. **Swivel clamp:** Usually located at either end of the rail, the clamp pivots. Any valgus or varus deformity that already exists, as well as any valgus deformity that may have developed during lengthening or shipping, can be corrected with a clamp. There are just four screw seats on this clamp.

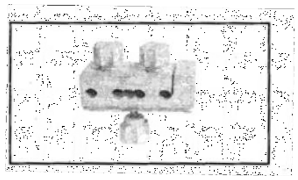


9. **Tapered threaded pins** : Two (or three) 5-6 millimetre tapered screws are used in each clamp when the diameter of the bone exceeds 20 mm. 3.5-4.5 mm tapered screws are utilised for small bones. The patient's X-ray should be used to determine the length of the tapered screw. The thread should be long enough to extend past the second cortex by approximately 2 m and continue outside the entering cortex by about 5 mm.

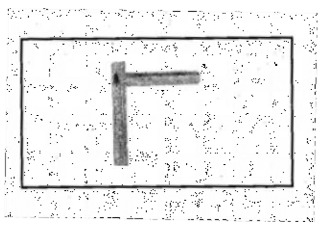


Instrumentation

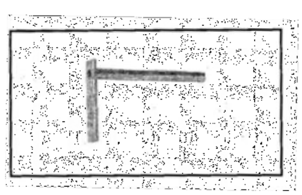
Clamp templates: These are used with the definitive rail to replace the clamps during screw insertion. For bone, three clamp templates are needed.Bifocal transport, monofocal lengthening, and compression distraction all require two; bifocal transport requires four



Screw guides: These guarantee that the screws will be placed correctly and perpendicular to the long axis of the bone.

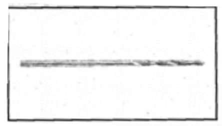


Drill guides: These are used in conjunction with drill bits that measure 4.8 mm and 3.2 mm. The drill guide's diameter will determine the drill bit's diameter. Additionally, the length will be determined by the length of the screw guide being utilised. [48]

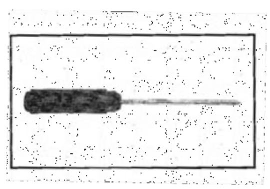


When inserting tapered screws which contains thread diameter of 5 to 6 millimetres, a 4.8 mm drill bit is needed. The length of the screw guide must be determined with consideration for the size of the soft tissues it must travel through.

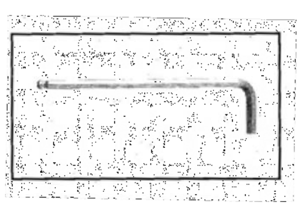
When inserting cortical screws with a 3.5–4.5 mm threaded diameter and cancellous bones with a thread diameter of 5–6 mm, a 3.2 mm drill bit is employed.



Trochar: This is utilised by the screw guide to identify the proper location on the cortex.



The clamp screws and clamp locking screws may be locked and unlocked using a 6mm Allen key.



Approaching a patient who is injured[39]

(a) Identification of situations that pose a hazard to life

Assessments must be made for airway blockage, severe shock, and bleeding in the area of injury. The Glasgow coma scale should be used to measure the patient's level of consciousness and CNS function. Before examining the spine, spinal column, and extremities to rule out any injuries, a detailed examination of chest, abdomen, and critical organs is needed.

(b) Examining the wounded limb

Capillary refill time, vein filling, and the condition of peripheral pulses are all indicators of the status of the blood flow in an injured limb and should all be monitored and recorded. It is necessary to assess the peripheral nerves' health, taking into account both each nerve's sensory and motor functions.

(c) Examining how the wound is doing.

The injury must be assessed for its site, dimensions (size, shape, depth, edges), underlying structures, amount of contamination, severity of hemorrhage as well as whether or not it communicates with associated fracture site, in accordance with Gustilo-Anderson's classification system for open fractures..[34,39]

(d) Skin surrounding wounds condition

Skin around wound should be checked for exposure of microorganisms and burns. The dimensions, pigmentation of skin, and connectivity of fracture site should also be recorded.

In certain situations, it may be appropriate to enter the incision with a gloved finger or a sterile blunt probe; if bone is touched or felt, the solution is nearby.

If the underlying haematoma escapes through the wound, proving that an open fracture exists, saline may be injected via prepared skin. Planning for a different line of care will be useful if the suspicion of an open fracture is verified. The wound needs to be debrided while using stringent aseptic measures.

(e) History of the patient

It is crucial to ask about the patient's tetanus immunity status and make a determination. The latest date of immunisation must be known; as a booster, just toxoid could be necessary. If in doubt, 250 - 500 units of human tetanus Ig should be administered, particularly if the patient has an injury which is susceptible to tetanus. For such people, it is also beneficial to start an active vaccination now, but solely for its potential benefit in the event of future accidents. Before giving any antibiotics, swabs for culture and sensitivity should be collected from the wound.

Radiographic evaluation:

All necessary X-rays should be obtained once the patient has been evaluated. The neighbouring joints of the broken bone should be included in the X-ray. An examination of individuals with a tibial or fibular fracture must at the very least include satisfactory anteroposterior and mediolateral X-rays. Tomograms may be useful for assessing union, particularly if the external fixator hides the fracture. Bone scans with technetium are highly regarded for detecting stress fractures.

IMMEDIATELY FOLLOWING INJURY, SOFT TISSUE AND BONE MANAGEMENT

FIRST STEP TO AN EMERGENCY

(A) Site of accident

(B) Initial emergency response at the hospital[39]

(a) Site of accident

- Bring in serenity to avoid disturbance.
- Quickly assessing the situation and alerting the police, fire department, ambulance service, etc.
- The victim's clothing is taken off.
- Airway obstruction is cleared
- Check the patient's limbs, head, chest, abdomen, and pulse.
- Over the bleeding wounds, use a pressure bandage.
- NBM (nil by mouth) is maintained.
- Access the IV and begin fluid treatment with RL.
- Splinting of the broken or damaged limb.
- Always verify the ABCs of resuscitation during transport.

(b) Initial emergency response at the hospital[39]

1. ABC of life preservation (Airway, Breathing, Circulation)
2. Maintaining the limb
3. Preventing infection
4. Maintenance of functionality

The suggested actions can be used to accomplish these objectives.

1. All open fractures should be treated urgently.
2. Carry out a comprehensive first assessment to identify any other life-threatening injuries.
3. Start the necessary antibiotic medication and continue it for two to three days.
4. Immediately do a thorough irrigation to debride the wound.
5. Make the fracture stable.
6. Permit the wound to remain open for 5 – 7 days.
7. Transplant autogenous cancellous bone as soon as possible.
8. Restore the affected limb.

The process must be carried out as soon as is practical. The golden hours are the first 6 hours. After 6 hours, contaminated injury is believed to be infected. An organism takes at least 6 to 8 hours to establish itself in a wound and start reproducing.

In addition to a history that includes tetanus immunity, diabetic mellitus, chronic steroid use, drug hypersensitivity, and the amount of time since the previous meal, resuscitation, patient stabilisation, bandaging, and splinting are all required.

For a surgical debridement:

(a) Anaesthesia and stabilisation

The sequence in which numerous fractures are treated is decided during preoperative planning. Open fractures frequently come with unpleasant surprises, thus a complete complement of bone and soft tissue devices must be provided.

(b) Tourniquet

In order to halt the significant bleeding that happens after a blood clot is removed from an unexpected major artery injury, the surgeon should consider putting a non-inflated tourniquet to the injured limb. However, tourniquet shouldn't be inflated in order to increase visibility or stop bleeding.

Skin capillaries flush once a tourniquet is released after about 10 minutes of inflation. This could be useful as a skin viability indicator.

Managing open fractures

Soft tissue, the source of the injury, and the chosen treatment method for stabilising the fracture all needed to be taken into account while treating open tibia fractures.

Successful therapy depends on five factors.[36] They are a s follows:

(1) Radical debridement and thorough irrigation

(2) Fracture stabilization

(3) Use of antibiotics

(4) Coverage of the soft tissue

(5) In individuals with severe energy trauma and bone loss, functional rehabilitation and presumed bone transplantation.

Debridement and irrigation [41,42]

Dilution is the solution to pollution. Isotonic saline should be used in large quantities to completely irrigate the wound. Obtain cultures to identify contaminated organisms and determine antibiotic susceptibility.

The benefits of irrigation

(1) Initial lavage cleans the wound by removing blood and debris.

(2) Irrigation fluid floats in places where it would not be noticed.

(3) Lavage of the tissue allows for the restoration of its natural colour and makes it easier to determine viability.

(4) Irrigation helps to lower bacterial levels.

The Debridement of wound

Debridement and irrigation goals [41,42] :

1. Extending the traumatized wound to locate the injured zone
2. Finding and removing foreign objects.
3. Finding and eliminating non-viable tissue.
4. Less bacterial contamination.

(a) Subcutaneous fat and skin[39]

The use of an extensile incision allows for efficient debridement viewing.

The elliptical incision created in this way is often closed with sutures but may also be left open to heal naturally, producing a straightforward linear scar.

When removing skin, especially in areas where it is more valuable, the surgeon must use caution.

Like a hand, foot, or leg. In locations with sufficient skin supply, A appropriate wound edge for subsequent closure is created by precisely excising the contaminated and contused skin edge 1 to 2 mm into high grade skin using a sharp blade.

With a base to length ratio of just 1:2, a distally based, traumatized skin flap frequently has a non-viable tip.

It could be feasible to collect skin from the resected flap if skin loss results in extremely large wounds and future coverage is anticipated to be challenging.

(b)Fascia

All open fractures caused by high intensity traumas require limited fasciotomy. If a fascial layer defect is discovered then fasciotomy is recommended.

(c) Muscle

Muscle is vulnerable to hydraulic damage due to its high water content. The main obstacle to bacterial development is necrotic muscle, which is extremely dangerous in anaerobic infections.

Therefore, the best strategy is to always take it out. The four criteria — Colour, Consistency, Contractibility, and Capacity to Bleed—are used to assess a muscle's viability.

Histological descriptions of three post-ischemic alteration zones have been made.[39]

1. An interior region of muscle necrosis without oedema.
2. An area of partially damaged muscle that still has a lot of salvageable muscle.
3. A typical muscle's periphery where there is no swelling.

Thus, during debridement, the surgeon must examine beyond the topmost layers.

Muscle viability factors [39]

Colour - Normally meaty red; occasionally deceptive carbon monoxide exposure

Consistency - Usually strong and difficult to sway

Being able to bleed - can be misleading since bleeding arterioles in necrotic muscle exist.

Contractility - responsive to low cautery setting or forceps pinch. Generally trustworthy

(d)Tendons

If a tendon is necessary for function, it should be kept unless it is clearly badly injured and polluted. In circumstances when covering the tendon by some soft tissue is not possible, conservation of the peritoneum is essential for tendon vitality.[39] A wet dressing is put on top of the peritoneum if it is soft. Up until the surgeon swings some soft tissue over it, it is maintained wet.

(e)Bone[31]

Invading germs may be defended against by muscle tissue, but due to its low blood supply, bone tissue is largely defenceless. Normally, it is preferred to remove any small cortical bone pieces that are not attached to soft tissues. A big bone piece with soft tissue connection should be kept in place if it is bleeding.

Debridement is necessary for completely devascularized bone portions. When trying to save the affected joint, major portions or the articular surface should be kept, even if they are avascular. However, non-union might result from the preservation of a sizable segmental avascular bone fragment. [50] Furthermore, repairing a significant segmental defect is preferable to waiting for a persistent infection to develop into chronic osteomyelitis, which might result in further bone loss. The presence of bleeding near the bone's edge is a symptom of bone viability.

(f)Joints

Exploration is required for every wound that penetrates a joint. Debridement of the incision in association with an arthroscopic assessment of the joint may be considered if a suitable arthrotomy cannot be done. By injecting, intraarticular penetration may be ruled out.

To stretch the joint capsule while keeping an eye out for fluid leakage from the open lesion, use sterile saline or methylene blue.

(g)Vessels and nerves

Before delaying primary closure, nerve injuries that can be repaired should be sutured.

During debridement, brisk small vessel or arterial bleeders necessitate prompt ligation or coagulation.

Inserting a temporary shunt may be preferable than performing an instantaneous end-to-end anastomosis or vein grafting in big vessels. This enables irrigation, debridement, and bone stabilisation prior to complete vascular restoration.

(h)Fasciotomy[39]

Massive swelling at a distance from the site of the repair is frequently observed following artery repair for full ischemia to the distal limb. Fasciotomy should be performed prophylactically if there is any uncertainty regarding the indication.

(c) Elevation

Constant or progressive swelling may make tissues tensed and the injury surface moist in order to prevent delayed primary closure. Edematous tissue puts more strain on the suture line and can cause necrosis of the marginal incision. The patient must be comfortable while the patient's limbs are lifted, and continual elevation at the level above the heart must be ensured.

(j)Antibiotics[43]

Since these wounds are infected with bacteria, antibiotic medications for open fracture injuries should be considered therapeutic rather than preventive.The purpose of antibiotics is to eliminate any remaining organisms or, at the very least, stop their development long enough for the host's defence mechanisms to do so.It's debatable how long antibiotics should be taken.They are administered for 48–72 hours, and if any indications of infection or discharge appear during that period, the wound is cultured. Then, the therapy is determined by the results of the culture reports.

Antibiotic therapy for open fractures[43]

	Type I	Type II	Type IIIA	Type IIIB	Type IIIC
Cephazolin (gram positive coverage) 1 gm, I.V. 8th hourly	✓	✓	✓	✓	✓
Aminoglycoside (gram negative coverage) 360 mg / 24 hour			✓	✓	✓
Penicillin (anaerobic coverage) i.e. clostridia 2,000,000 units I.V. 4th hourly			✓	✓	✓

Beads infused with antibiotics[43]

Polymethyl methacrylate (P.M.M.A.) can include a variety of antibiotics to deliver enough amounts of bactericidal substances in the tissues and fluids around.

MESS (mangled extremity severe score), developed by Helfer et al., has been proven to be extremely helpful in decision-making. In their investigation, limbs with scores between 7 and 12 eventually needed to be amputated. Legs that scored between 3 and 6 were viable. NISSA, soft tissue injury, skeletal injury, ischaemia, nerve damage and ageing are all consequences of attempts to alter MESS.

Complications

1. Skin loss

The tibia's subcutaneous location makes the leg susceptible to skin loss or injury when it breaks. Type I and II open fractures should be left untreated for 3 to 5 days after the accident to allow for drainage and delayed closure. Within 5 to 7 days of the injury, skin grafting or vascularized free flaps are frequently needed for type IIIA and IIIB open fractures. A local rotation flap or free flap is preferable to skin grafting over exposed bone since it is less frequently successful.

2. Vascular damage

With the exception of high intensity trauma, which results in comminuted, noticeably displaced, and frequently open tibial fractures, vascular injuries are uncommon at the moment of tibial fracture. The upper part of tibia, where anterior tibial artery penetrates through interosseous membrane from behind, is location where vascular damage that occurs most frequently. The artery may be ruptured, lacerated, or blocked as a result of a bone fracture, soft tissue oedema, or direct pressure from the bone. At the site of the injury, initial amputation may be necessary due to irreparable vascular damage. The posterior tibial and dorsalis pedis pulses should both be assessed; the absence of either necessitates the rapid delineation or treatment of the vascular damage. It could be feasible to repair the artery or insert a saphenous graft. The loss of either the anterior or posterior tibial artery often has little effect on the lower leg. Clinical indications of arterial blood supply impairment, such as colour change, can be seen even when peripheral pulses are present. The requirement for an arteriogram to assess the arterial tree's patency is indicated by symptoms of muscle ischaemia such as dusky colour discoloration, sluggish capillary refill, or slow capillary refilling.

When the foot and lower tibia are shifted posteriorly, extending the artery over a sharp proximal segment and forcing it to travel retrograde and put pressure on the artery, the anterior tibial artery may be injured distally. The fracture has to be minimised right away, pushing the distal fragment as far forward as feasible.

In tibial fractures, the posterior tibial artery is less usually affected. If the posterior tibial artery is totally patent, the anterior compartment muscles may not survive even if the anterior tibial artery is completely blocked.

3. Nerve injury:

In tibial or fibular shaft fractures, primary nerve damage from blunt trauma is infrequent. Rarely, the peroneal nerve may be damaged by high-energy trauma that results in proximal, tibial, or fibular fractures, together with extensive varus displacement of the distal fragment or direct trauma to the fibular neck. Although it's not frequent, secondary nerve dysfunction does exist. Once the fracture has been reduced, the foot and toes can often be actively dorsiflexed and plantar flexed. More frequently, soft tissue edoema or cast pressure on the fibular neck are to blame for nerve damage in the lower leg following fractures. Around the fibular head and neck, the cast has to be thoroughly cushioned. Not too tightly should padding be compressed. Four-hour intervals should be used to assess the toes' dorsiflexion and plantar flexion. Permanent nerve injury might result from pressure for six to twelve hours. If palsy develops, the foot is splinted in place while waiting for nerve function to restore. After six weeks, it is possible to do periodic electromyograms to track the healing process.

If there is no indication of a recovery of sensory or motor function, neurolysis at the fibular neck, nerve exploration, and perhaps fibular head removal have all been recorded. The posterior tibial muscle can be moved onto the dorsum of the foot in cases of complete paralysis of the foot dorsiflexors to restore adequate function. An ankle-foot polypropylene orthosis can be used to treat the majority of patients.

3. Bone defects [47]

According to Harmon, autogenous cancellous bone grafting is most usually employed to form a synostosis between the tibia and fibula, particularly when the posterolateral approach results in anterior tibial bone loss. The fibula can be anchored to the tibia both proximally and distally for substantial bone abnormalities. Free vascularized grafts into the tibial gap have shown promising outcomes. It has been suggested to use the Ilizarov ring fixator and our limb constructive system approach to stimulate bone growth to fill the deficiency. This surgery involves performing a corticotomy far from the non-union site and moving a bone fragment either distally or proximally. After compression and distraction treatment, the generated faults far from the initial fracture site progressively fill up with new bone. [47]

Anteroposterior and medial plane angulation, shortening, rotational malalignment, and displacement are the four most crucial aspects in determining alignment of tibia. If ankle clinical symptoms or knee discomfort are higher than 15 to 20, a corrective osteotomy may be necessary. It is okay to have more external rotation than internal rotation. While external rotation of up to 20 normally does not result in major gait problems, internal rotation of more than 10 may create gait abnormalities.

With tibial fractures, there is often some degree of shortening; however, shortening of 8 mm or less is not functionally relevant.

However, a shortening of greater than 2 cm typically causes the patient significant discomfort.

Although surgical equalisation with the shortening of the opposing leg or the lengthening of the diseased limb may be explored, leg/limb length equality is achieved through heel/sole lifts.

When a malunion needs to be corrected due to functional restrictions, controlled osteotomy, internal fixation, and bone grafting are recommended.

5. Fat embolism

Fat embolism often manifests as hypoxemia, tachycardia, fever, restlessness, and disorientation between 24 and 72 hours after the injury.

In 10 to 15% of instances, it is lethal.

Chest X-ray reveals spotty infiltrates on both sides. Methylprednisolone used as a preventative measure following trauma lowers its occurrence.

6. Infections

The most serious side effects of open tibial fracture are osteomyelitis of tibia and infected non-union, both of which commonly need amputation. The incidence of infection is highest following high-velocity, open wounds with skin necrosis or loss, as well as following open reduction and internal fixation with unsuccessful flaps or skin covering.

Antibiotic use before, during, and after surgery has been found to reduce the frequency of deep wound infections. Drainage of the infected region, debridement of all devascularized bone and soft tissues, secure fixation, correctly timed soft tissue covering, and administration of suitable antibiotics based on culture sensitivity data are general therapeutic concepts for infection. Tomograms might be useful for locating the bone sequestrum, and sinograms could show how much of the region is contaminated.

Both the patient and the physician must be informed that it can take multiple staged surgical procedures to achieve an infection-free union when dealing with an infected non-union. The conventional strategy is to eliminate the illness first, then establish union. Large defects may also call for soft tissue covering.

If alignment is acceptable, posteromedial or, preferable, posterolateral bone grafting can be performed without disturbing the non-union. For stability and excellent access to open wounds, external fixation is preferable. Placing antibiotic beads in any bony cavity or defect may aid in preventing infection and create room for autogenous bone transplantation in the future.

7. Compartment syndrome

Although it can happen after an open fracture, anterior compartment syndrome is more prevalent in closed tibial fractures.

The anterior tibial compartment, which is bordered by the tibia, the compartment fascia, the fibula, and the interosseous membrane, is where the condition originates.

After a fracture, bleeding and soft tissue oedema raise the pressure inside the compartment, obstructing venous outflow and progressively occluding the tiny arterioles and capillaries that provide blood to muscles.

After an accident, symptoms may not manifest for up to 24 hours, during which time cast immobilisation may further obstruct capillaries and arterioles that provide circulation to the tissues inside the closed compartment.

Even after fracture reduction and casting, increasing pain is one of the clinical indicators. The limb should be examined, and the cast should be bivalved quickly. An indicator of compartment syndrome is severe discomfort, tenseness, and swelling over muscles in the anterior compartment rather than over the fracture site. Lack of feeling in the first dorsal cleft is one of the indications of peroneal nerve involvement and compartment syndrome. Extensor hallucis longus, tibialis anterior, and extensor digitorum longus, muscles experience significant discomfort, weakness, and paralysis as a result of relaxed stretching of these muscles in affected compartment.

Complete fasciotomy of the anterior compartment should begin when anterior compartment syndrome is suspected. But if at all possible, avoid the fracture site. After fasciotomy, external fixation or unreamed intramedullary nailing is required. Severe discomfort across the compartment, plantar hypoaesthesia, and weakness in toe flexion are the hallmarks of posterior compartment syndrome. Passive toe extension causes more pain. Claw toe deformity or posterior tibial neuropathy can result from untreated posterior compartment syndrome. The peroneal muscles are located in the lateral compartment, and lateral compartment syndrome is indicated by weakening in these muscles as well as localised discomfort. Rarely is the lateral compartment affected by itself. However, it can infrequently affect the anterior, posterior, or both compartments.

8. Joint Stiffness and ankylosis

After a tibial fracture, bony or fibrous ankylosis is uncommon, although joint stiffness may affect the knee, ankle, or subtalar joint. Some people thought it was caused by being immobile for a long time, while others thought it was caused by a primary soft tissue damage or a subsequent infection. After a tibial fracture, significant loss of knee extension is uncommon, although partial loss of knee flexion is typical. For enabling early joint range of motion in the knee and ankle, Sarmiento created the patellar tendon bearing cast and short leg brace. Additionally, early weight bearing appears to lessen joint stiffness. Once the cast is off, regular walking and going upstairs and downstairs increases the mobility in both the ankle and knee joints. For an aided active exercise programme, inversion and eversion of the foot are more challenging to restore and frequently require physiotherapy.

9. Delayed and non union

When healing has not progressed at the typical rate (for about 3months) for the site and kind of fracture, delayed union is taken into account.

10. Arthritis due to trauma

Unless the fracture has extended into the joint, traumatic arthritis is uncommon.

11. Post-traumatic dystrophy

After a tibial fracture, post-traumatic dystrophy (Sudeck's atrophy) is most frequently seen in individuals who are unable to bear weight right away and in those who are kept in casts for an extended period of time. The huge sympathetic reaction in the leg and foot first shows up as pain and swelling, and then it progresses to limb atrophy. Treatment for post-traumatic dystrophy typically involves gradually adding weight. First, it is necessary to reduce the edema and swelling by using active muscle workouts, elastomeric stockings, and occasional elevation. Crutches are originally employed and as weight carrying increases, they are abandoned. In the distal tibia and foot bones, post-traumatic dystrophy is shown radiographically as patchy regions of demineralization.

Although it may not always be feasible to prevent post-traumatic dystrophy, early joint mobilisation and weight bearing will lessen this consequence. Sympathetic blocks could be helpful.

12. A deformed claw toe

While the patient is wearing the cast, frequent toe flexion and extension should be advised, and passive stretching should be performed at least once per day.

EXTERNAL SKELETAL FIXATION GENERAL PRINCIPLES AND TECHNIQUES[55]

Regardless of the particular fixator chosen, the general approaches for employing external fixators are difficult. To maximise the benefits of the device and reduce any potentially catastrophic consequences, attention to detail is extremely necessary. Prior to choosing an external fixator, the first course of therapy for the disease must be taken into account, including irrigation, debridement, and reduction for severe open fractures and drainage, debridement, and sequestrectomy for fractures with infections. Prior to using a fixator, the proper primary therapy for these disorders must be given. Irrespective of intended kind of device, a complete collection of external skeletal fixator devices must be given before any attempts to cure a fracture are attempted. The surgeon should be well-versed in the apparatus, ideally via prior experience or by use of it in a workshop or psychomotor skills lab. Prior to using the device, it is a good idea to study the tools and general techniques that apply to the patient. Before starting the method, it is important to decide on the ideal pin placement, frame length, clamp design, and clamp placement. Will compression, neutralisation, or distraction be possible given the fracture's shape. The placement of the pin should be made to make it easier to change the dressing or do skin grafts or alternative treatments later on. Additionally, it is important to consider the patient's comfortability. It is necessary to use the external fixator in the operating room when the patient is under general or spinal anaesthesia, under stringent aseptic / sterile conditions, and ideally under fluoroscopic or image intensification control.

The soft tissue and bone pieces should be cleansed, debrided, and the bone length, orientation, and overall alignment of the limb should be maintained before introducing pins in an open fracture. By placing pins before fracture reduction, the surgery will be more difficult and the soft tissue will shift significantly, decapitating the pins where they penetrated the skin. The fracture pieces should be anatomically restored under direct view if the open wound permits. If feasible, Kirschner wires or screws should be used to stabilise unstable fragments before the fixation pins and frames are inserted. As much anatomically as possible should be applied to reduce the fracture. Because stiff external fixation for fracture healing is predominantly endosteal, it is comparable to the fracture healing with rigid internal fixation.

Many delayed unions and non-unions are caused by large fracture gaps in environments where minimal callus will form. If such a gap still exists, early bone grafting and supplementary internal fixation using Kirschner wire or interfragmentary fixation will help prevent these late issues. The Kirschner wires or screws could be removed if preferred once the external fixator has been applied and the fracture has been firmly immobilised. It is advisable to compress the region with the use of a distraction compression device connected between both the two clamps on each side of the fracture site.

Pins[3]

There are two different kinds of pins: half pins and transfixation pins. A threaded portion at the end or middle of the pin provides pin purchase in the bone. Self-tapping parts have threads. Use of smooth pins is not advised. The thread length of half pins is matched to the diameter of the bone to be crossed and is threaded at various distances from the tips. Half pins are inserted via soft tissues, proximal cortex, medullary canal, and distal cortex.

The soft tissue across from the insertion place is not where the pins escape. When a more firm fixation is required, Schanz fixation pins with a threaded middle section are frequently chosen. Similar to half pins, they are implanted, but tip of pin extends into distal cortex and soft tissue before emerging on other side of the insertion location.

Both kinds of screws may either be placed into a predrilled hole or comprise a self-drilling point. To increase thread retention in cortex and lessen likelihood of necrosis due to high temperature around hole, predrilling is suggested. Self-drilling half pins carry the risk of having improperly bought proximal cortical threads. As drilling site crosses medullary canal and encounters resistance from distal cortex, the threaded proximal cortex may be removed and anchoring in that cortex may be compromised. Minimal pin tract issues and better fixation. For instance, the predrilled method causes loosening, infection, and ring requestra.

It is essential to choose the appropriate pins in order for the thread length approximately corresponds to bone diameter. Pin thread, that is either short or too long runs the risk of causing soft tissue harm. Half pins must be picked carefully, paying particular regard to the threaded area's right length. This may be done with sufficient accuracy by introducing a self-drilling pin into predrilled holes or by precisely determining the circumference of the bone on roentgenograms.

Pin insertion[56:]

It is recommended to make large (1.0 - 1.5 centimetre) skin incisions for the pins. Dissection to find a natural gap between nearby muscle bellies is preferred if a pin insertion must pass through a muscle compartment in order to prevent the pin from piercing a muscle or tendon. [56]

Position is decided by the extent of fracture comminution, safe zones, soft tissue damage, and another factors. Drilling the pin hole or penetrating the antagonistic cortices with a pin, screw tip, or intramedullary wires before inserting the pins can help identify the greatest diameter of the bone through which to place the pins.

Avoiding the thick anterior cortex while implanting the pin in the tibia is especially crucial since doing so commonly causes thermal necrosis around the pins and a subsequent infection of the pin tract. Drilling causes heat to be produced. The osteonecrosis brought on by the heat might result in the pins coming free. Soaking in salt water while drilling is safe and lowers this danger.

Depending on the particular clamps and frame being utilised, the extra pins are placed using pin guides. To ensure that the pins are in a straight line, the following pins are put along the correct axis. Additionally, they ought to be placed parallel to the bone's axis. In most cases, it's recommended to place atleast of 2 pins in the main pieces upper and lower to fracture. The joint should be moved within a limited range of motion after each pin is inserted to make that the device has not injured a tendon or muscle and won't prevent further joint mobility. If pins are necessary to cross the anterior compartment of the leg, a helper should insert them while maintaining maximal dorsiflexion of the ankle.

If this practical aspect is not kept in mind, crossing the anterior muscle compartment might lead to equinus contracture and weakened dorsiflexion.

Care of the extremity following frame applications:

After treating the main issue with pins and a frame, the surgeon's duty does not finish. To avoid issues typical with external fixators, the extremities must be given very careful consideration. Important factors consist of:

1. Elevating the affected extremity to reduce oedema This may be done in conjunction with strapping fixator to bed's above frame with ropes or by maintaining affected leg covered by Bohler Braun's splint. Elevation might not be ideal if the limb's vascular supply is unstable.

2. Use of dressing pads or slings to support the soft tissue in the dependent posterior area. This method also helps to avoid oedema and haemorrhages in these tissues.

3. Use the proper splinting to support the ankle and prevent contractures. Ropes, rubber hose, or specially designed, frame-connected commercialized splints can all be utilised for this. If this crucial factor is overlooked, heel cord tightness or contractures are frequently observed.

4. Movement of the joints near and far from the fixator.

Cleaning the pin location on a regular basis. Cleaning must be done carefully and in a sterile environment. Soft tissue needs to be pulled away from the pins and layer of discharge or blood which is dried needs to be striped away. Antiseptic, antibiotic treatment around pin-skin contact is not required. Unless it is anticipated that the dressings for concomitant soft tissue injuries would necessitate it, the pin skin junction is often not wrapped.

4. Although no comparative evaluation of these pin tract operating procedures has been conducted in the past, using this strategy may reduce pin tract difficulties.. Longer the fixator is in place, the more frequently pin tract issues occur.

5. As the swelling recedes, keep an eye out for any changes in the skin's tightness around the pins. When the swelling goes down, the skin may move, putting strain on a skin portal that was earlier suitable. If this happens, local anaesthesia should be used to incise the skin and fascia surrounding the pins' bases. If the pin is loose and the discomfort and discharge from the site of insertion of the pin continue after treatment, the pin should be withdrawn. A serious pin tract issue cannot be resolved just by local or systemic antibiotic treatment. For the first seven to ten days, you should gradually raise the compression of CD unit between clamps. Individualization of the duration of the fixator's stay based on the traits of the primary ailment, the condition of the soft tissues, etc.

   The fixator should stay in place if applied to severe, open Gustilo's type II or type III fractures until a good, stable wound and skin covering have been obtained. The duration ranges from 2 to 3 weeks in a similar circumstance to 12 to 14 weeks in others. Generally, the fixator used for fracture treatment should be removed after the fracture has been closed and the proper internal fixation or cast methods may be applied. The fixator used for fracture treatment should typically be removed once the fracture has been closed and adequate internal fixation or cast methods may be applied.

Complications 57,58

External skeletal fixators (ESF) are known to be problematic. Some of the issues have workable solutions. Accurate reduction, early bone grafting, and early fixator removal can all help prevent delayed union. By paying attention to anatomy of intersection of the third and fourth sections of leg, nerve and vascular damage can be prevented. External skeletal fixator system pin tract infections persist, but are reduced by paying close attention to tissue necrosis at the pin to skin and pin to bone interfaces. External fixators, which are routinely used for open fractures, immediately immobilise bone with soft tissue while providing access to the site. This consistent mechanical setting promotes repair of soft tissue and prevents wound infection.

1. Tardy Union

Fixators have a long history of delayed or non-union, and they are capable of doing so for the reasons listed below. The fixator delays the natural mobility of the fracture, which reduces callus development. Instead, the fracture hemotoma develops into collagenous scar tissues. Any rigid fixation system should aim to promote primary bone healing, but this seldom happens when there is too much micromotion at the fracture site.
When external fixation is used to stabilise comminuted fractures, the fixator can divert fracture fragments that are often seen.

In considering all of these factors, the following three fundamental measures aid in preventing fixator-related non-unions:

1. Accurate reduction
2. Cancellous bone grafting (autogenous)
3. Removal of fixator early

Anatomic alignment is quickly accomplished by applying a fixator through a wound to a fracture that is open. Contrarily, with closed fractures, it could be essential to open fracture site and sufficient exposure of fracture site in order to perform a precise reduction. Even with open fractures, butterfly fragments can be securely fastened to main shaft by applying inter-fragmentary compression screws. Whether internal or external, rigid fracture fixation techniques often prevent the development of periosteal callous. Any osseous defect or gap with fractures kept in an external fixator might delay union. For this deficit, an autogenous bone transplant can be used. In case of segmenal bone loss, absence of more than one-third of cortical diameter, or severe comminution with fracture fragment separation, some injuries inevitably call for bone grafting. If the soft tissues are of excellent quality, the graft may be administered at the moment the fixator is applied or a few weeks later.

If any area of the graft mass doesn't seem to be maturing appropriately, bone grafting is repeated at intervals of six to eight weeks. Fixators are typically used on limb injuries where bone damage is overshadowed by soft tissue trauma. When treating soft tissues, the surgeon may decide to leave the fixator in place for a few months. A fresh cancellous bone graft (autogenous) positioned in a sound tissue bed next to bone will help to avoid non-union during skin management programme. The posterolateral technique works effectively for tibial fractures.

Early fixator removal is goal of fixator management, which is the third fundamental approach for preventing non-union. When a fracture first starts to heal, a fibrous envelope (also known as an early fracture callus) forms around it to support it. If this fibrous envelope is not physically stimulated, however, it may eventually develop into collagenous scar tissue. Removal of fixator six to eight weeks of application promotes ossification of fracture callus.

Until full healing has occurred, the limb should be supported by orthosis or a cast. After the frame is removed, fracture may lose its location or alignment, therefore it must be carefully monitored. Fragmented pieces will telescope freely when the distraction-compression mechanism of the fixator is disengaged, causing strain to healing fracture while overall aligment is maintained by fixator. The surgeon can move the single bar unilateral fixator away from patient's limb on the pins, which reduces the stiffness of the fixator's bone arrangement. Any of these methods might encourage the development of mature callus into solid bone.

2. Fixator issues

Fixator parts seldom ever experience wear and tear over time. Pin breakage has been recorded, although given that the pins are only used once, it is improbable. When the pin and clamps are too close to skin, pressure necrosis from the fixator ensues. To prevent these issues, allow two or three fingerbreadths from the skin to the fixator.

3. Nerve and blood vessel damage

Thankfully, there aren't many reports of fixator-related nerve or vascular injury. However, paraesthesia might happen sometimes. A pin aimed towards a nerve or blood artery will often cause the structure to move instead of transfixing it. As a result, when a neurovascular bundle rests on a pin, it may progressively erode the vessel, resulting in sudden bleeding, or, if it. Thus, some places must be taken into account. Because anterior tibial artery with deep peroneal nerve traverse lateral aspect of tibia while descending from interosseous membrane to the front of ankle, the middle and lower third of leg are dangerous for pin insertion.

4. Infections of the pin tract

It is most frequent issue with using an external fixator. It led to the introduction of the ideas of major and minor pin tract infection. The symptoms of a significant pin tract infection include redness, pain, and discharge (seropurulent) which may need hospitalisation for IV antibiotic treatment, pin removal, or removal of complete fixator, as well as prolonged drainage following pin removal. Any more pin responses, including those that produce a purulent discharge, are considered mild.

Operative Technique

We need to know which plane to apply the LRS external fixator in and why before we do so. The application of implants or instruments is based on the tensile force side. However, in order to neutralise the compressive force of muscles that are present posterolaterally, which is the tensile force side, this apparatus must only be put on side of compressive force ,which is medially or anteromedially.

Fig. 6: Implants used

Figure 7: Instrument set and implants used

We're utilising a simple, conventional model. It possesses:

1. Railing: This is similar to the bone's lever and is constructed of strong carbon.

2. For connecting the three clamps, each of which has an 8 mm 3 threaded bolt with two on the front and one on the rear, the clamps are attached to the railing.

3. A distraction and compression clamp

4. Schanz pins that are threaded and 5 mm long, depending on the bone's diameter.

5. Allen key

6. 14mm spanner

7. Swiveling clamps for the repair of malunions, non-unions, and minor metaphyseal abnormalities. Swiveling clamps must be used in deformity

treatment in place of distal fragment clamps, depending on whether the deformity is valgus or varus.

8. Coupling of ball joints. When there is rotational malunion present, this rotational clamp may be employed.

9. T-clamp: It may be fastened to the rail's ends at either end. It is immovable and possesses a Tamplet of its own. We can secure the Ilizarov rings to this T-clamp in order to treat the equinus and varus foot deformities.

8. The dyna ring is fastened to the rail with the silicon cushion facing the clamp, which has been unlocked for dynamization. It only allows limited dynamization of the fragment to prevent fragment collapse. Therefore, it enables early switching from a rigid to a dynamic state and, as a result, a shorter neutralising period.

Application of LRS in tibia

Three Schanz pins were inserted into the tibia's condyles slightly below the articular surface anteromedially after the part had been cleaned and prepared. This trio of pins is attached to the LRS's proximal clamp. For the application of Schanz pins, we must measure the distal piece and take into account its length. 2 clamps and 6 Schanz pins if the distal fragment is two-thirds of the tibia. 4 Schanz pins and 1 clamp for the proximal third.

The following procedure should be followed while inserting Schanz pins[2] :

(a) Put the triple trocar together and poke an incision through soft tissue to reach the bone's surface.

(b) Remove the trocar and use 3.5 mm of drill bit to drill both cortices.

(c) Remove the drill sleeve, and then drill the near cortex with a long 4.5mm drill bit through the remaining 6 or 5 mm of the sleeve. It is advised to utilise a three-fluted drill bit together with an oscillating attachment.

(d) Hook the distant cortex with probe sleeve of depth gauge.

(e) Loosen the locking pin, move knurled disc to the top of the drill sleeve, and then tighten locking pin.

(f) Take out the probe. Insert threaded Schanz pin’s into the knurled disk's Schanz pin recess.

(g) Move universal chuck over the Schanz pin's unthreaded end until the probe's tip meets end of the chuck. In this position, tighten universal chuck onto Schanz pin.

(h) Insert Schanz pin into far cortex all the way to the point where the universal chuck almost reaches the top of the drill sleeve.

(i) In order to install the adjustable clamp, first remove the drill sleeve.

Fig 8 : Wound debridement and fracture site exploration

Fig 9: Technique of pin insertion and LRS-fixator application after fracture reduction

Fig 10: Fracture stabilised with LRS-fixator

To increase the distal fragment's stability because it is a mobile fragment. After application, this needs to be secured with bolts at the back of the railing with the use of a spanner. Between the proximal clamp of the proximal segment and the distal first clamp of the distal fragment, the compression distraction clamp must be fixed.

As you are aware, the use of LRS is based on the same Ilizarovian concept for every diaphyseal complex fracture, i.e. compression distraction osteogenesis approach. However, LRS is only applied in one plane, and its stability is on equal with Ilizarov's.

Techniques for reducing a fracture

Simple transverse fractures can be stabilised at the fracture site by pushing the primary pieces against one another while being careful to prevent the fragments from tending to angulate. Neutralization frame is utilised in comminuted fractures.

The following should be taken into account in order to reduce motion at the fracture site and enhance frame rigidity.[2]

(a) Principal frame should be used in sagittal plane.

(b) Preload Schanz pin’s.

(c) Adding more pins to each piece of bone.

(d) Widening the distribution of pins inside each piece.

(e) Narrowing the gap between the bone and the railing.

Fixators should be applied in a way that keeps them away from area of wound. If a soft tissue covering technique is subsequently needed, the railing installation is to be done in a way that leaves adequate room for the anticipated soft tissue surgery.

In the event of comminuted and butterfly fragment fractures, the fixator was set to neutralisation mode. Compression is used to close the fracture gap and provide stability when there is a transverse, oblique, or segmental fracture.

To prevent skin compression, relaxing skin incisions were made around the pin tracts. Overlying muscles were used to cover the bone, and stay sutures were used to appoint the skin to the bone.

After the treatment, the foot and ankle were moved to make sure there were no half pins anchoring the musculotendinous tissues together. antibiotic medication were carried out. In the initial postoperative phase, CD method was initiated at 1 mm every week alternately based on fracture pattern.

Once the incision was clear and covered in good granulation tissue after three to four weeks, a plastic surgeon's opinion was obtained and treated appropriately.

All the 30 patients who had primary and secondary suturing recovered well. All patients received training to perform compression distraction cycles on a rotating basis at a rate of 1 mm each week.

Following up with each of these patients took place every four weeks. At the follow-up visit, patients were evaluated clinically and radiologically for wound healing, wound status, tenderness at the fracture site, presence of a pin tract infection, degree of weight bearing, callus, gap at the fracture site, sclerosis at the fracture ends, obliteration of the medullary canal, and range of motion at the knee and ankle joints. The patient was permitted to bear weight on his toes with the help of a walking frame or crutches if he shown satisfactory clinical and radiographic indicators of fracture healing. The stiffness of nearby joints was assessed at each follow-up visit, and physiotherapy was administered.

CASE NO.1

Fig. 11 : Pre op X-rays

Fig. 12. : Post op X-rays

Fig. 13. : Fracture stabilised with LRS with knee extended

Fig 14. : At 3 month follow-up X-ray

CASE NO. 2

Fig 15. : Pre-op xray

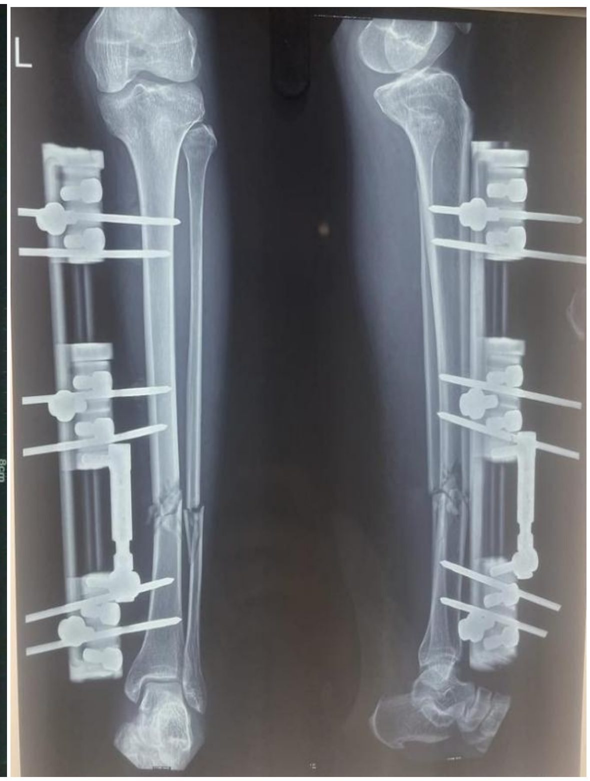


Fig. 16 : Post-op xray

Fig 17 : Clinical picture post op xray

Fig. 18: 6week post op xray

Fig 19:18 month postop

CASE NO. 3

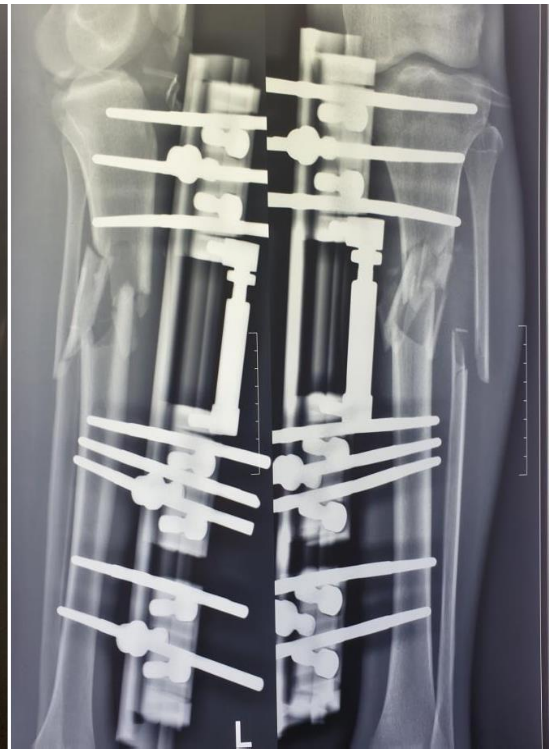


Fig 20: Pre-op xray **Fig 21: Post-op xray**

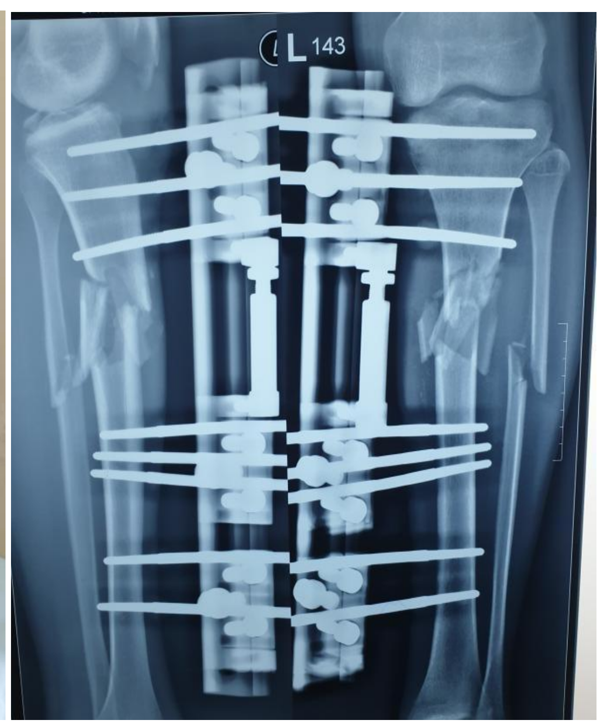


Fig 22 : Clinical picture at follow up **Fig 23: 3 month post op xray**

Sample size

With anticipated Proportion of good result by Anderson and Hutchinson's criteria in open fractures of long bones 80%(ref), the study would require a sample size of 30 patients with 95**%** level of confidence and 15% absolute precision**.**

Formula used

- $$\mathbf{n=\frac{z^2\, p*q}{d^2}}$$

Where Z= Z statistic at α level of significance

d^2= Absolute error

P= Proportion rate

q= 100-p

Statistical Analysis

- The data obtained will be entered in a Microsoft Excel sheet, and statistical analysis will be performed using statistical package for the social sciences (Verson 20).

Results will be presented as Mean (Median) ±SD, counts and percentages and diagrams.

RESULTS

In BLDE Hospital and research centre , Between November 2010 and August 2012, 25 open tibial fracture cases were chosen and followed up by the Department of Orthopaedics. During this time, we chose both the male and female patients who had visited the emergency room or outpatient clinic with an open tibial fracture. The most frequent factor was a traffic accident. The current investigation into the surgical treatment of a complex tibial fracture using an external fixator of the LRS type produced the following results.

1. Age incidence
2. Sex incidence
3. Mode of injury
4. Classification / Type of fracture
5. Site of fracture
6. Side of fracture
7. Secondary procedures done
8. Associate medical diseases
9. Hospital stay
10. Complications
11. Results

1. Age incidence

Age in years	Number of patients
21 to 30	8
31 to 40	10
41 to 50	9
51 to 60	3
Total	30

Table no. 1 : Age Incidence

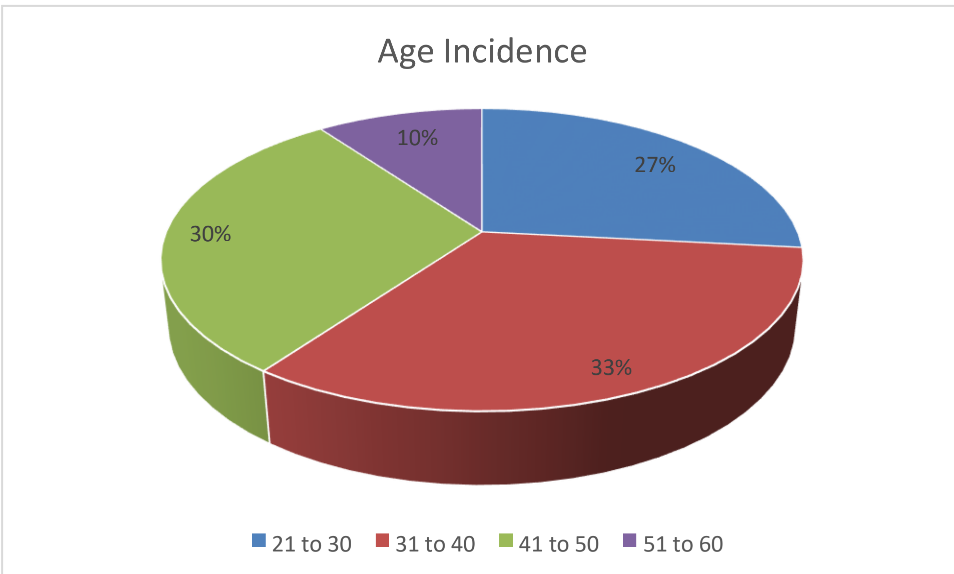


Fig. 24: Age Incidence

Patients above the ages of 18 were included in our study, with the majority of patients falling between the ages of 31 and 40. The oldest is 60 years old, while the youngest is 21 years old.

2) Sex Incidence

	Number of patients	Percentage
Male	26	86.7
Female	4	13.3

Table 2: Sex incidence

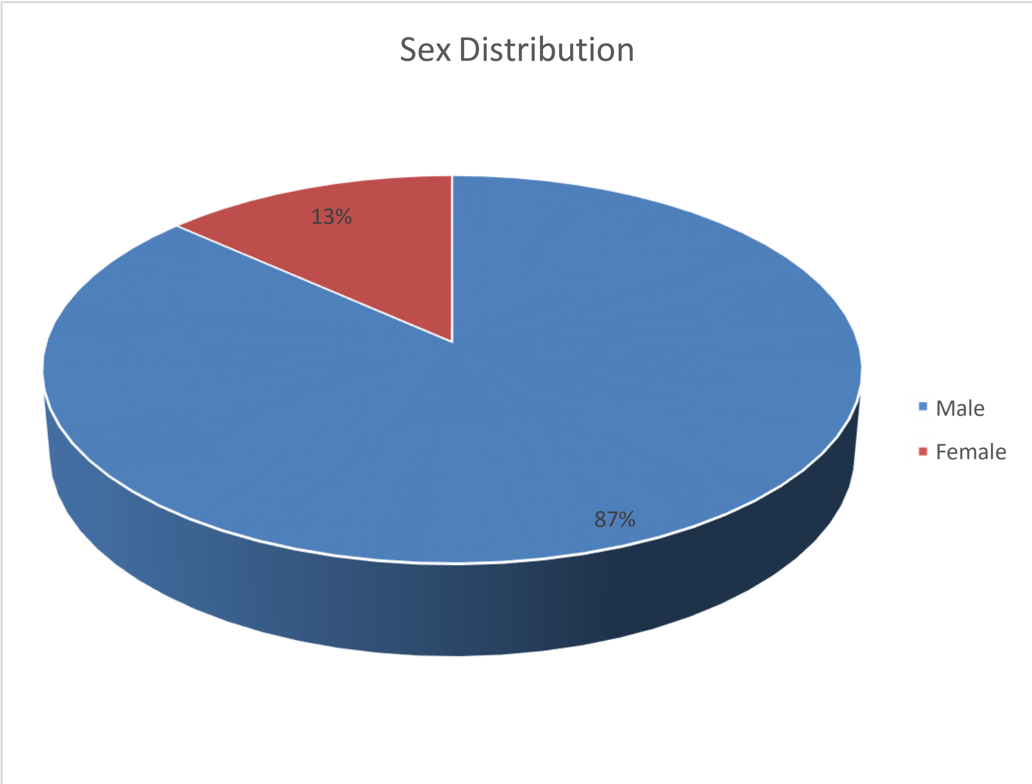


Fig. 25: Sex incidence

In our study, majority of participants were male, which may indicate that men engage in more activities and are more mobile.

3) Mode of Injury

Mechanism of injury	Number of cases
High velocity injury	
Road traffic accidents	30
Fall from height	0
Low velocity injury	
Field injuries	0
Domestic injuries	0
Cycle injuries	0
Hay stack fall	0
Fall by slip	0

Table 3: Mode of injury

Road traffic accidents accounted for 30 out of 30 instances (100%) in our research. Each was brought on by a high-velocity injury.

4) Classification – Type of facture

Type	**Number of patients**
Type – II	15
Type – II segmental	3
Type – III A	8
Type – III B	4

Table 4: Classification of fracture

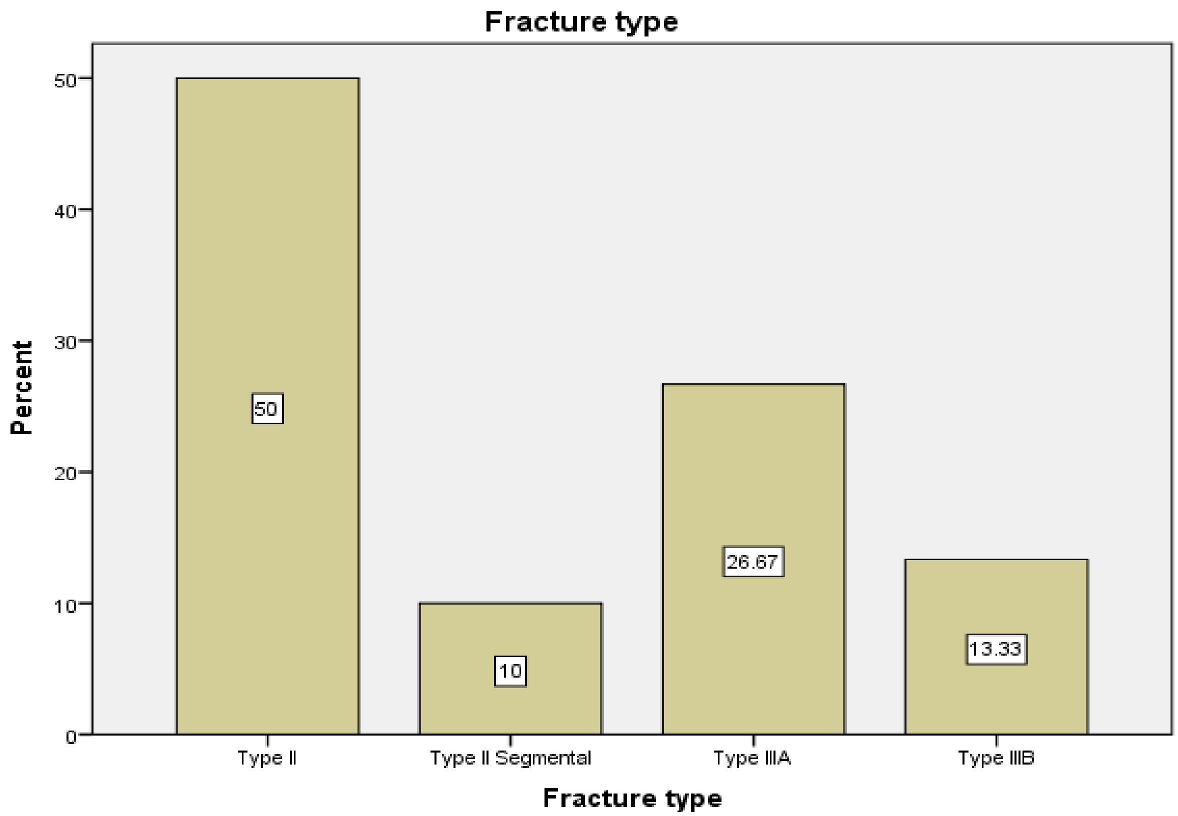


Fig. 26: Classification of fracture

In our study,as per Gustilo-Andersen's classification maximum number of type II patients in our study was 18, making up this group. Groups IIIA and IIIB, with 8 and 4 examples respectively.

5) Site of fracture

Site of fracture	Number of patients
Proximal 1/3rd	8
Middle 1/3rd	6
Lower 1/3rd	13
Segmental fractures	3

Table 5: Site of fracture

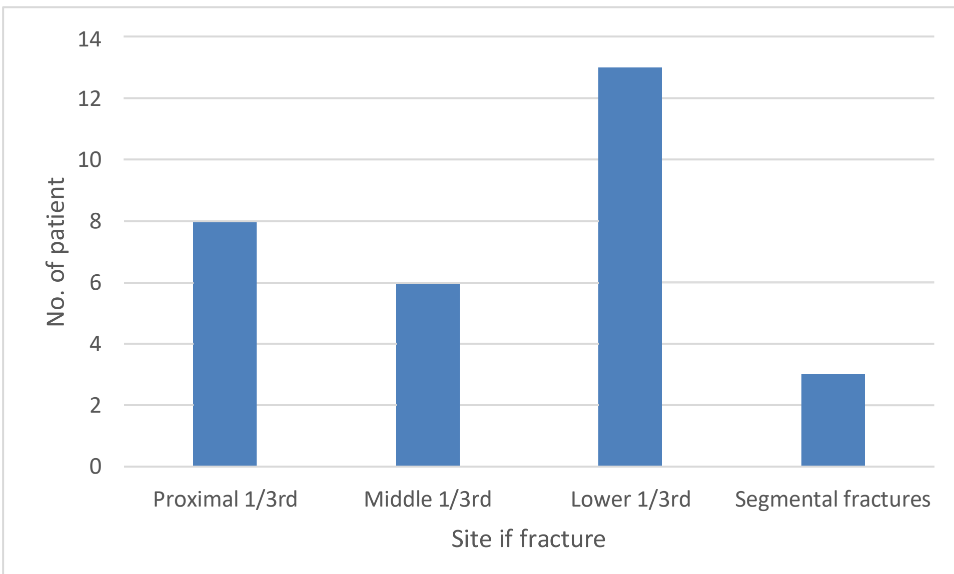


Fig. 27: Site of fracture

In our study, 43.33% of fractures occurred in lower third, followed by 20% in the mid third, 26.7% in proximal third, and 10% were segmental fractures.

6) Side of fracture

Side of fracture	Number of patients
Right	16
Left	14

Table 6: Side of fracture

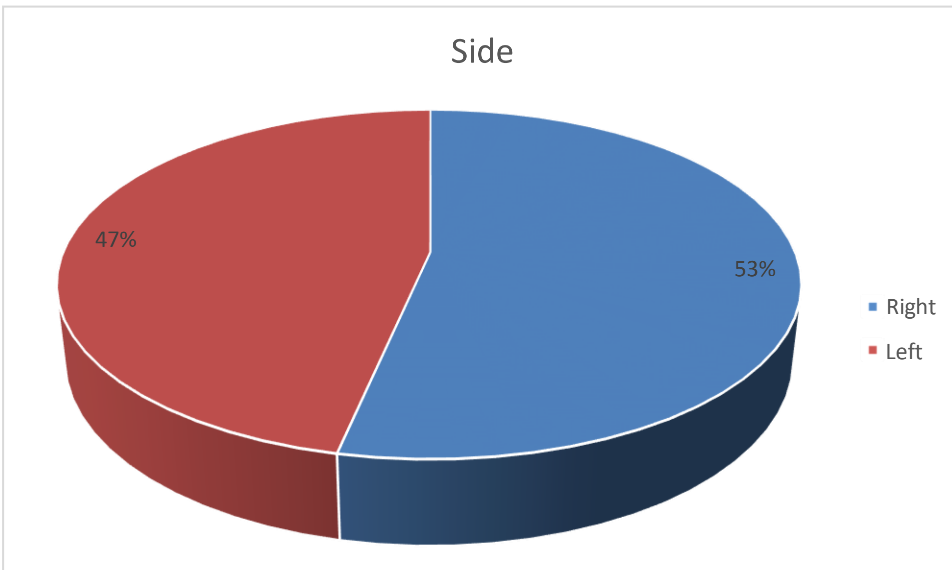


Fig. 28 : Side of fracture

In our analysis, there was a 53.3% right-sided prevalence.

7) Other Secondary procedures

(a) Soft tissue reconstruction: Of the patients in our series, 7 (23.3% of them) had split skin grafts, one had muscle pedicle flaps.

(b) Bone grafting was necessary in 3 cases wih soft tissue reconstruction

(c) The intact or joined fibula may prevent the compression of the fracture site , hence one patient (3.3%)in our study needed a fibulotomy.

(d) Delayed primary closer and secondary closer: In our study, two patient underwent secondary closer, while one patients received delayed primary closer.

Secondary procedures	**Number of cases**
Split skin grafting	7
Muscle pedicle graft	1
Bone graft	3
Fibulotomy	1
Delayed primary closer	1
Secondary closer	2

Table 7: Secondary procedures

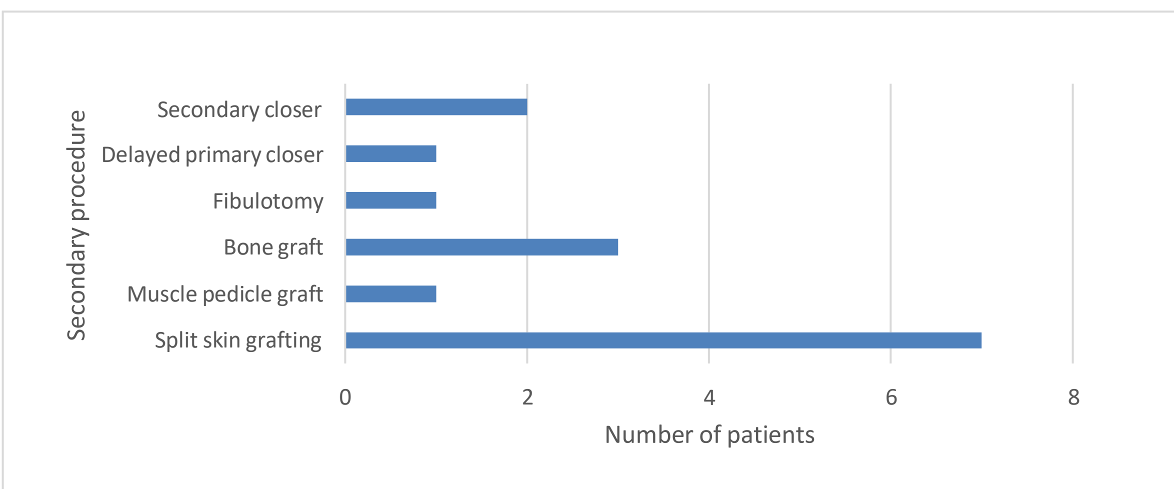


Fig. 29 : Secondary procedures required

8) Associated Medical diseases

Associated disease	Number of cases
Hypertension	2
Diabetes	1
Asthma	1

Table 8: Associated medical diseases

One type IIIB and one type II fracture patient in our dataset had hypertension and were given antihypertensives. Human Actrapid Insulin successfully treated one patients who had type II diabetes. Two patient had a history of asthma and was using a deriphylin pill and salbutamol nebulizer.

9) The average duration of hospital stay was 33 days, while maximum stay was 50 days and minimum 18 days.

10) Complications

In our study, pin tract infections and shortening were the most frequent complications. After receiving a culture and sensitivity report, pin tract infections were treated with parenteral antibiotics.Eight cases of shortening were observed, which the equinus deformity somewhat compensated for. In one instance, deep infection took place. In two cases, the union was delayed.

Complications	**Number of patients**
Pin tract infections	6
Shortening	8
Equinus deformity	1
Deep infection	1
Malunion	1
Delayed union	2

Table 9: Complications

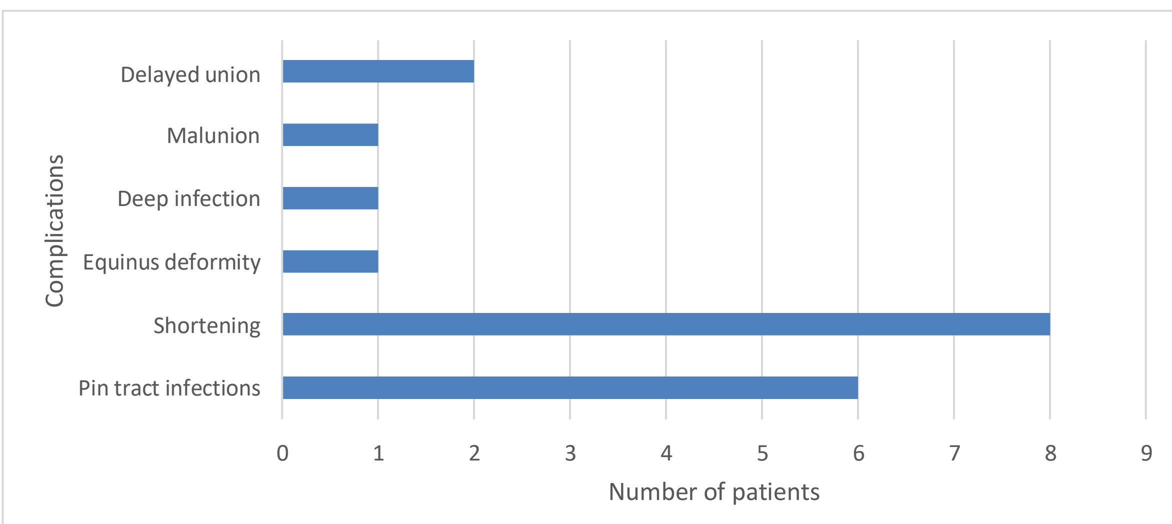


Fig. 30 : Complications

11) Results

Results	**Number of patients**	**Percentage**
Good	22	73.3
Moderate	5	16.7
Poor	3	10

Table 10: Results

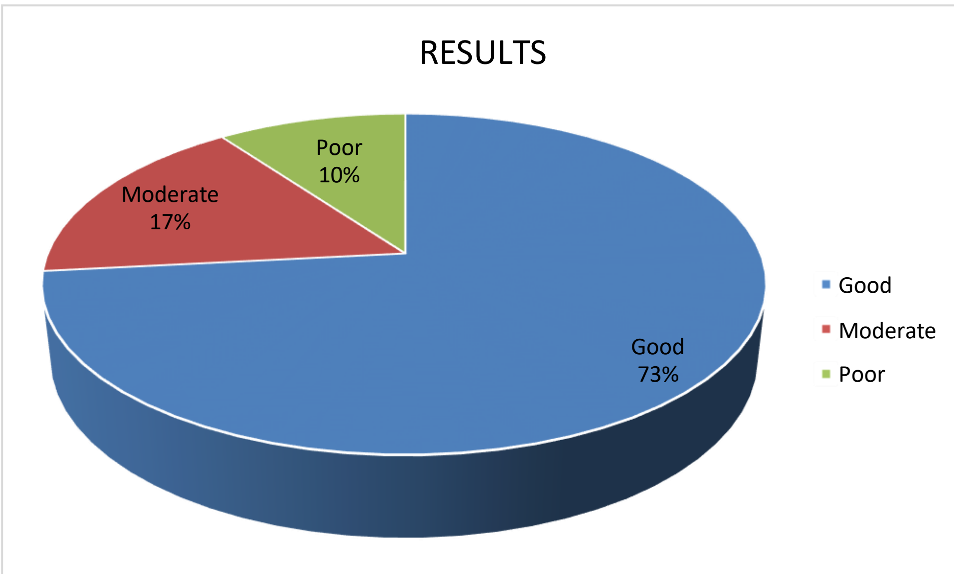


Fig. 31: Result

The modified Anderson and Hutchin's criteria were used to determine the degree of deformity and limb length disparity.

The outcomes were rated as

"Good: no discomfort, swelling, or deformity (angulation) less than 5 varus/valgus ; <10 degree anterior/posterior, limb length discrepancy 1 cm, complete range of motion in the knees and ankles, painless walking, normal cross-legged sitting, and normal squatting."

"Moderate: Minimal deformity (angulation) of 5 to 10 degrees varus or valgus, 10 to 20 degrees anterior or posterior, a difference of 1-2 cm in limb length, and negligible loss of mobility at the knee and ankle."

"Poor: Leg length discrepancy > 2 cm, substantial loss of mobility at knee and ankle, deformity (angulation) > 10 degree varus/valgus, > 20 degree anterior/posterior angulation."

Table 11: Modified Anderson's and Hutchin's criteria

Results	Shortening	Grade of deformity in Angulation (Malunion)
Good	< 1 cm	Upto 5°varus / valgus Upto 10° Anterior /Posterior
Moderate	1-2 cm	5-10° varus / valgus 10-20° Anterior / Posterior
Poor	> 2 cm	> 10° varus / valgus > 20° Anterior / posterior Angulation

The ankle and knee movements were graded as: Fullrange -Normal

Significant loss of movement:

In the knee: loss of extension upto >10 degree

In the ankle: loss of 25 degree but < 50 degree of flexion / extension

Insignificant loss of movement: Any reduction in motion that is negligible and falls within the typical range

Significant loss: Loss of > 50 percent flexion and extension in the ankle and knee.

DISCUSSION

Open fractures are medical crises that may be better understood as partial amputations. All physicians in charge of making medical decisions must aim to preserve life, preserve limb, avoid infection, and maintain limb function.

The following variables were examined in connection to the patients and the kinds of fractures that took place.

1. Age incidence

All of the individuals involved in the current study ranged in age from 20 to 60. Most of the patients were between 31 and 40. Our study's average age was almost 38.3 years old. While the mean age in Thakur and Patankar's[7] study was also 38 years old.

2. Sex incidence

The fact that 86.7% of the patients in our research were men may indicate that men engage in more activities and are more mobile than women. The remaining 13.3% of the research group was made up of female patients. While 83.5% of the participants are male in the research conducted by Anand J. Thakur and Joy Patankar[7] and 16.5% are female.

3. Injury mode

In our study, all injuries resulted from traffic-related incidents. While in research by Pedro Antich Adrover et al.[19], 81.9% of cases in group A and 90% of cases in group B had injuries as a result of traffic accidents. Road traffic accidents were the root cause of 87.3% of open fractures in the Thakur and Patankar[7] series.

4. Classification - Fracture Type

According to Gustilo-Anderson's classification we included types II upto IIIB in our study. The majority of the patients in our research (60% of all patients) belonged to the Type II Gustilo-Anderson group. The Type IIIA and Type IIIB groups came next, each accounting for 26.7% and 13.3% of cases respectively. There were 40 comminuted fractures, 27 transverse or short oblique fractures, and 12 spiral or long oblique fractures in the Thakur and Patankar[7] series. 45% of the patients in research by Hans P. Granhed and Abbas H. Karladani[24] were of type IIIB Gustilo, while the remaining 55% were of type IIIC Gustilo.

5. Fracture site

In our study, 43.3% of the fractures occurred in the lower third, 20% in the mid third, 26.7% in proximal third, and 10% segmental fractures. In contrast, in a research by Henley MB, Chapman JR, Agel J et al.[21], 4% of fractures occurred in proximal third, 78% in mid third, and 10% at distal third.

6.Additional secondary techniques

(a) Reconstruction of soft tissues

In our series, 7 patients (23.3% of the total) had split skin grafts, one patient had a muscle pedical flap, one patients had delayed primary closure, and two patient had secondary closure. In contrast, in the Thakur and Patankar[7] study, where skin grafting was necessary for 43 patients and 5 wounds, delayed primary or secondary closure was used to treat 16 wounds. In the Tornetta III et al.[11] study, a skin graft or muscle flap was used to achieve tissue cover in each patient

(b) Bone grafting

Bone grafting was done in three case (10% of total cases) after radiography revealed non-union symptoms. In contrast, bone grafting was performed in 44 case (60.3% of total cases) in Thakur and Patankar's[7] study, with an average recovery time of 6.2 weeks.

7.Complications

In our research, 8 patients (26.7%) each experienced limb shortening and 7 patients (23.3%) with pin tract infections, which were both frequent complications. With the exception of one case, all seven of these pin tract infections successfully treated with the appropriate IV antibiotics following culture and sensitivity testing. Poor nutritional condition, nosocomial infections, and patient's inability to pay for pricey drugs were considered to be the main contributing factors to infection. In the research by Bhandari et al.[22], 1 (3.3%) of the patients had deep infections. In our research, deep infections affected 3.3% of patients and pin tract infections 23.3 % of individuals.

8.Results

In the current study, 22 patients (73.3%) had good outcomes, 5 had moderate results (16.7%), and 3 had poor results (10%).

CONCLUSION

Due to the tibia's subcutaneous location, high energy trauma, and frequent encounters with moving vehicles travelling at high speeds, open fractures of the tibia are quite common. This is particularly true in our nation, where there is a high level of traffic congestion brought on by an increase in the number of vehicles, poor infrastructure, poor vehicle maintenance, and reckless and careless driving by young people.

- Due to their increased level of activity, adult males between the ages of 20 and 40 are frequently diagnosed with open tibia fractures.

- Patients with open tibial fractures classified as Gustilo-Anderson Type II and Type III should get irrigation, serial debridement, antimicrobial medication, appropriate fixation with an external fixator (LRS), and enough viable soft tissue covering as first care.

- External fixators are the preferred method of treatment for open tibia fractures, particularly in cases with comminuted and severe Gustilo-Anderson type III damage. This is because LRS external fixators produced good to moderate outcomes in our series. In addition, the fracture has healed in 90% of instances, and 3 patient required a bone graft due to a delayed union.

- By properly treating the initial wound within 24 hours and using an external fixator of the LRS type to stabilise the fracture, infection can be effectively managed.

- A good fixation is made possible by the frame arrangement and LRS external fixing.
- The placement of an external fixator makes it simple to accompany soft tissue surgeries such skin grafting, myocutaneous, and muscle pedicle flap.
- The LRS external fixator can be used in conjunction with resection of the devitalized bone, simultaneous compression of the fracture gap or site, secondary limb lengthening by proximal corticotomy, compression and distraction procedures, and low rates of infection and non-union.
- Due to distal third tibia's subcutaneous position, limited blood flow, inadequate muscle covering, external fixators can be very helpful in circumstances when fracture healing is problematic.
- There are few complications and adequate ankle and knee ranges of motion. It is not as difficult as Iliazarov and is an ex-fixator that is simple to maintain.
- The LRS external fixation technique frequently succeeds in saving limbs that would have been very susceptible to amputation.

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Annexure I

Ethical committee certificate

B.L.D.E. (DEEMED TO BE UNIVERSITY)

(Declared vide notification No. F.9-37/2007-U.3 (A) Dated. 29-2-2008 of the MHRD, Government of India under Section 3 of the UGC Act, 1956)

The Constituent College

SHRI. B. M. PATIL MEDICAL COLLEGE, HOSPITAL AND RESEARCH CENTRE

IEC/No. 09/2021
Date-22/01/2021

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Institutional ethical committee of this college met on 11-01-2021 at 11 am to scrutinize the synopsis of Postgraduate students of this college from Ethical Clearance point of view. After scrutiny the following original/corrected and revised version synopsis of the Thesis has been accorded Ethical Clearance

Title: Functional outcome in management of open tibial diaphyseal fractures by limb reconstruction system as primary and definitive tool - A prospective study.

Name of PG student: Dr Jayesh Kumari Soni, Department of Orthopaedics

Name of Guide/Co-investigator: Dr Santosh S Nandi, Professor of Orthopaedics

DR .S.V.PATIL
CHAIRMAN, IEC

Institutional Ethical Committee
B L D E (Deemed to be University)
Shri B.M. Patil Medical College,
VIJAYAPUR-586103 (Karnataka)

Following documents were placed before Ethical Committee for Scrutinization:

1. Copy of Synopsis / Research project
2. Copy of informed consent form
3. Any other relevant documents.

Annexure II

B.L.D.E (DEEMED TO BE UNIVERSITY) SHRI B.M. PATIL MEDICAL COLLEGE HOSPITAL AND RESEARCH CENTRE, VIJAYAPUR-586103

INFORMED CONSENT FOR PARTICIPATION IN DISSERTATION/RESEARCH

I, the undersigned,________________, S/O D/O W/O_________________, aged__years, ordinarily resident of______________do hereby state/declare that **Dr. Jayesh kumar soni** of Shri. B. M. Patil Medical College Hospital and Research Centre has examined me thoroughly on________________at _______________(place) and it has been explained to me in my own language that I am suffering from _________________ disease (condition) and this disease/condition mimic following diseases. Further **Dr. Jayesh kumar soni** informed me that he/she is conducting dissertation/research titled "FUNCTIONAL OUTCOME IN MANAGEMENT OF OPEN TIBIAL DIAPHYSEAL FRACTURES BY LIMB RECONSTRUCTION SYSTEM AS PRIMARY AND DEFINITIVE TOOL - A PROSPECTIVE STUDY" under the guidance of **Dr. Santosh S Nandi** requesting my participation in the study. Apart from routine treatment procedure, the pre-operative, operative, post-operative and follow-up observations will be utilized for the study as reference data.

Doctor has also informed me that during conduct of this procedure like adverse results may be encountered. Among the above complications most of them are treatable but are not anticipated hence there is chance of aggravation of my condition and in rare circumstances it may prove fatal in spite of anticipated diagnosis and best treatment made available. Further Doctor has informed me that my participation in this study help in evaluation of the results of the study which is useful reference to treatment of other similar cases in near future, and also I may be benefited in getting relieved of suffering or cure of the disease I am suffering.

The Doctor has also informed me that information given by me, observations made/ photographs/ video graphs taken upon me by the investigator will be kept secret and not assessed by the person other than me or my legal hirer except for academic purposes.

The Doctor did inform me that though my participation is purely voluntary, based on information given by me, I can ask any clarification during the course of treatment / study related to diagnosis, procedure of treatment, result of treatment or prognosis. At the same time I have been informed that I can withdraw from my participation in this study at any time if I want or the investigator can terminate me from the study at any time from the study but not the procedure of treatment and follow-up unless I request to be discharged.

After understanding the nature of dissertation or research, diagnosis made, mode of treatment, I the undersigned Shri/Smt______________________________under my full conscious state of mind agree to participate in the said research/dissertation.

Signature of patient:

Signature of doctor:

Witness: 1. 2.

Date:
Place:

Annexure III

PROFORMA

Name	:	IPNo.	:
Age	:	DOA	:
Sex	:	DOS	:
Occupation	:	DOD	:
Address	:		

Presenting complaints:

History of injury:

a. Date and time of injury

b. Place of accident

c. Nature of violence

Direct	**Indirect**
Vehicular accident	Trivial – Slipping
Fall from height	Stumbling
Assault	Twisting
Industrial	etc.

d. Any primary treatment received

e. History of treatment by local bone setter /osteopath

f. Pain: Site / onset / related to movements

g. Was patient able to walk soon after the incident or he was carried to hospital

h. History of head injury

Loss of

consciousness

Vomiting

Ear / Nose / Throat bleeding

i. History of associated regional injuries

- Chest wall
- Abdominal
- Spinal injuries ,etc.

j. History of past medical disease

- Diabetes mellitus
- Hypertension /IHD
- COPD
- Pulmonary tuberculosis
- Epilepsy

g. Personal and family history

Examination

General physical examination

1. Built and nourishment

2. Signs

   Pallor, Icterus, clubbing, cyanosis, oedema, lymphadenopathy

3. Vital parameters:

   Pulse :

   BP :

   Respiratory rate:

4. Pupillary reaction and Glasgow coma scale(GCS)

Systemic Examination:

CVS

RS

P/A

CNS

Other limb and joint function

Local Examination

(a) Inspection

- Attitude of limb /deformity
- Soft tissue injury
- Open wound description
- Shortening
- Swelling
- Active bleeding from the wound

(b) Palpation

- Temperature
- Tenderness
- Bony irregularities
- Crepitus
- Abnormal mobility
- Movements at the adjacent joints
- Vascular / Neurological status

(c) Measurements

Complications

-Associated injury

-Neurological injury

-Vascular injury

Management

-Reception at casualty

-First aid measures instituted

-Hypovolaemia corrections

-Primary wound debridement

-Stabilisation of fracture with slab / splint

Investigations

1. Blood (routine)
    - -Hb%
    - -BT CT
    - -Blood grouping / Typing
    - -Serum creatinine
    - -Blood urea
    - -ELISA for HIV 1 & 2 / HBsAg
    - -Blood sugar
2. Urine routine :
    - -Sugar
    - -Albumin
    - -Microscopy
3. ECG in all chest leads with rhythm strip
4. X-ray of the affected limb including adjacent joints AP / Lateral views

5. Chest X-ray PA view

6. Others like:

   -Echocardiography
   -CT scan of head
   -USG
   -LFT
   -Serum electrolytes If indicated specifically

7. Pus for culture and sensitivity

Treatment

I. Initial treatment

- Improvement of general condition of the patient
- To the fracture / open wound
    - Wound toileting
    - Fracture reduction and stabilization
    - Duration
- Radiological examination

II. Operative treatment

Time period between injury and surgery

1. Date and time of surgery
2. Indication
3. Consent
4. Anaesthesia
5. Operative findings
6. Difficulties encountered during the surgery

7. Soft tissue procedure done if any

8. Type of fixator used

III. Postoperative treatment

1. Antibiotics and analgesics

2. Transfusions – Fluids

   – Blood

3. Postoperative limb position

4. Postoperative wound care

5. Check X-ray:

   Date :

   Report :

6. Date of suture removal

7. Rate of compression and distraction cycles started

8. Active motion started on

9. Physiotherapy – exercises begun on:

10. Partial weight bearing on:

11. Full weight bearing on:

12. Regular follow-up check-up

    - Follow-up interval
    - Check X-ray
    - Wound status, pin tract site
    - Active range of movements of neighbouring joint

- Compression – Distraction rate
- Look for complications if any

Complications

1. Intraoperative

    -Difficulty in achieving stable reduction

    -Injury to neurovascular structures

    -Difficulty in achieving soft tissue coverage

    -Anaesthetic problems

2. Postoperative

Early complications

-Delayed wound healing and wound gaping

-Pulmonary / cardiac complications

-Loss of fracture reduction

Late complications

-DVT

-Pin tract infection and osteomyelitis

-Joint stiffness

-Malunion

-Delayed union

-Non-union

-Shortening and deformities if any

-

KEY TO MASTER CHART

A/K	Above knee
BG	Bone grafting
CD	Compression-Distraction
DF	Dorsiflexion
DOA	Date of admission
E	Extension
FU	Follow-up
FWB	Full weight bearing
HS	Hospital stay
IM	Immobilisation
L	Left
LRS	Limb reconstructive system
MOI	Mechanism of injury
PF	Plantar flexion
PTB	Patellar tendon bearing
PTI	Pin tract infections
PWB	Partial weight bearing
R	Right
RTA	Road traffic accident
SP	Secondary procedure
SSG	Split skin grafting

MASTER CHART

Sl no.	Name of patient	Age (years)	Sex	IP no.	DOA	MOI	Fracture type	Side	Site of fracture	LRS applied on	SP	HS(days)	FU	CD (cycles)	PWB (weeks)	FWB (months)	Shortening (in cm)	Movement of ankle and knee				Date of LRS removal	IM	Complication	Result
																		flexion	Extension	DF	PF				
1	Sangappa	28	M	11359	04-01-2021	RTA	Type II	R	Low 1/3rd	07-01-2021	Nil	24	1 years	7	6	7	Nil	110	0	10	45	12-07-2021	A/K cast	Nil	Good
2	Sateesh	21	M	1540	12-01-2021	RTA	Type II	L	Mid 1/3rd	14-01-2021	SSG	30	11 months	9	5	5	Nil	120	0	10	45	25-07-2021	A/K cast	PTI	Good
3	Gangamma	35	F	31083	16-01-2021	RTA	Type IIIA	R	Low 1/3rd	26-01-2021	SSG + BONE GRAFT	45	10 months	8	6	6	Nil	120	0	10	45	28-08-2021	A/K cast	Nil	Good
4	Mantesh	43	M	12255	24-01-2021	RTA	Type II Segmental	R	Low 1/3rd	29-01-2021	SSG	28	10 months	8	4	5	Nil	100	0	10	40	05-10-2021	A/K cast	Nil	Good
5	Parashuran	60	M	39739	28-01-2021	RTA	Type II	L	Low 1/3rd	02-02-2021	Nil	34	10 months	7	4	6	Nil	110	0	10	45	15-10-2021	A/K cast	PTI	Good
6	Mohan	28	M	48319	06-02-2021	RTA	Type IIIA	R	Low 1/3rd	09-02-2021	Nil	40	11 months	9	6	5	Nil	110	0	10	40	11-11-2021	PTB	Nil	Good
7	kallappa	47	M	57514	08-02-2021	RTA	Type II	L	Upper 1/3rd	16-02-2021	Fibulotomy	35	10 months	8	5	5	2	100	0	10	30	04-10-2021	A/K cast	Nil	Moderate
8	Amit	39	M	82244	27-02-2021	RTA	Type II Segmental	R	Mid 1/3rd	09-03-2021	Nil	28	9 months	6	7	6	Nil	120	0	10	45	14-10-2021	A/K cast	Nil	Good
9	Basawaraj	33	M	91042	07-03-2021	RTA	Type IIIA	L	Upper 1/3rd	16-03-2021	SSG + BONE GRAFT	35	10 months	9	5	5	Nil	120	5	10	45	08-10-2021	A/K cast	Nil	Good
10	Shanappa	38	M	113807	30-03-2021	RTA	Type II	L	Mid 1/3rd	06-04-2021	Nil	41	10 months	7	6	4	2.5	120	0	10	25	22-11-2021	A/K cast	PTI, Delayed union	Poor
11	Shrujan	26	M	131063	18-04-2021	RTA	Type IIIB	L	Low 1/3rd	20-04-2021	Nil	30	1 years	10	7	6	Nil	110	0	10	45	20-12-2021	A/K cast	Nil	Good
12	Manoj	27	M	116983	25-04-2021	RTA	Type IIIA	R	Upper 1/3rd	27-04-2022	SSG	22	11 months	9	5	6	Nil	120	0	5	45	30-11-2021	PTB	PTI	Good
13	Saipan	50	M	91073	08-06-2021	RTA	Type II	L	Upper 1/3rd	10-06-2021	Nil	18	10 months	8	5	5	Nil	100	0	5	45	17-12-2021	A/K cast	Nil	Good
14	Nagappa	28	M	209842	13-06-2022	RTA	Type II	R	Low 1/3rd	22-06-2021	Nil	32	11 months	8	4	5	1	110	0	10	40	29-12-2021	A/K cast	Nil	moderate
15	Hasansab	38	M	228413	03-07-2021	RTA	Type IIIB	L	Mid 1/3rd	06-07-2021	Secondary closure	38	10 months	10	8	6	Nil	100	0	10	45	16-01-2022	A/K cast	Nil	Good
16	Mahadevi	45	F	34103	11-07-2021	RTA	Type IIIA	R	Low 1/3rd	13-07-2021	Delayed primary closure	40	10 months	7	4	5	1.5	100	0	10	40	10-03-2022	A/K cast	Deep infection	Moderate
17	Basavaraj	60	M	169316	25-09-2021	RTA	Type IIIB	R	Low 1/3rd	29-09-2021	Nil	30	1 years	9	5	4	Nil	120	0	10	45	12-04-2022	A/K cast	Nil	Good
18	Sachin	40	M	200492	28-09-2021	RTA	Type II	R	Upper 1/3rd	06-10-2021	Nil	25	11 months	8	5	6	Nil	120	0	10	45	26-04-2022	A/K cast	Nil	Good
19	Dayanand	45	M	210003	11-10-2021	RTA	Type II	R	Low 1/3rd	13-10-2021	Nil	50	11 months	6	7	8	Nil	110	5	10	40	07-05-2022	PTB	Nil	Good
20	Bhavani	33	F	210030	11-10-2021	RTA	Type II	L	Low 1/3rd	13-10-2021	Nil	18	10 months	9	6	6	Nil	120	0	10	45	26-04-2022	A/K cast	Nil	Good
21	Asif	47	M	228015	24-10-2021	RTA	Type IIIA	R	Mid 1/3rd	27-10-2021	Muscle pedicle graft	45	1 years	10	6	7	Nil	100	0	10	45	20-04-2022	PTB	Nil	Good
22	Anand	33	M	228017	24-10-2021	RTA	Type IIIB	L	Upper 1/3rd	27-10-2021	SSG + Bone graft	42	10 months	9	5	6	2.5	100	0	0	30	16-05-2022	A/K cast	Equinus deformity	Poor
23	Dhawavva	48	F	65901	27-10-2021	RTA	Type II	L	Upper 1/3rd	30-10-2021	Nil	25	9 months	13	8	5	1	110	0	10	45	12-04-2022	A/K cast	Nil	Moderate
24	Veeresh	26	M	245795	30-10-2021	RTA	Type II	R	Low 1/3rd	01-11-2021	Nil	35	10 months	6	7	6	Nil	110	0	10	20	01-05-2022	A/K cast	Nil	Good
25	Raghuram	33	M	26238	19-11-2021	RTA	Type II Segmental	L	Low 1/3rd	24-11-2021	Nil	28	9 months	11	8	6	3	120	0	10	45	28-06-2022	A/K cast	PTI, 10 degree valgus union	Poor
26	Ashok	42	M	288291	22-11-2021	RTA	Type IIIA	R	Mid 1/3rd	01-12-2021	SSG	29	10 months	9	6	5	Nil	110	0	10	45	20-05-2022	A/K cast	Nil	Good
27	Sharanbasa	28	M	282604	11-12-2021	RTA	Type II	R	Upper 1/3rd	15-12-2021	Nil	31	7 months	7	4	5	Nil	110	0	10	45	29-05-2022	A/K cast	Nil	Good
28	Basappa	55	M	311623	20-12-2021	RTA	Type II	R	Mid 1/3rd	29-12-2021	Nil	36	9 months	6	6	7	Nil	120	0	10	45	05-06-2022	A/K cast	Nil	Good
29	Anand	32	M	2346	02-01-2022	RTA	Type II	L	Low 1/3rd	05-01-2022	Nil	27	8 months	10	5	6	2	110	0	5	40	16-06-2022	A/K cast	PTI, Delayed union	Moderate
30	Sangappa	42	M	11841	10-01-2022	RTA	Type IIIA	L	Low 1/3rd	12-01-2022	Secondary closure	44	8 months	7	6	6	Nil	100	0	10	45	28-06-2022	A/K cast	Nil	Good