"SURGICAL MANAGEMENT OF ISOLATED TIBIAL SHAFT FRACTURES WITH CLOSED INTRAMEDULLARY INTERLOCKING NAIL"

By

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IN

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ABSTRACT

BACKGROUND AND OBJECTIVE

Tibial diaphyseal fractures are one of the commonest long bone fractures encountered by most of the Orthopaedic surgeons. There are many methods of treatment for tibial diaphyseal fractures. But now-a-days closed intramedullary interlocking nailing is emerging as treatment of choice for all closed tibial diaphyseal fractures, most of type I and type II open fractures in adults.

The Tibial shaft fractures with intact fibula had difficulties in the orthopedic treatment of leg fractures like reduction of the tibial and an unusually high rate of varus malunion , delayed union and non-union.

Fractures of tibial diaphysis associated with an intact fibula have always interested Orthopaedic surgeons. There has been debate as to whether the intact fibula was associated with an improved or worse prognosis. The aim of this prospective study was to assess the outcome of isolated tibial shaft fractures treated with intramedullary interlocking nail.

METHODS:

A total of 30 patients with isolated tibial diaphyseal fractures (closed fractures, type I open fractures and type II open fractures) were operated with closed intramedullary interlocking nailing in the Department of Orthopaedics, R.L.J Hospital attached to Sri Devaraj urs medical college and Research Centre, kolar, Karnataka during the period from July 2013 to December 2015. This prospective study was done over a period of 2 ½ years with regular follow-up.

RESULTS

Excellent functional results were obtained in 70% of cases. Good functional results were obtained in 14%, fair functional results in 3% and poor functional results in 13%, According to Johner and Wruh’s criteria.

Complications include Infection, anterior knee pain, delayed union and non-union.

INTERPRETATION AND CONCLUSION

Intramedullary Interlocking Nailing is the reliable and effective Treatment for Undisplaced and minimally displaced closed isolated tibial shaft fractures, also in open Type I, tibial shaft fractures. Closed Minimal and Undisplaced fractures have united well. Displaced, comminuted fractures of tibial shaft with intact fibula is prone to delayed union and non-union. Intramedullary Interlocking Nailing minimizes the hospital stay and reduces the economic burden and enhances early return to work.

Key words: Tibial shaft fracture, Fibula intact, Intramedullary Nailing

LIST OF ABBREVIATIONS

AO	⇒	Arbeitrgemeinschaftfuer Osteosynthes fragen
AP	⇒	Anteroposterior
ASIF	⇒	Association for study of internal fixation
DCP	⇒	Dynamic compression plate
DOA	⇒	Date of admission
DOD	⇒	Date of discharge
Fig	⇒	Figure
FWB	⇒	Full weight bearing
IL Nail	⇒	Interlocking nail
IP No.	⇒	Inpatient number
Lt	⇒	Left
MVA	⇒	Motor vehicle accident
NWB	⇒	Non-weight bearing
OTA	⇒	Orthopaedic trauma association
P&S	⇒	Plate and screws
PWB	⇒	Partial weight bearing
ROM	⇒	Range of motion
Rt	⇒	Right
RTA	⇒	Road traffic accident

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INTRODUCTION

"We still have long way to go before the best method of treating a fracture of the shaft of Tibia can be stated with finality".

- Sir John charnley, 1961 [1]

The management of tibial diaphyseal fractures has always held a particular interest for Orthopaedic surgeons. Not only are they relatively common, but they are often difficult to treat. The subcutaneous location of the anteromedial surface of the tibia means that severe bone and soft tissue injury is not infrequent and there is a high incidence of open fractures compared with other long bones.[2]

Tibial diaphyseal fractures are the most common long-bone fracture encountered by most Orthopaedic surgeons. In an average population, there are about 26 tibial diaphyseal fractures per 100,000 of the population per year. Males are more commonly affected than females, as the male incidence is about 41 per 100,000 per year and the female incidence is about 12 per 100,000 per year. The average age of a tibial fracture population is about 37 years. This indicates bimodal distribution with a preponderance of young males.[3]

Fractures of Tibial shaft cannot be treated by simple set of rules. It is the most commonly fractured long bone. Because one third of the tibial surface is subcutaneous throughout most of its length, open fractures are more common in the tibia than in any other major long bone. The blood supply to the tibia is more precarious than that of bones enclosed by heavy muscles. High-energy tibial fractures may be associated with compartment syndrome or neural or vascular injury. The presence of hinge joints at the knee and the ankle allows no adjustment for rotary deformity after fracture, and special care is necessary during reduction to correct such deformity. Delayed union, nonunion, and infection are relatively common complications of tibial shaft fractures.[4]

Isolated closed fractures of the tibial shaft traditionally have been treated with closed reduction and a cast, while operative treatment has been reserved for situations in which an adequate closed reduction could not be obtained or maintained. Treatment of displaced tibial shaft fractures with intramedullary nailing with reaming provides functional results that are superior to those obtained with use of cast.[5]

Although many closed fractures of the tibial shaft can be treated non-operatively, the preferred method of operative treatment remains controversial. Intramedullary fixation with a locking nail has become a popular technique because of reported excellent results in clinical comparative studies, the smaller diameter nails may afford less stability to the bone and may thereby retard healing compared with that achieved with larger diameter nails inserted after reaming.[6]

Controversy exists over optimal method of stabilization of open fractures of tibia. External fixation devices have been quite popular in the management of these fractures. But recently unreamed intramedullary nailing, as initial definitive management of these fractures, has been gaining acceptance and reaming disturbs cortical blood flow to a greater extent than unreamed nails, possibly increasing susceptibility to infection. Few studies suggested that unreamed nails are superior to external fixator or reamed nail in management of open fractures of tibia.[7]

When the fibula remains intact, a tibio fibular length discrepancy develops and causes altered strain patterns in the tibia and fibula. These may lead to delayed union, non-union, or malunion of the tibia with the sequelae of joint disturbances.

The lower incidence of complications in patients less than twenty years old may be due to the greater compliance of their fibulae and soft tissues[8].

Minimally displaced tibial fracture in the presence of an intact fibula has a good prognosis. Although the initial force may be great enough to break the tibia and tear local soft tissues, the fibula is protected from fracture by its innate flexibility and the significant compliance of its proximal and distal ligaments.[8]

The main difficulties encountered in the orthopedic treatment of leg fractures with intact fibula are reduction of the tibial and an unusually high rate of varus malunion, and non-unions . Nailing is a reliable technique for treatment of tibial shaft fractures with an intact fibula [9].

Fractures of tibial diaphysis associated with an intact fibula have always interested Orthopaedic surgeons. There has been debate as to whether the intact fibula was associated with an improved or worse prognosis[10, 14]. The aim of this prospective study was to assess the outcome of isolated tibial shaft fractures treated with intramedullary interlocking nail.

OBJECTIVES

- To study the efficacy of interlocking intramedullary nailing in achieving anatomical reduction and stable fixation and early return to function.
- To study the period of union on radiological evidence.
- To Study the range of movements at knee and ankle joint post operatively.

REVIEW OF LITERATURE

Watson-jones and coltart (1943) found that in a series of closed tibial fractures treated with immobilization with continuous traction but without distraction produced union within 16 weeks, where as continuous immobilization without traction produced union within same period.[11]

Nicoll (1964), concluded the important factors affecting union are

(1) The amount of initial displacement,

(2) The degree of comminution,

(3) Infection and

(4) The severity of the soft-tissue injury excluding infection[11]

Nicoll also found that the presence or absence of a fibular fracture did not influence the prognosis and intact fibula is significant only in so far as it affects the degree of initial displacement and stability of fracture.[11]

Sarmiento et al. (1974) reported that closed treatment with use of a prefabricated Functional below-the-knee brace was effective in a closed diaphyseal fractures of the tibia. However, those authors had strict criteria for use of the fracture-brace. An intact fibula is a relative contraindication to functional bracing because angular deformity is more likely to develop.[12]

Torsional fractures tend to create a longitudinal tear of the periosteum and may not disrupt endosteal vessels, whereas transverse fractures usually tear the periosteum circumferentially and completely disrupt the endosteal circulation, hence torsional fractures have better prognosis. Reduction was difficult in displaced spiral fractures of the distal third of the tibia[13]

Hoaglund and States classified fractures of the tibia as being caused by either high-energy or low-energy trauma and found this classification useful in prognosis. Fractures in the high-energy group resulted from accidents such as automobile collisions and crush injuries. This group included more than half the total fractures and 90% of the open fractures; fractures in this group healed in an average of 6 months. Fractures in the low-energy group resulted from accidents such as falls on ice and while skiing; these healed in an average of about 4 months. These researchers found that the level of fracture was not significant in the prognosis, but that the amount of bony contact was. Fractures in which contact between the fragments after reduction was 50% to 90% of normal healed significantly faster than fractures in which contact was less.[13]

Displacement of more than 50% of the width of the tibia at the fracture site was a significant cause of delayed union or nonunion, Reduction was difficult to maintain in fractures with more than 50% initial displacement, and that comminution delayed fracture healing. Fractures with more than 50% comminution are considered unstable and usually are associated with high-energy trauma[13]

Teitz CC et al (1980) had done study on Problems associated with tibial fractures with intact fibulae and concluded that when the fibula remains intact, a tibiofibular length discrepancy develops and causes altered strain patterns in the tibia and fibula. These may lead to delayed union, non-union, or malunion of the tibia with the sequelae of joint disturbances[14].

O'Dwyer KJ et al (1992)had done study on tibial shaft fractures with intact fibula and concluded that Delayed union rates were lower when the fibula remained intact, thus confirming that this is a good prognostic indicator.[15]

Lawrence B. Bone et al (1997), concluded that the treatment of displaced isolated fractures of the tibial shaft with closed intramedullary nailing with reaming provides functional results that are superior to those obtained with use of a cast.[5]

P.A.Blachut et al (1997) had done prospective study on interlocking intramedullary nailing with and without reaming for the treatment of tibial shaft fractures and concluded that no major advantages to nailing without reaming as compared with nailing with reaming and there was higher prevalence of delayed union and breakage of screws without reaming.[6]

Bonnevialle P et al (2000) had done study on Tibial fracture with intact fibula treated by reamed nailing and concluded that Nailing is a reliable technique for the treatment of tibial fractures with an intact fibula and Weight bearing should be encouraged as early as possible.[9]

M. Ferguson et al (2003-2004) al had done study on Outcomes of isolated tibial shaft fractures treated at level 1 trauma centres and after 1 year follow up concluded that long-term physical disability remains a problem for many patients following tibial shaft fracture, and they should be considered when providing prognostic information to patients.[16]

K.A. Lefaivre et al (2008) , concluded at a median 14 years after tibial nailing of isolated tibial shaft fractures, patients function is comparable to population norms, but objective and subjective evaluation shows persistent sequelae which are not insignificant. This study is the first to describe the long-term functional outcomes after isolated tibial shaft fractures treated with intramedullary nailing nails.[17]

Robert W. Wysocki (2008) had concluded that stastically locked intramedullary nailing with simultaneous intraoperative travelling traction external fixation as treatment for proximal and distal one-third tibial shaft fractures is successful in achieving a high rate of acceptable post-operative alignment.[21]

J.Cowie et al (2012) conclude that intramedullary nailing will remain treatment of choice for diaphyseal fractures, however modern plates are become less invasive it is associated with more soft tissue stripping and potential devascularisation.[18]

Mohan et al (2014) concluded that isolated tibial shaft fractures with intact fibulae are more prone for complications like delayed and nonunion. Nonunion cases are managed successfully with dynamization and later by bone grafting.[8]

EVOLUTION OF INTERLOCKING INTRAMEDULLARY INTRAMEDULLARY NAIL

Histological evolution of intramedullary nailing dates back to 16th century. The Spanish archives briefly mentions that the Incas and Aztecs used resinous Wooden pegs in the medullary canal of long bones for the treatment of non-unions.[19]

Ivory pegs were used by Birches and Ophers in 1886 and also by Koenig of Germany in 1913. Hoglund used bone instead of ivory pegs in 1917.[19] Nicolaysen of Norway described the biomechanical principles of intramedullary devices in the treatment of proximal femur fractures. Nicolaysen proposed that the length of intramedullary implants be maximized to provide for the best biomechanical advantage.[19]

Metal was first used by Lambotte and Heygrooves. Lambotte of Belgium (1907) employed grooved nails and long screws in clavicle and femur.[19] Heygrooves of England used intramedullary fixation for gunshot femur fractures during First World War.[19]

In 1937, Rush brothers, reported use of intramedullary Steinmen pin for the treatment of compound moteggia fracture. They also developed flexible nail systems with pins of four different diameters which can be used in all parts of the body later known as “Rush nail”.[19]

In the 1930s, Gerhard Küntscher developed his V-shaped and clover leaf nails, but it was not until nearly 50 years later that rigid intramedullary nailing became a widely accepted treatment for tibial shaft fractures. Later Herzog modified the straight Küntscher nail to accommodate the eccentric proximal portal. [20]

In the 1950s, Lottes developed a rigid nail that could be inserted without reaming using either an open or a closed technique. Lottes reviewed tibial fractures treated with his triflanged intramedullary nail and reported infections in only 0.9% of closed fractures and 7.3% of open fractures. He reported a 2.3% nonunion rate in his overall series using the closed method of nailing. He developed his technique without image intensifiers or fracture tables and was able to perform closed nailing in 99% of fractures[20].

Flexible intramedullary nails also have been used successfully to treat tibial shaft fractures. Wiss et al, suggested that fractures from 7.5cm below knee to 7.5 cm above ankle, with atleast 25% cortical apposition, can be treated with ender pins.[20]

In 1970s, Grosse and Kempf and Klemm and schellmann developed nails with interlocking screws, which expanded the indications for nailing to include more proximal, distal and unstable fractures.[20]

SURGICAL ANATOMY

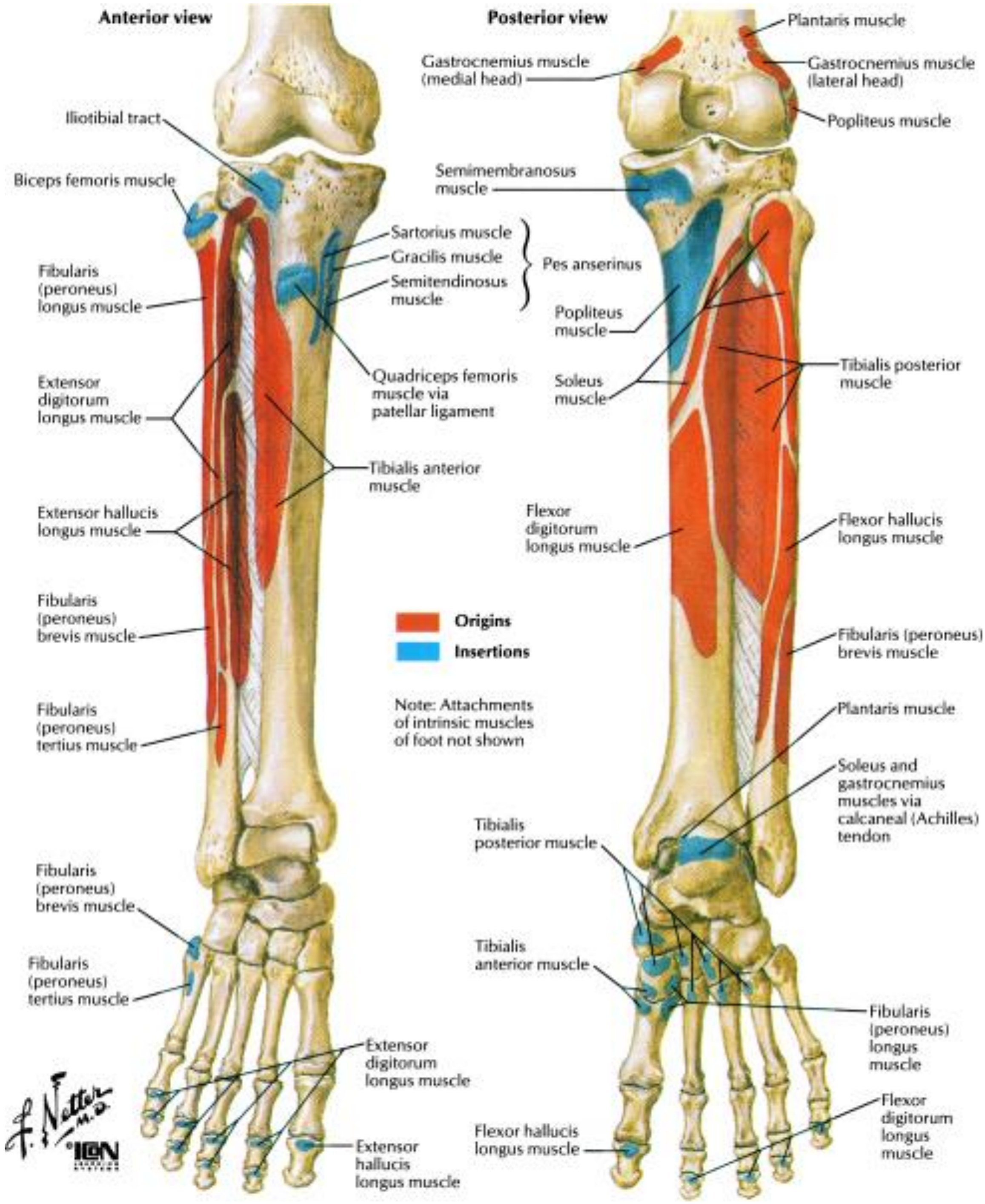


Fig 1: lower limb – bony attachments of muscles of leg

The location of the tibia and the fact that its anteromedial border is subcutaneous renders the bone susceptible to injury. The diaphysis becomes thinner distally, which means that it is particularly at risk from twisting injuries. It is not uncommon for surgeons to be presented with a spiral fracture occurring at the junction of the middle and distal thirds of the bone[22]

The tibia with its asymmetrical surrounding soft tissues determines the shape of the leg. The shaft of the tibia is a long tube of heavy bone which is abruptly Broadened at its upper end to support the condyles of femur and moderately expanded at its lower end to rest on talus.

The leg is divided into four compartments that contain all the muscles, nerves, and blood vessels. The compartments are surrounded by nondistensible fascia, and it is the nondistensibility of the fascia that causes compartment syndrome.[22]

The **anterior compartment** contains four muscles, the tibialis anterior, extensor hallucis longus, extensor digitorum longus, and peroneus tertius. This compartment contains the anterior tibial artery with its venae comitantes, and the deep peroneal nerve, which arises from the common peroneal nerve after it passes around the neck of the fibula. This nerve is at particular risk of damage from external fixator pins or from proximal intramedullary cross screws.

The **lateral compartment** contains two muscles, the peroneus longus and peroneus brevis muscles, as well as the superficial peroneal nerve there are two posterior compartments, the superficial and the deep compartment. There are three muscles in the superficial posterior compartment: the gastrocnemius, plantaris, and soleus muscles. The gastrocnemius and soleus muscles are of considerable importance to plastic surgeons, as they are very useful for covering the soft tissue defects associated with open proximal tibial diaphyseal fractures.[22]

The **deep posterior compartment** is important because combined with the anterior compartment, it is commonly involved in compartment syndrome. It contains the flexor digitorum longus, flexor hallucis longus, and the tibialis posterior, in addition to the posterior tibial artery, its venae comitantes, and the posterior tibial nerve. As the posterior tibial nerve supplies motor power to the foot muscles and innervates much of the sole of the foot, damage to this nerve may help the surgeon to decide between limb salvage and amputation.[22]

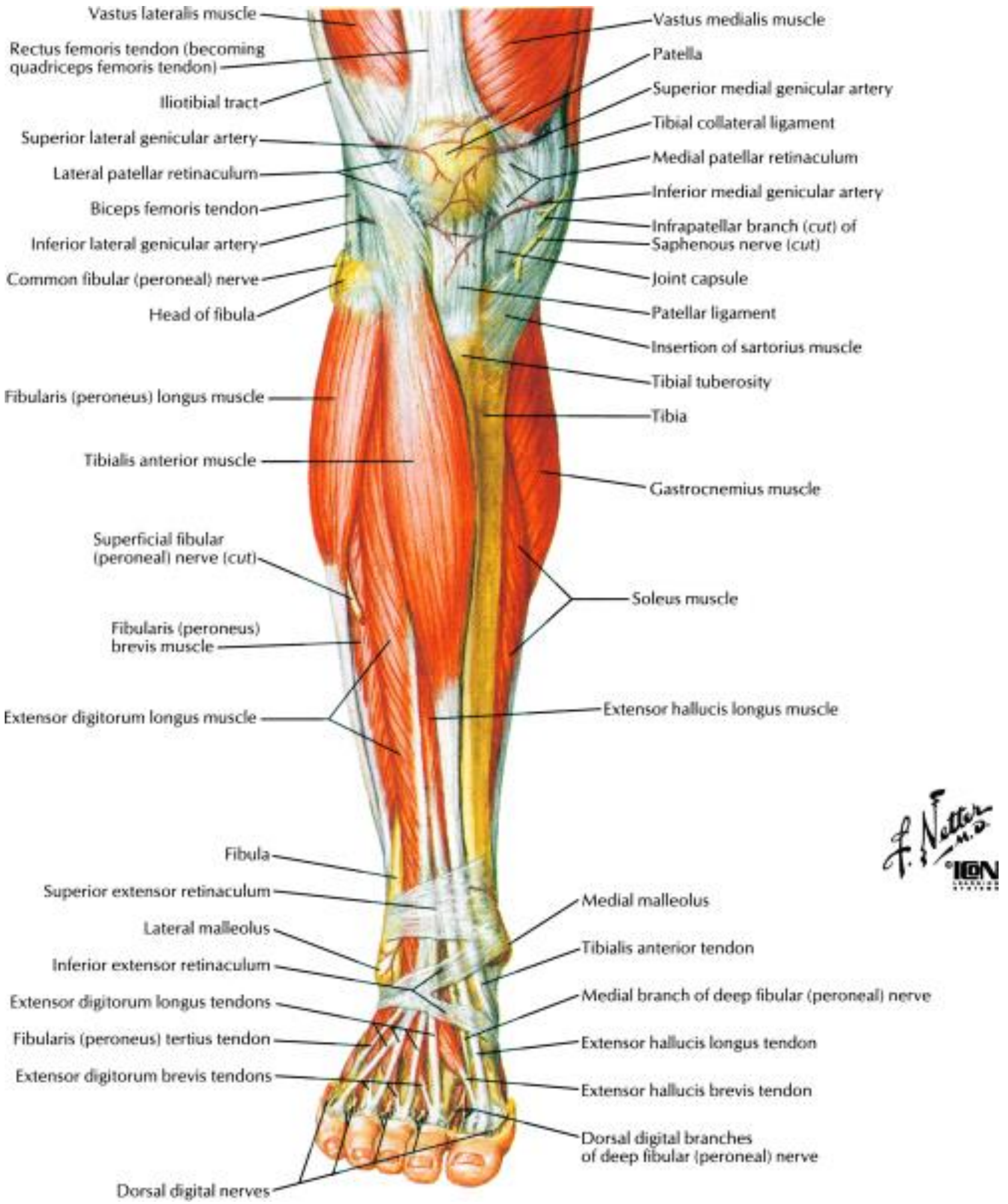


Fig 2: Muscles of **anterior compartment of leg**

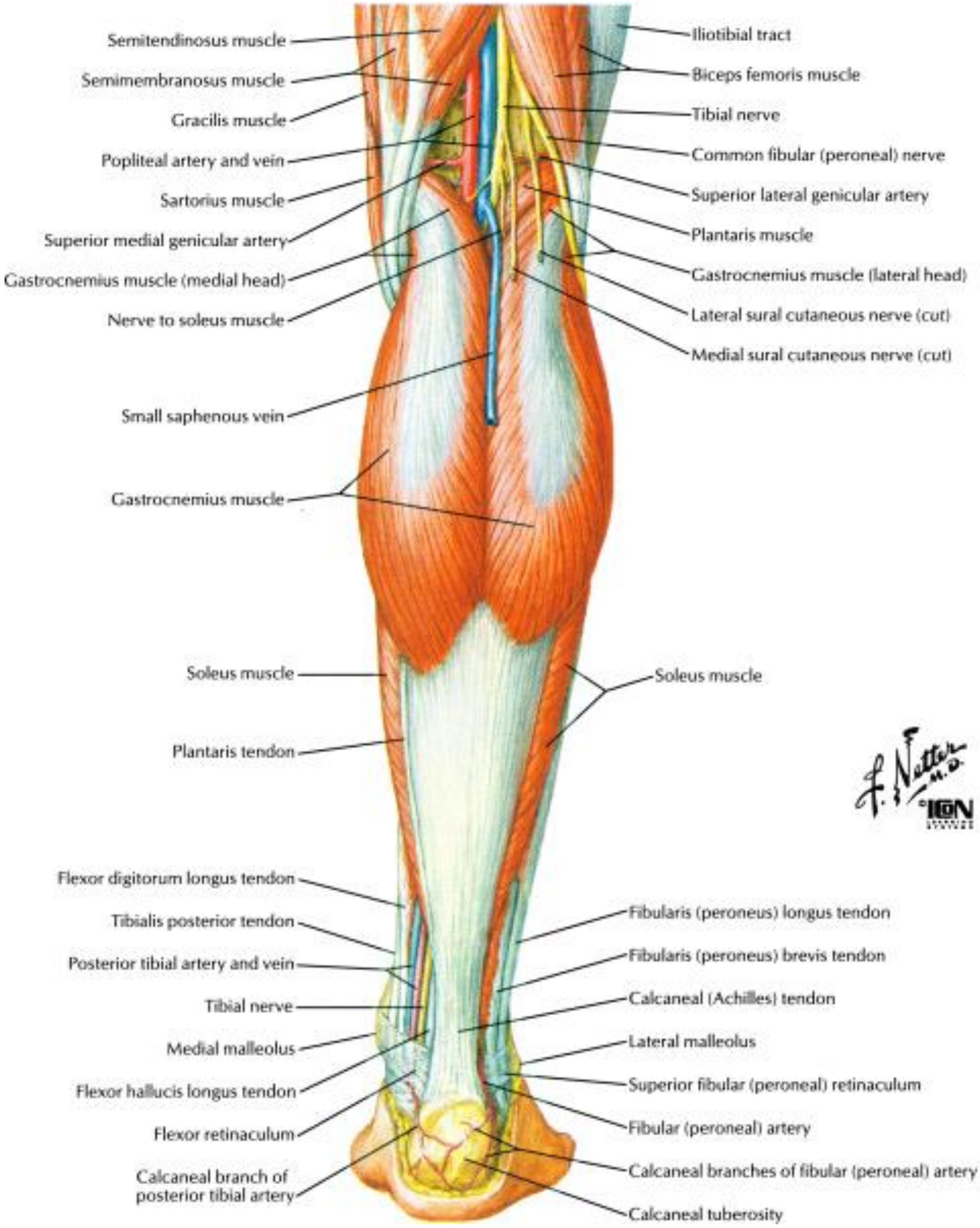


Fig 3: Muscles of superficial posterior compartment of leg

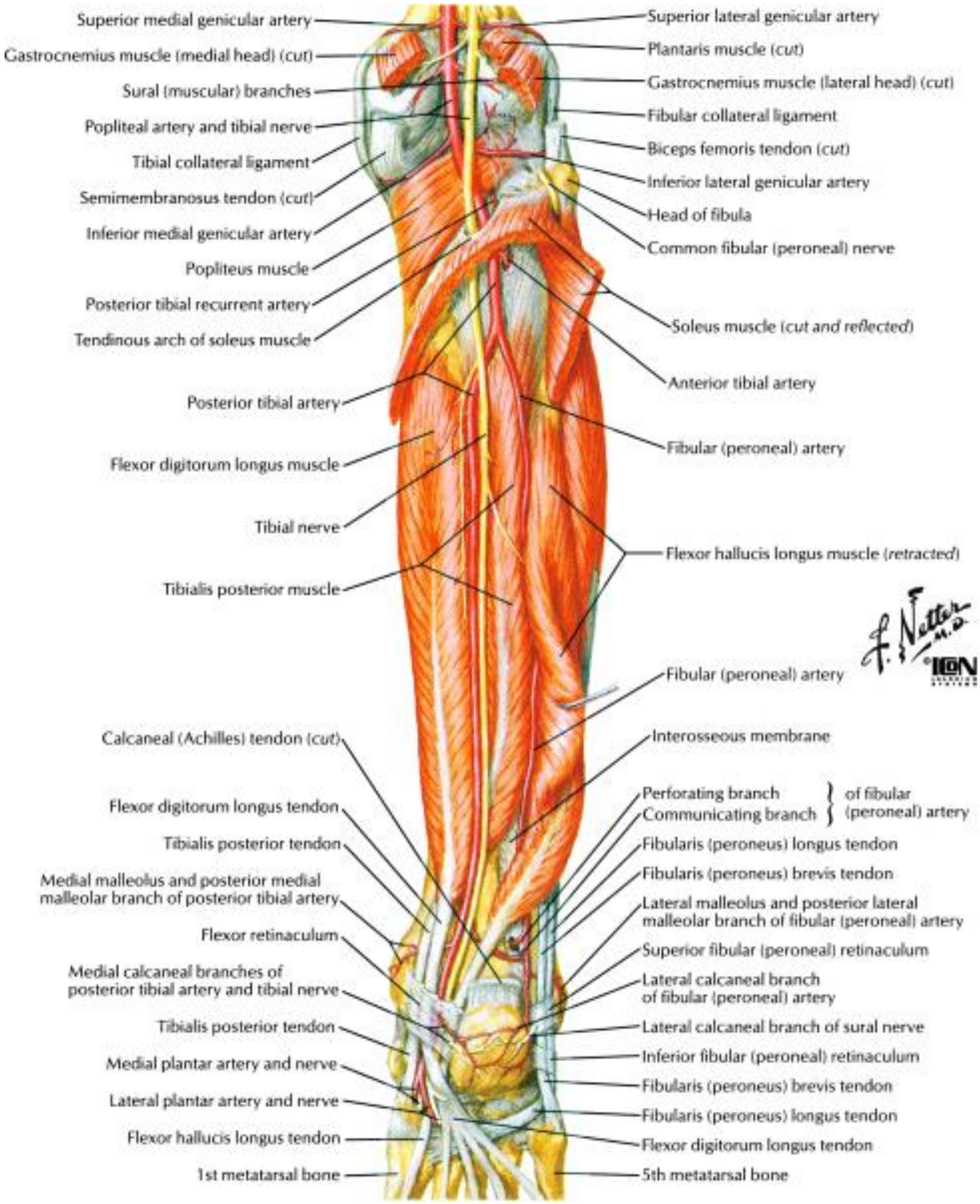


Fig 4: Muscles of deep posterior compartment of leg

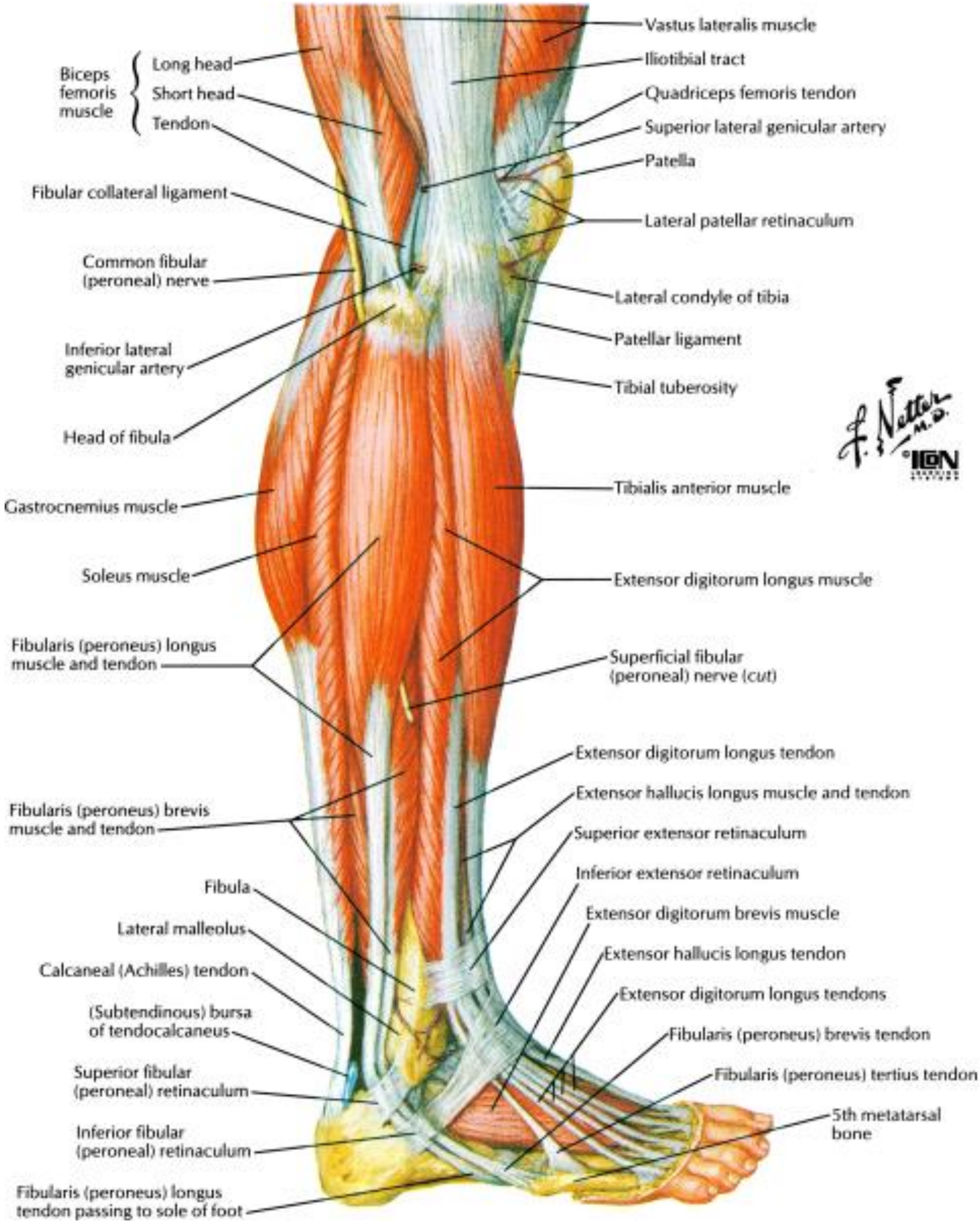


Fig 5: Muscles of lateral compartment of leg

BLOOD SUPPLY OF TIBIA

According to George and co-workers of Mayo Clinic[23] tibia is supplied by

Three main systems of vessels namely:

1. The epiphyseal-metaphyseal vessels
2. The nutrient artery
3. The periosteal vessels

1. The epiphyseal-metaphyseal vessels

In this region there are numerous vessels indicating copious blood supply. In The proximal part of tibia, the prominent vessels originate from middle genicular artery. Numerous vessels that enter from periphery of the epiphysis appear like the spokes of a wheel. Each spoke is composed of several arteries and their Accompanying veins. From each spoke like vessels, many branches come off at right angles to form dense interlocking vascular network. Similar system of vessels is also present at the lower end. The direction of circulation is centripetal, that is from periosteal to medullary canal.

2. The nutrient artery

Nutrient artery of tibia arises from the posterior tibial artery and penetrates the Posterolateral cortex at a point just below the oblique line of the tibia, the origin of the soleus. After entering the cortex of the tibia, the vessel crosses diagonally through the cortical bone for approximately five centimeters before it enters the marrow cavity. Two thin walled veins and myelinated nerve also accompany it.

In the medullary canal it divides into several ascending branches and single Major descending branch to lie close to the endosteal side of the medial cortex of the tibia. The ascending and descending arteries in the marrow cavity gives off small branches that proceed radially to pierce the endosteal surface of the cortex and then subdivide into small vessels that supply the haversian canals.

Blood flow through the diaphyseal cortex of tibia is centrifugal. Nutrient artery supplies approximately 70% of the arterial blood to the diaphysis and has also got anastomosis with metaphyseal and periosteal vessels.

3. The periosteal vessels

There is an abundant vascular network in the periosteum of the tibia and the Major source of these vessels is anterior tibial artery. Anterior tibial artery while Descending along the anterior surface of the interosseous membrane give off small Horizontal vessels that cross medially to divide at interosseous border of tibia into two twigs, one going transversely across the posterior surface of the tibia and other on the lateral surface. These are accompanied by veins. Periosteal vessels enter the cortex at firm fascial attachments along the long longitudinal axis of the tibia. These vessels penetrate the cortex at variable depth supplying outer third of the cortex.

EFFECT OF NAILING ON NORMAL BLOOD SUPPLY

According to Trueta and Cavadias[24] after damage to nutrient artery by nailing, periosteal vascular proliferation will occur. If the circulation from the bone marrow and that of the periosteum is interrupted, an increase in blood flow through the Metaphyseal arterial systems is able to supplement each other if one of the routes is compromised. But this process does not occur immediately, nor does the process Involve reversal of periosteal flow through anastomosis between the two systems.

Among the methods used in this investigation was suppression of one or other of the three main vascular sources of supply to the long bones (periosteal, metaphyseal-epiphyseal, and medullary) because it is known that the interruption of one or two of these sources stimulates those that remain to take over after a varying interval, an effect that is being used in this Centre to stimulate bone growth.

CLASSIFICATIONS

Numerous classification systems have been proposed for tibial fractures

Ellis Classification (1958)[25]

He used displacement, comminution and wound severity for classification of Tibial fractures.

(a) **Minor injury:** Undisplaced fractures or had only angular deformity, open wound if present was small and comminution was either absent or minimal. **Moderate injury:** Fractures with complete displacement but with more than a minor comminution.

(c) **Major injury:** Fractures including all these with significant comminution or Major open wound.

Nicoll's Classification[11]

He identified the fracture characteristics that seemed to be most useful for prognosis in the closed treatment of tibial fractures. He considered following three factors.

(a) Degree of initial displacement

(b) Comminution

(c) Soft tissue injury

He arbitrarily assigned one of the three grades for each factor.

(a) Nil or Slight

(b) Moderate

(c) Severe

ORTHOPAEDIC TRAUMA ASSOCIATION (OTA) AO CLASSIFICATION OF TIBIAL DIAPHYSEAL FRACTURES[26]

Type A: Unifocal fractures

Group A1	Spiral Fracture
Subgroups	A1.1 Intact fibula
	A1.2 Tibia and fibula fractures at different Level
	A1.3 Tibia and fibula fractures at same level
Group A2	Oblique fractures (fracture line > 30*)
Sub groups	A2.1 Intact fibula
	A2.2 Tibia and fibula fractures at different Level
	A2.3 Tibia and fibula fractures at same level
Group A3	Transverse fracture (fracture liken < 30*)
Subgroups	A3.1 Intact fibula
	A3.2 Tibia and fibula fractures at different Level
	A3.3 Tibia and fibula fractures at same level

Type B: Wedge fractures

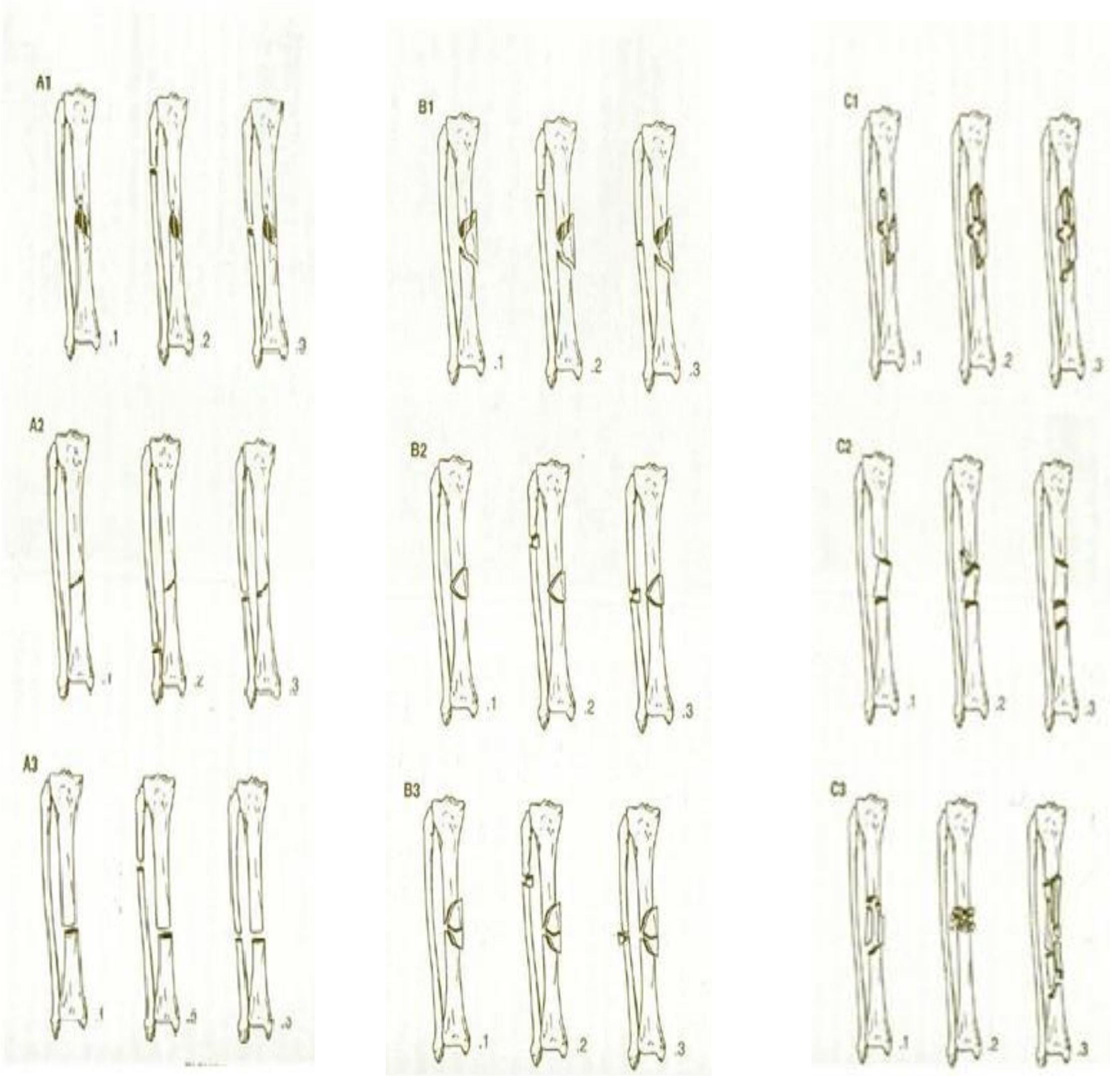
Group B1	Intact spiral wedge fractures
Subgroups	B1.1 Intact fibula
	B1.2 Tibia and fibula fractures at different Level
	B1.3 Tibia and fibula fractures at same level
Group B2	Intact bending wedge fractures
Subgroups	B2.1 Intact fibula
	B2.2 Tibia and fibula fractures at different Level
	B2.3 Tibia and fibula fractures at same level
Group B3	Comminuted wedge fractures
Subgroup	B3.1 Intact fibula
	B3.2 Tibia and fibula fractures at different Level
	B3.3 Tibia and fibula fractures at same level

Type C: Complex fractures (multifragmentary, segmental, or comminuted fractures)

Group C1	Spiral wedge fractures
Subgroups	C1.1 Two intermediate fragment
	C1.2 Three intermediate fragments
	C1.3More than three intermediate fragments

Group C2	Segmental fractures
Subgroups	C2.1 One segmental fragment
	C2.2 Segmental fragments and additional wedge fragment
	C2.3 Two segmental fragments
Group C3	Comminuted fractures
Subgroups	C3.1 Two or three intermediate fragments
	C3.2 Limited comminution (< 4 cm)
	C3.3 Extensive comminution (> 4 cm)

FIG 6: AO CLASSIFICATION



A TYPE **B TYPE** **C TYPE**

Gustillo and Anderson's Classification for open wounds[27]

The Gustilo classification has been the most widely used system and is generally accepted as the primary classification system for open fractures. This system takes into consideration the energy of the fracture, soft-tissue damage, and the degree of contamination. It has been modified since the original classification to allow a more accurate prognosis for more severe injuries

Gustilo type	Definition	Example fracture patterns
I	Open fracture, clean wound, wound <1 cm in length	Simple transverse or short oblique fractures
II	Open fracture, wound > 1 cm in length without extensive soft-tissue damage, flaps, avulsions	Simple transverse or short oblique fractures
III	Open fracture with extensive soft-tissue laceration, Damage, or loss or an open segmental fracture. This type also includes open fractures caused by farm injuries, fractures requiring vascular repair, or fractures that have been open for 8 h prior to treatment	High energy fracture pattern with significant involvement of surrounding tissues
IIIA	Type III fracture with adequate periosteal coverage of the fracture bone despite the extensive soft-tissue laceration or damage	Gunshot injuries or segmental fractures
IIIB	Type III fracture with extensive soft-tissue loss and periosteal stripping and bone damage. Usually associated with massive contamination. Will often need further soft-tissue coverage procedure (i.e. free or rotational flap)	Above patterns but usually very contaminated
IIIC	Type III fracture associated with an arterial injury requiring repair, irrespective of degree of Soft-tissue injury.	Above patterns but with vascular injury needing repair

The mangled extremity severity scale[27]

Multiple studies have examined the efficacy of the MESS both retrospectively and prospectively and have found it to correlate well with the treatment of major limb trauma. It has been suggested that a score of greater than or equal to 7 is predictive of amputation with nearly 100% accuracy

Component	Point
Skeletal and soft-tissue injury	
Low energy (stab; simple fracture civilian gunshot wound)	1
Medium energy (open or multiple fractures, dislocation)	2
High energy (close-range shotgun or military gunshot wound, crush injury)	3
Very high energy (same as above plus gross contamination, soft tissue avulsion)	4
Limb ischemia (score is doubled for ischemia >6 h)	
Pulse reduced or absent but perfusion normal	1
Pulselessness; paresthesia, diminished capillary refill	2
Cool, paralyzed, insensate, numb	3
Shock	
Systolic blood pressure always >90 mm Hg	0
Hypotensive transiently	1
Persistent hypotension	2
Age (years)	
<30	0
30–50	1
>50	2

METHODS OF TREATMENT

There are four principal methods of treating tibial diaphyseal fractures, although each method has a number of variants. Non operative management can be undertaken using either long leg casts, patellar tendon-bearing casts which allow knee movement, or functional braces, which permit both knee and hind foot movement.

The three basic operative techniques are plating, intramedullary nailing and external fixation. Plating was in vogue in the 1960s and 1970s and remains popular in some parts of the world. Currently, intramedullary nailing of tibial fractures is usually undertaken with an interlocking intramedullary nail[28].

I. FUNCTIONAL CAST BRACING

In 1970, Sarmiento[29] published a report on 135 tibial fractures treated by a total contact functional brace that allowed both knee and ankle movement. He reported an average time to union of 15.5 weeks with no nonunion.

Sarmiento et al[30] analyzed 1,000 consecutive closed tibial fractures. They stressed that the final shortening did not exceed the initial fracture shortening, and that the method was very inexpensive and had few complications. Keep in mind that none of these articles contain reference to patient function, and the incidence of hind foot stiffness, gait abnormalities, and the loss of function is unknown. Recent years that surgeons have stopped using fracture union as the only measure of successful treatment. As they have started to examine parameters such as joint stiffness, gait abnormality, and return to function and employment, it has become clear that there are a number of drawbacks to the use of casts or braces.

II. EXTERNAL FIXATION

In the 1970s and 1980s, and many surgeons continue to use external fixation, particularly for severe open tibial fractures, in the belief that the incidence of infection is less, as there is no metal implant across the fracture site and that the technique is associated with less vascular damage in tibiae that are already compromised.

Court-Brown and Hughes analyzed a uniplanar fixator to determine which configuration gave rise to more rigid fracture fixation. They showed that altering the pin location, pin angle, and pin length affected the rigidity of fracture fixation. By analyzing the configuration of the frames applied to 48 tibial fractures, they were able to show that the outcome was not affected by the frame configuration but was affected by the quality of fracture reduction and the length of time that the fixator was maintained on the tibia.[31]

Ilizarov [32,33]devised this concept for the treatment of tibial fracture complications rather than as a primary treatment, however the Ilizarov device has been used for the primary treatment of tibial fractures[34, 35]

Tucker et al reported on the treatment of 26 tibial fractures, six of which were closed. None of the fractures had bone loss. The average union time was 25.6 weeks, and they stated that only one patient did not have an excellent or good result.

Approximately 10% of the wires showed evidence of sepsis, and 19.2% had a malunion. The surgeons suggested that the method offered a minimally invasive means of treating tibial fractures, but the results they achieved are comparable with those obtained with much simpler frames[35].

Pin tract sepsis may be common, but it is rarely a problem, and pin will have to be changed only occasionally. The main drawback of pin tract sepsis is that either the patient must be taught to care for his or her pin tracts or regular nursing has to be arranged. Thus, pin tract sepsis is time-consuming and costly, although it rarely results in osteomyelitis.

Giovanni et al, has done study on the treatment of fractures with a dynamic axial fixator and concluded in fresh fractures average healing times ranging from 3.4 months to 6.5 months. In ununited fractures also average healing time ranging from 4.7 to 6.5 months. The device is versatile and can be applied in an average of 15 minutes. It permits ambulatory fracture care without sacrificing a sound anatomical result[43].

III. INTERNAL FIXATION: WITH PLATE AND SCREWS

N.J.Blockey et al concluded that treatment of tibia shaft fractures by the application of a plate may fail if rigid fixation is not achieved and maintained. Union may be very slow if bone ends are widely stripped. If fixation is firm all along, union will result in time. The greatest disadvantage of routine use of plates for fractures of tibia is infection and healthy skin is essential pre-requisite of the operation[36]

With modern plates, using plates has become less invasive. However it is still more invasive than intramedullary nailing and is associated with more soft-tissue stripping and potential devascularisation[37]

IV. INTRAMEDULLARY FIXATION

The introduction of locked intramedullary nailing of the tibial diaphysis revolutionalised the treatment of both closed and open tibial diaphyseal fractures. Court-Brown and Caesar summarized the available literature in 2006. They showed that in closed and Gustilo I and II open tibial fractures the union time averaged 16.6 weeks. The infection rate averaged 1.9% and the non-union rate averaged 2.9% with the malunion rate averaging 7.6%. Joint stiffness, usually of the hind foot.[37]

There are however still a number of discussion points concerning the use of nails in tibial diaphyseal fractures. The main ones are the use of reaming to facilitate the introduction of the intramedullary nails, the use of exchange nailing in the treatment of non-union and the frequency and consequences of knee pain, which is the most common complication of nailing. Other complications are relatively few unless treating a Gustilo IIIB fracture, in which case, the prevalence of non-union and infection is much higher[37].

Reamed vs unreamed.

Initially intramedullary tibial nails were reamed nails. They were unlocked nails and maximum stability was gained from broad contact between the nail and the endosteal surface of the tibia. This was facilitated by reaming the endosteal surface so that a large diameter nail, often measuring 14 mm or 15 mm, could be inserted. With the introduction of locked nailing, stability was radically improved but concern was expressed about the effects of reaming on the endosteal blood supply[37].

However there was a considerable debate about the advantages and disadvantages of reaming particularly as research indicated that reaming increased the periosteal blood flow.[38]

The biggest study of the effects of reaming was undertaken by the SPRINT group in the USA, Canada and the Netherlands. They analyzed 1226 patients who were randomized to reamed or unreamed nailing of their tibial diaphyseal fractures. The authors stated that their results supported the use of reamed nailing for closed fractures and they felt that their results suggested that surgeons should wait longer than six months before undertaking exchange nailing for nonunion of a tibial diaphyseal fracture[39].

BIOMECHANICS OF INTRAMEDULLARY INTERLOCKING NAILS

The factors usually cited in evaluating failure of bone are the type, magnitude, and rate of load and the material and structural properties of bone. Bone is an anisotropic material in that it exhibits different stress-strain relationships depending on the direction in which the stress is applied. Cancellous and cortical bone also differ because of the porosity and diameter of their respective cross sections[40].

Cortical bone fractures in vitro when strain exceeds 2% of the original length, whereas Cancellous bone does not fail until strain exceeds 7%. In analyzing fracture patterns, the mode of loading offers insight into the mechanism of injury and possible associated injuries. Loads usually are described as tension, compression, bending, shear, torsion, or a combination of these. The mode of bone failure can predict the soft-tissue injury and stability of the fracture[40]

Devices used to stabilize the skeleton are subjected to loading and deforming forces that rarely cause acute load-to-failure as occurs with the fracture, but these devices can fail because of fatigue if the bone does not regenerate to accommodate the load. Material properties, as noted, are expressed by stress-strain curves and structural properties are expressed by load deformation curves[40]

LOAD DEFLECTION CURVE

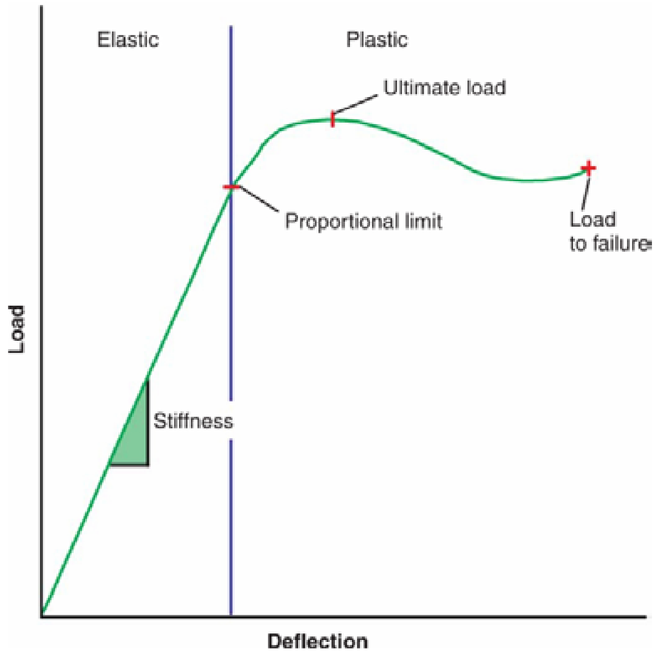


Fig 7: load deflection curve

The elastic phase is the working area of the medullary implant. Part of the elastic portion is the stiffness of the object. The higher the stiffness the more rigid the object. As stiffness decreases the object becomes more flexible. An object will return to its original shape following load removal. Once the load exceeds the proportional limit, a plastic deformation takes place, and the shape of the object changes. Hence the implant should not be loaded beyond its proportional limits.[41]

STRESS STRAIN CURVE

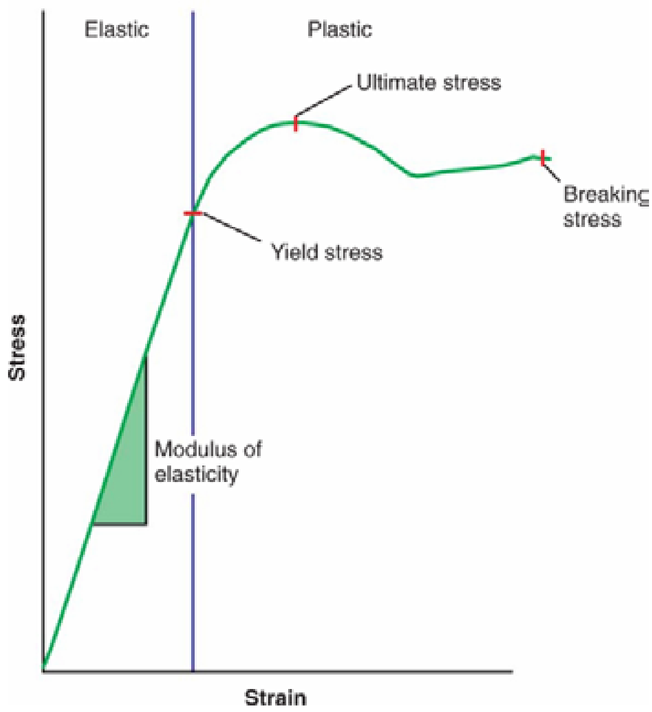


Fig 8: stress strain curve

Material properties are defined geometrically in the stress-strain curve. The stress is defined as load per unit area and strain is the change in length divided by the original length. The slope of this curve is called "Modulus of Elasticity" (Young's Modulus). It is the constant proportionality between the stress and strain. It is a material property. A material with a high modulus is stiff, i.e. for high stress, little strain is produced. Titanium has more strength because of low modulus.[41]

STRENGTH

It is the stress at which the implant fails. The yield strength is at which the implant undergoes plastic deformation. The structural characteristics and mechanical factors important in the design and evaluation of IM implants are: strength, stiffness and rigidity. Fatigue failure occurs when an implant is cyclically loaded to a certain stress level. IM nails are designed to share the load with the bone for a limited period. They are designed to bear significant loads for few million cycles, until the fracture unites.

Results of fatigue and single cycle tests show that locking mechanisms and stress concentrators at critical locations on the nail. These critical stress concentrators reduced the strength of all devices far below the working length strength.

Working length is defined as the length of a spanning the fracture site from its distal point of fixation in the proximal fragment to its proximal point of fixation in the distal fragment. A less technical definition state that it is the distance between the two points on either side of fracture where the bone firmly grips the metal. Thus, working length is the unsupported portion of the nail between the two major bone fragments and reflects the length of nail carrying the majority of the load across the fracture site[41].

The bending stiffness of a nail is inversely proportional to the square of its working length while the torsional stiffness is inversely proportional to its working length. Shorter working length means stronger fixation.

Working length is affected by various factors. A nail has a shorter working length in fixation of a transverse fracture than in stabilizing a comminuted fracture.[41]

Interlocking fixation is defined as dynamic, static, and double-locked. Dynamic fixation controls bending and rotational deformation, but allows nearly full axial load transfer by bone. Dynamic fixation is used in axially stable fractures and some non-unions.

Static fixation controls rotation, bending, and axial load and makes the implant a more load-bearing device with the potential for a reduced fatigue life. It is especially useful in comminuted, nonisthmal fractures of the femur and tibia.

The double-locked mode controls bending, rotational forces, and some axial deformation, but because of the capability of axial translation of the screw within the nail, some shortening is possible[40]

Dynamization:

Dynamization refers to the conversion of a statically locked intramedullary nail to a dynamically locked nail by the removal of either the proximal or distal cross screws. Court-Brown et al reported that dynamization seemed to have little effect on the speed of fracture union, and Wu and Shih demonstrated only a 54% success rate in tibial and femoral fractures after dynamization.

Dynamization, however, is useful in reducing any gap that exists between fracture fragments after nailing. Distraction is associated with nonunion, and the conversion of a static to a dynamic fix may reduce the distraction. Care must be taken in proximal and distal fractures not to remove the cross screws too early, as a malunion may result.[42]

COMPLICATIONS OF INTRAMEDULLARY INTERLOCKING NAILING OF TIBIA

I. During surgical technique (immediate)

a) Fracture comminution

b) Incarceration of the nail

c) Improper fixation

d) Vertical splitting of tibia

e) Skin trauma

f) Shock

II. During postoperative period (early)

a) Compartment syndrome

b) Tourniquet palsy

c) Thromboembolism

d) Infection

e) Fat embolism

III. During follow-up (late)

a) Tibial eminence avulsion

b) ACL injury

c) Infected non-union

d) Aseptic non-union

e) Breakage of implant either nail or screw

f) Nail migration into ankle or knee

g) Delayed union

h) Malunion

I) Shortening

METHODOLOGY

Source of Data

The present study was undertaken at the Department of Orthopaedics, R.L.J Hospital attached to Sri Devaraj urs medical college and Research Centre, kolar, Karnataka.

30 patients who had isolated tibial shaft fractures were treated with closed intramedullary interlocking nailing, during period from July 2013 to December 2015.

This prospective study was done over a period of 2 ½ years with regular follow-up.

METHOD OF COLLECTION OF DATA

Sample size: 30 cases meeting criteria for the present study.

Sampling size: Simple random sampling

All cases presenting to the outpatient and fulfilling the below mentioned criteria were taken up for the study.

Inclusion Criteria

1. Closed tibial fractures with intact fibula.
2. Open fractures of tibia with intact fibula, Type I, Type II, TYPE IIIA as classified by Gustillo-Anderson grading.
3. Tibial fractures in the age group above 18years.

Exclusion Criteria

1. Open diaphyseal fractures of tibia Type III B, C. (Gustillo- Anderson)
2. Tibial fractures with Intraarticular extensions.
3. Pathological fractures.

On admission general condition of the patient was assessed with regards to hypovolemia, associated Orthopaedic or systemic injuries and resuscitative measures taken accordingly. All patients received analgesia in the form of IM and antibiotics IV for open fractures. A thorough clinical examination was performed including detailed history relating to age, sex, occupation, mode of injury, past and associated medical illness.

The limb was immobilized in the form of above knee plaster of Paris posterior slab. Limb elevation over a pillow was given to all patients.

Routine investigations were done for all patients. All patients were evaluated clinically and radiologically to assess injuries. X-rays were taken in two planes: AP view and lateral view. Patients were operated as early as possible once the general condition of the patient was stable and was fit for surgery.

Pre operatively the length of the nail is calculated by measuring from just above the tibial tuberosity to the medial malleolus. Medullary canal is measured at the isthmus on X-ray for nail diameter. Accordingly a stock of interlocking nails 2 cm above and below the measured length and 1 mm above and below the required diameter were kept.

PREOPERATIVE PREPARATION

- Patients were kept nil per oral for 8 to 10 hours before surgery.
- Preparation of whole extremity/private parts and back was done.
- Written informed consent was taken.
- Soap water enema.
- Tranquilizers
- Adequate amount of compatible blood if needed was arranged.
- IV antibiotics half an hour before surgery.

Determination of Nail Length: Measurement is especially important for very tall or very short patients who may require a nail either longer or shorter than is commonly kept in inventory. The most accurate method for determining correct nail length of four methods tested (full-length scanograms, “spotograms,” acrylic template overlays, and tibial tubercle–medial malleolar distance [TMD]) was the TMD.

The TMD is determined by measuring the length between the highest (most prominent) points on the medial malleolus and the tibial tubercle. The TMD is an easy, inexpensive, and accurate method of preoperative determination of correct nail length. The diameter of the nail is assessed by measuring the tibia at its narrowest point, which is best appreciated on lateral radiographs.

Determination of Nail Diameter: The diameter of nail is assessed by measuring the tibia at its narrowest point, which is best appreciated on lateral roentgenograms.

SURGICAL TECHNIQUE:

Patients were operated under spinal / general anesthesia. Patient is placed in supine position over a radiolucent operating table. The injured leg is positioned freely, with knee flexed 90^0 over the edge of operating table to relax the gastro soleus muscle and allow traction by gravity.

The uninjured leg is placed in abduction, flexion and external rotation to ensure free movements of the image intensifier from A.P. to lateral plane. The table is adjusted to a comfortable operating height.

Pneumatic tourniquet was used in all patients. The affected limb is thoroughly scrubbed from mid – thigh to foot with Betadine scrub and savlon. Then limb is painted with betadine solution from mid-thigh to foot. Rest of the body and other limb is properly draped with sterile drapes. Sterile gloves are applied to the foot and sterile – drape over the leg from knee joint to ankle.

Measurement of rotation:

Measure the amount of tibial torsion in the uninjured extremity with the knee fully extended and a C-arm image intensifier placed in the lateral position with the beam parallel to the floor.

Rotate the leg until a perfect lateral view of the distal femur is obtained with the condyles superimposed exactly. Hold the knee and foot in this position while the C-arm is brought into the antero posterior position with the beam perpendicular to the floor to image the ankle.

Rotate the C-arm until a tangential image of the inner surface of the medial malleolus is seen. This is the reference line at the ankle. Tilt the beam cranially 5 degrees to obtain a better image of the ankle. Center the structures to be imaged in the radiographic field. The amount of tibial torsion is equal to the difference between the reference line at the ankle and a line perpendicular to the floor.

If the tangential view of the medial malleolus is obtained with the C-arm rotated laterally 10 degrees from perpendicular, tibial torsion is 10 degrees. Alternatively, rotational alignment can be obtained by aligning the iliac crest, patella, and second ray of the foot. Close attention to operative technique can greatly decrease the risk of complications after tibial nailing

Reduction techniques:

According to AO principles, Diaphyseal fracture of tibia can be reduced manually, with percutaneous forceps, with the large distractor, or with an extra wide tourniquet. Once leg is draped, fresh fracture can often be reduced by manual traction, while the reaming rod or nail is passed across fracture gap. If little or no traction is needed, percutaneously placed pointed reduction clamps or an extra wide tourniquet can reduce and hold fracture for nail insertion.[44]

The fracture should be held well reduced while passing the nail into the distal fragment, which is considered as an important step. The advantages of not reaming the distal fragment and also getting the nail till the sub articular bone is that the nail is impacted well into the Cancellous bone of the lower metaphysis of the tibia which gives added angulatory and translator stability when augmented with two to three distal locking screws. If two distal locking screws were used, we preferred to use them at right angle to each other.[45]

NAIL PLACEMENT:

Begin the entry portal by making a 5-cm incision along the medial border of the patellar tendon, extending from the tibial tubercle in a proximal direction. It may be necessary to extend the incision farther proximally through skin and subcutaneous tissue only to protect the soft tissues around the knee during reaming and nail insertion

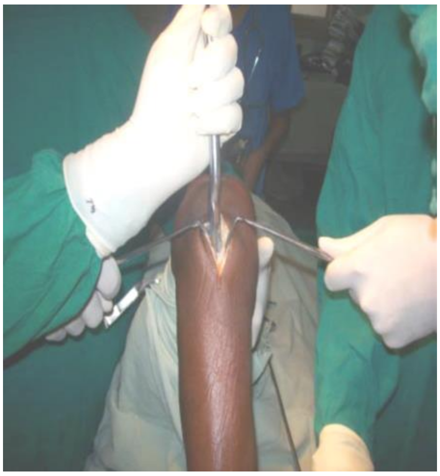


Fig 9: awl insertion

Insert a curved awl through the metaphysis anteriorly to gain access to the medullary canal (fig 9). Place the tip of the awl proximal to the tibial tubercle at the level of the tip of the fibular head (approximately 1.5 cm distal to the knee joint) and in line with the center of the medullary canal on the anteroposterior view.

Confirm proper position on anteroposterior and lateral fluoroscopic views before awl insertion. Obtain a true anteroposterior view of the tibia when assessing the placement of the awl. If the limb is externally rotated, the portal may be placed too medially and violate the tibial plateau and injure the intermeniscal ligament. A portal placed too distally may damage the insertion of the patellar tendon or cause the nail to enter the tibia at too steep of an angle, which may cause the tibia to split or cause the nail to penetrate the posterior cortex.

Check the process of Awl Insertion on lateral fluoroscopic views. The safe zone for tibial nail placement is just medial to the lateral tibial spine on the anteroposterior view and immediately adjacent and anterior to the articular surface on the lateral view.

Direct the awl nearly perpendicular to the shaft when it first penetrates the cortex, but gradually bring it down to a position more parallel to the shaft as it is inserted more deeply to prevent violation of the posterior cortex. The entry portal also can be made by inserting a Kirschner wire into the anterior tibia and reaming over it with a rigid reamer.

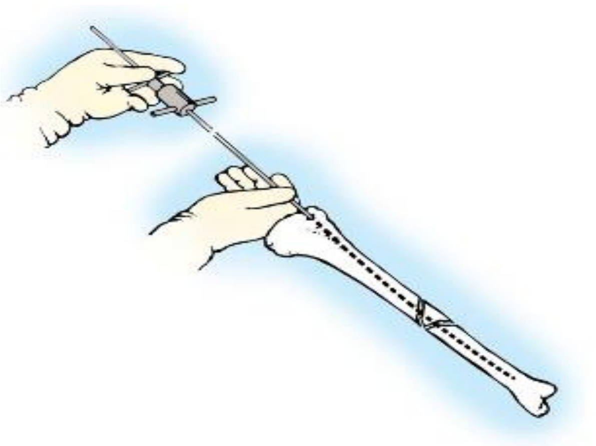


Fig 10: Reduction of fracture with guide rod

Insert a ball-tipped guide wire (fig 10) through the entry portal into the tibial canal, and pass it across the fracture site into the tibia under fluoroscopic guidance.

The guide rod should be centered within the distal fragment on anteroposterior and lateral views and advanced to within 1 cm to 0.5 cm of the ankle joint.

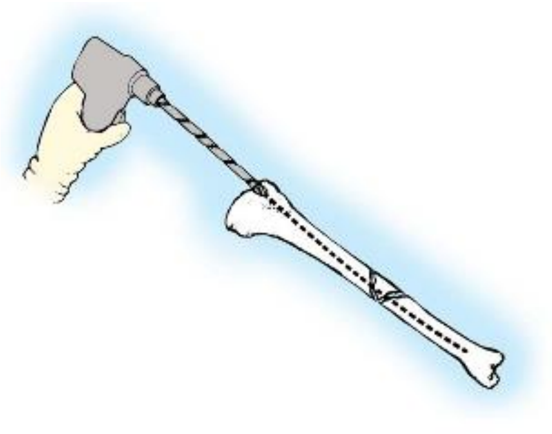


Fig 11: reaming of tibia

If a reamed technique is chosen, ream the canal in 0.5-mm increments, starting with a reamer smaller than the measured diameter of the tibial canal (fig 11). Ream with the knee in flexion to avoid excessive reaming of the anterior cortex. Hold the fracture reduced during reaming to decrease the risk of iatrogenic comminution. Prevent the guide rod from being partially withdrawn during reaming. We prefer “minimal” reaming, with no more than 2 mm of reaming after cortical contact was initiated. Other traumatologists believe that 4 mm of cortical Contact is acceptable.

Choose a nail diameter that is 1 to 1.5 mm smaller than the last reamer used. Ream the entry site large enough to accept the proximal diameter of the chosen nail. It is important never to ream with the tourniquet inflated because this may lead to thermal necrosis of bone and soft tissue, especially in individuals with small-diameter medullary canals.

If an unreamed technique is chosen, ream only the cancellous bone of the entry portal to accommodate the proximal portion of the nail. The canal diameter can be determined in open fractures after debridement by passing sounds of different sizes through the fracture site and across the isthmus.

Alternatively, flexible reamers or flexible sounds can be manually pushed without power through the entry portal and across the isthmus. The largest sound or reamer that can be inserted without excessive force corresponds to the correct nail diameter.

Canal diameter also can be measured radiographically, but is less accurate. Never insert a nail with a diameter larger than the canal. It also is important not to undersize the nail because a loose-fitting nail would be less stable, and the smaller implants are not as strong and may be more prone to hardware failure. In general, the largest implant suitable for a given patient should be used.

When reaming is completed, exchange the ball-tipped guide rod for one with a smooth tip for nail insertion. Solid nails are inserted without a guide wire. Determine the length of the nail by placing the tip of a guide wire of the same length at the most distal edge of the entry portal. Subtract the length of the overlapped portions of the guide rods from the full length of the guide rod to determine the length of the nail, making sure the fracture is held out to length during this measurement. A radiopaque ruler also can be used to measure the distance between the anterior edge of the entry portal and a point 0.5 to 1 cm proximal to the ankle joint.

The fluoroscopic beam must be perpendicular to the tibial shaft to obtain an accurate measurement. When the ruler is properly placed over the distal tibia under fluoroscopic guidance, it should not be moved until the measurement is taken. A hemostat placed at the distal edge of the entry portal ensures a more accurate reading. Comminuted fractures may require preoperative radiographic measurement of the contralateral tibia to assess length properly. Approximately 5 mm should be subtracted from the measured length to allow countersinking of the nail.

Attach the insertion device and proximal locking screw guide to the nail. Direct the apex of the proximal bend in the nail posteriorly, and mount the drill guide to direct screws from medial to lateral. Some nail systems use oblique proximal locking screws, which are directed anteromedial to posterolateral and anterolateral to posteromedial. Insert the nail with the knee in flexion (except in some proximal third fractures) to avoid impingement on the patella.

Evaluate rotational alignment by aligning the iliac crest, patella, and second ray of the foot. Tremendous force should not be necessary to insert the nail. Moderate manual pressure with a gentle back-and-forth twisting motion usually is sufficient for nail insertion. If a mallet is used, the nail should advance with each blow. If the nail does not advance, withdraw the nail, and perform further reaming or insert a smaller diameter nail. It is important to keep the fracture well aligned during nail insertion to prevent iatrogenic comminution and misalignment.

When the nail has passed well into the distal fragment, remove the guide wire to avoid incarceration, and during final seating of the nail, release traction to allow impaction of the fracture. Do not shorten fractures excessively with segmental Comminution. When the nail is fully inserted, the proximal end should lie approximately 0.5 to 1 cm below the cortical opening of the entry portal. This Position is best seen on a lateral fluoroscopic view.

If the nail protrudes too far proximally, knee pain and difficulty with kneeling may result. Excessive countersinking also should be avoided because it makes nail removal more difficult. The distal tip of the nail should lie approximately 0.5 to 2 cm from the subchondral bone of the ankle joint. Distal fractures require nail insertion near the more distal end of this range.

Insert proximal locking screws using the jig attached to the nail insertion device. Place the drill sleeve through a small incision down to bone. Measure the length of the screw from calibrations on the drill bit. The screw should protrude approximately 5 mm beyond the far cortex to enable the screw to be removed more easily if breakage occurs. Use two proximal locking screws in most fractures. Tighten all connections between the insertion device, drill guide, and nail before screw insertion.

Perform distal locking by using a freehand technique after “perfect circles” are obtained by fluoroscopy. In the lateral position, adjust the fluoroscopic beam until it is directed straight through the distal screw holes and the holes appear perfectly round.

Place a drill bit through a small incision overlying the hole, and center the tip in the hole. Taking care not to move the location of the tip, bring the drill bit in line with the fluoroscopic beam, and drill through the near (medial) cortex. Detach the drill from the bit, and check the position of the drill bit with fluoroscopy to ensure that it is passing through the screw hole. When proper position is confirmed, drive the drill bit through the far (lateral) cortex.

Measure the screw length using drill sleeves and calibrated bits, or check the anteroposterior view on the fluoroscopy screen, using the known diameter of the nail as a reference for length.

After screw insertion, obtain a lateral image to ensure the screws have been inserted through the screw holes. Two distal locking screws are used in most fractures.

Some nail systems have the option of placing an anteroposterior distal locking screw. “Perfect circles” are obtained in the anteroposterior fluoroscopic view. Do not injure the anterior tibial tendon or nearby neurovascular structures. Make an incision medial to the anterior tibial tendon, and retract the tendon laterally as necessary to allow the drill bit to be centered over the screw hole. A drill sleeve protects the tendon further.

Before interlocking, inspect the fracture site for possible distraction. If the fracture is distracted, place the distal locking screws first.

After distal locking is complete, impact the fracture by carefully driving the nail backward while watching the fracture site under fluoroscopy. Keep the knee flexed until the nail insertion instruments are removed to avoid damage to the soft tissues around the patella.

Most nails are statically locked. Minimally comminuted transverse diaphyseal fractures can be dynamically locked; however, comminuted or metaphyseal fractures should be statically locked. If there is any question about stability, perform static locking. Because the nail may not prevent misalignment of unstable fractures before it is locked, it is crucial to maintain accurate reduction until proximal and distal locking is complete.

Incised wound is washed with betadine and normal saline, wound sutured in layers. Sterile dressings applied over the wound. Compression bandage given. Tourniquet is deflated. Capillary filling and peripheral arterial pulsations checked.

Fig. 12: Instruments and Implants for IM nailing

PHOTOS OF OPERATIVE PROCEDURE

Figure 13: Patient positioning

Figure 14: Incision

Figure 15: Entry point

Figure 16: AWL insertion

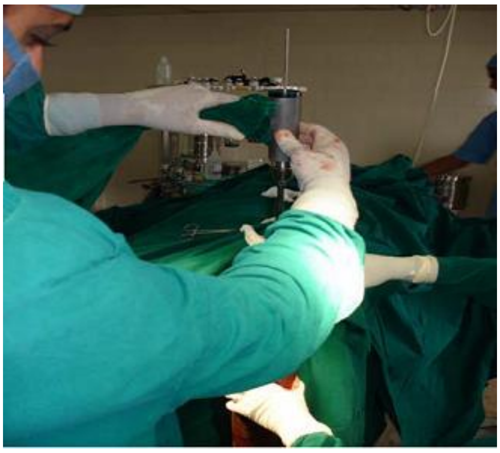


FIG 17: Guide wire insertion

FIG 18: Reaming

FIG 19: Nail inserted with reduced fracture

FIG 20: Proximal locking

Post-Operative Care:

Immediate:

- NBM 4-6 hours post operatively
- IV fluids / blood transfusions
- IV antibiotics
- IM analgesics
- Limb elevation over pillows
- Watch for active bleeding
- Active toe movements
- TPR / BP chart every hourly
- Input / output chart
- Check X-ray of the operated tibia (full length) including knee and ankle joints in both AP and lateral view.

Post operatively creepe bandage applied and the limbs elevation over pillows. I.V antibiotics is given for 5 days postoperatively. Culture from the wound if necessary sent. Switch over the oral antibiotics is done on the 5th postoperative day. Analgesics if required given. Active knee, ankle and toe mobilization started after over come from anesthesia.

Patient was allowed non – weight bearing crutch walking / walker on next post-operative day if associated injuries permits, general condition and tolerance of patient. Skin sutures were removed on 14 the postoperative day.

Depending upon the culture report and wound condition antibiotics are stopped / continued. Partial weight bearing crutch walking / walker commenced depending upon the type of fracture, rigidity of the fixation and associated injuries.

Further follow up was advised at 6 weekly intervals at 6th, 12th, 18^{th}, 24^{th} weeks after discharge. Each patient is individually assessed clinically and radiographically according to the proforma.

RESULTS

The present study includes 30 fractures of isolated tibial shaft surgically treated with closed intramedullary interlocking nailing during period from July 2013 to December 2015 in the Department of Orthopaedics, R.L.J Hospital attached to Sri Devaraj urs medical college and Research Centre, kolar, Karnataka. All the patients were available for follow-up. Period of follow-up was 6 to 8 months.

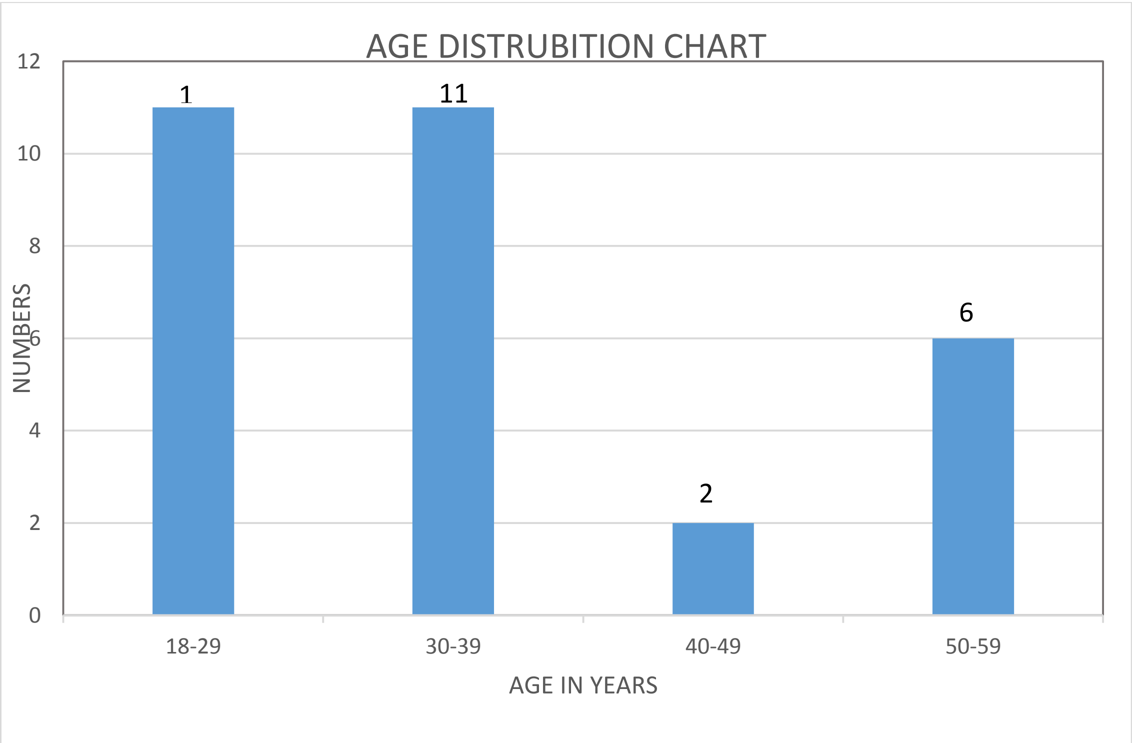
1. Age distribution

Table 1: Age distribution

AGE (years)	No. of cases	Percentage
18-29	11	36.7%
30-39	11	36.7%
40-49	2	6.6%
50-59	6	20%
TOTAL	30	100 %

Majority of patients are from age group 18-39years (73.3%). The youngest patient was 19 years old and oldest patient was 58 years old. Majority of nonunion cases were elderly with open type 2 fractures, these patients are also having co – morbidities of diabetes mellitus and hypo-proteinuria.

Figure 21: Graph showing age distribution

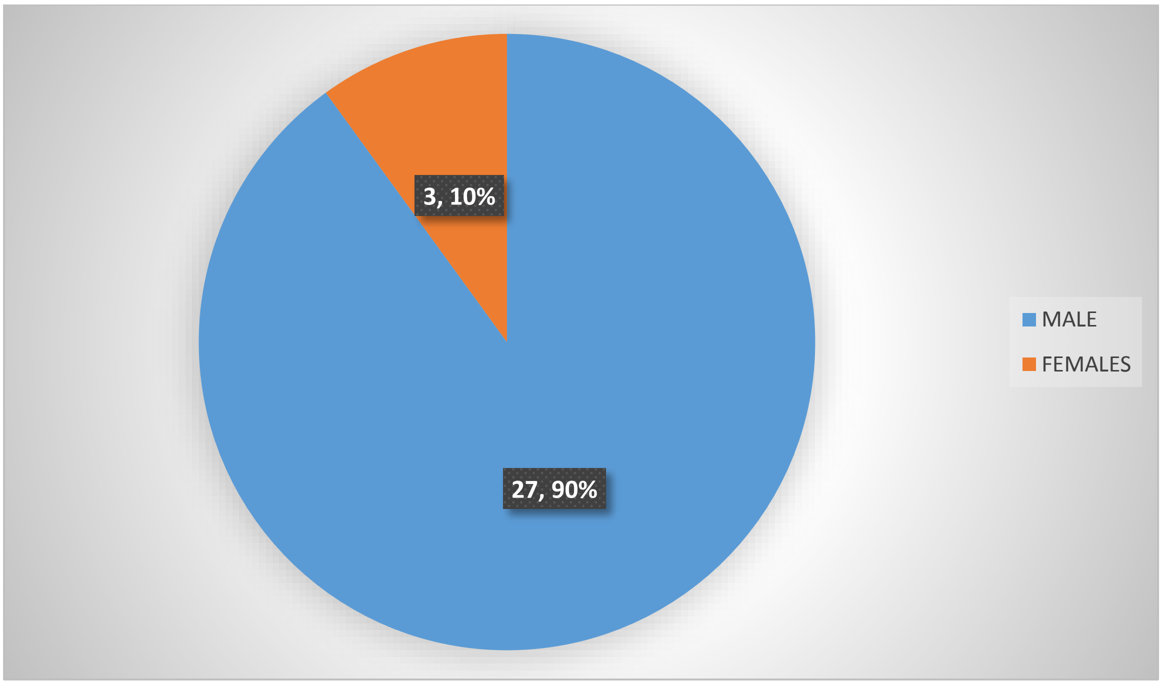


2. Sex distribution

Table 2: Sex distribution

GENDER	NO. OF CASES	PERCENTAGE
MALE	27	90
FEMALES	3	10
TOTAL	30	100

Figure 22: Pie chart showing sex distribution



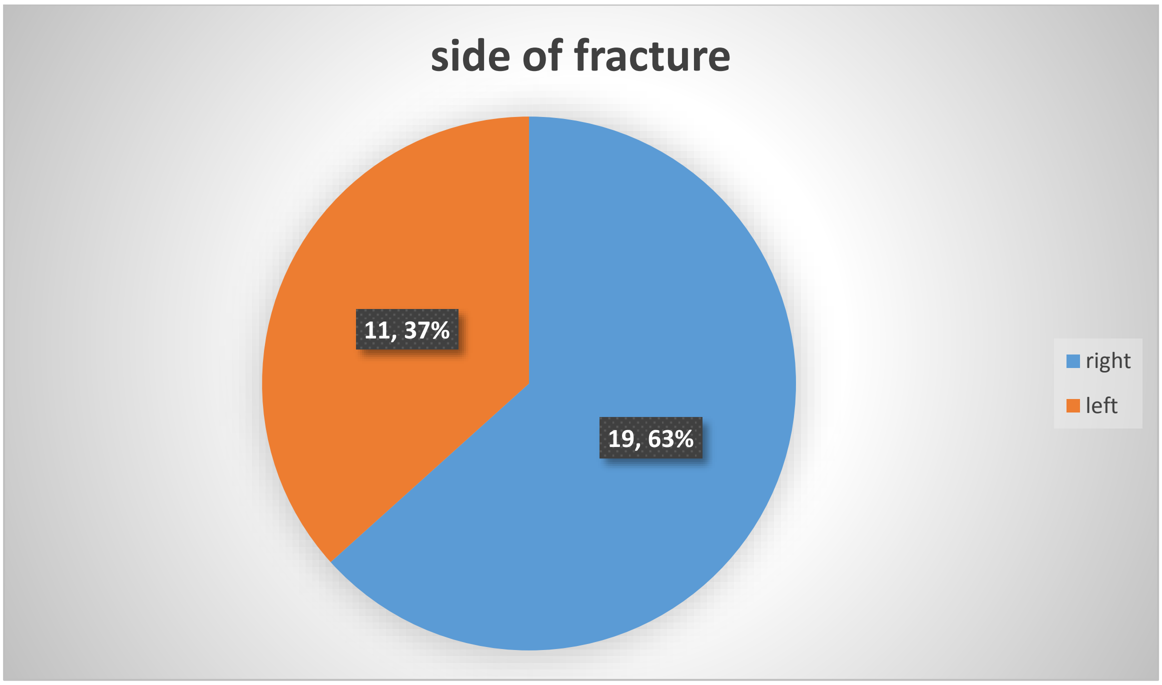
Majority of patients (90%) are males. The remaining (10%) patients are females.

3. **Side of fracture**

Table 3: Side of fracture

SIDE	NO. OF CASES	PERCENTAGE
Right	19	63.3%
Left	11	36.6%
Total	30	100%

Figure 23: Pie chart showing side of fracture



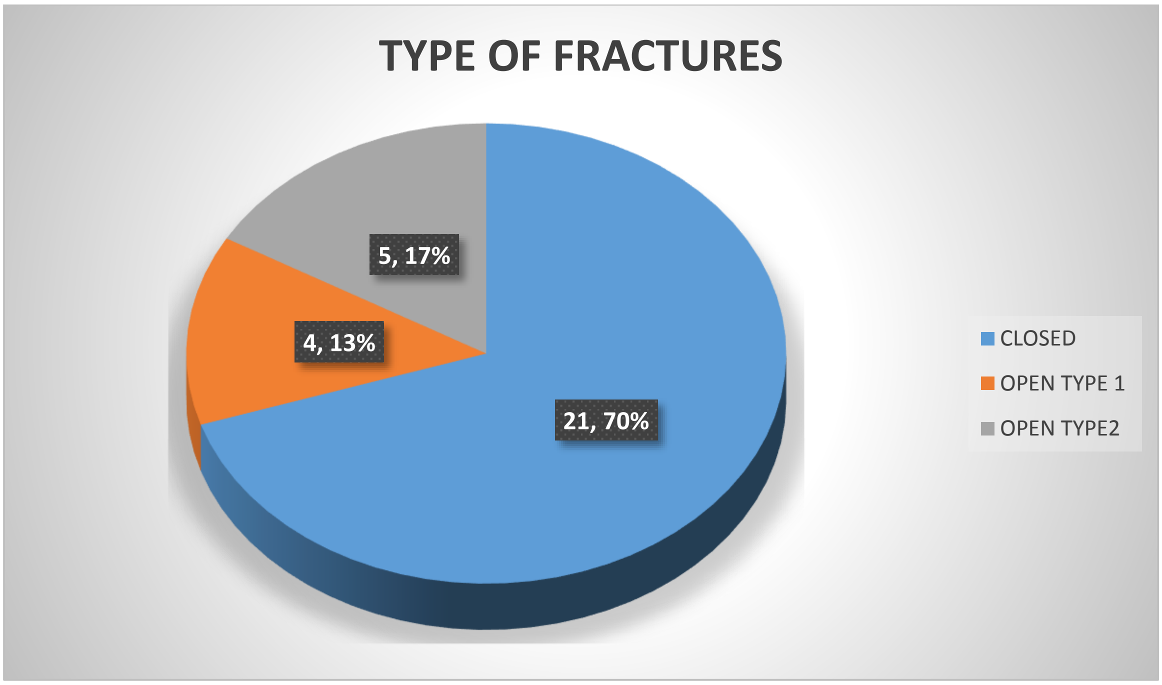
Right tibial fractures in our study constitutes 63% and left are 37%.

4. Type of fracture

Table 4: Type of fracture

TYPE	NO. OF CASES	PERCENTAGE
CLOSED	21	70%
OPEN TYPE 1	4	13.3%
OPEN TYPE 2	5	16.6%
TOTAL	30	100%

Figure 24: Pie Chart showing type of fractures



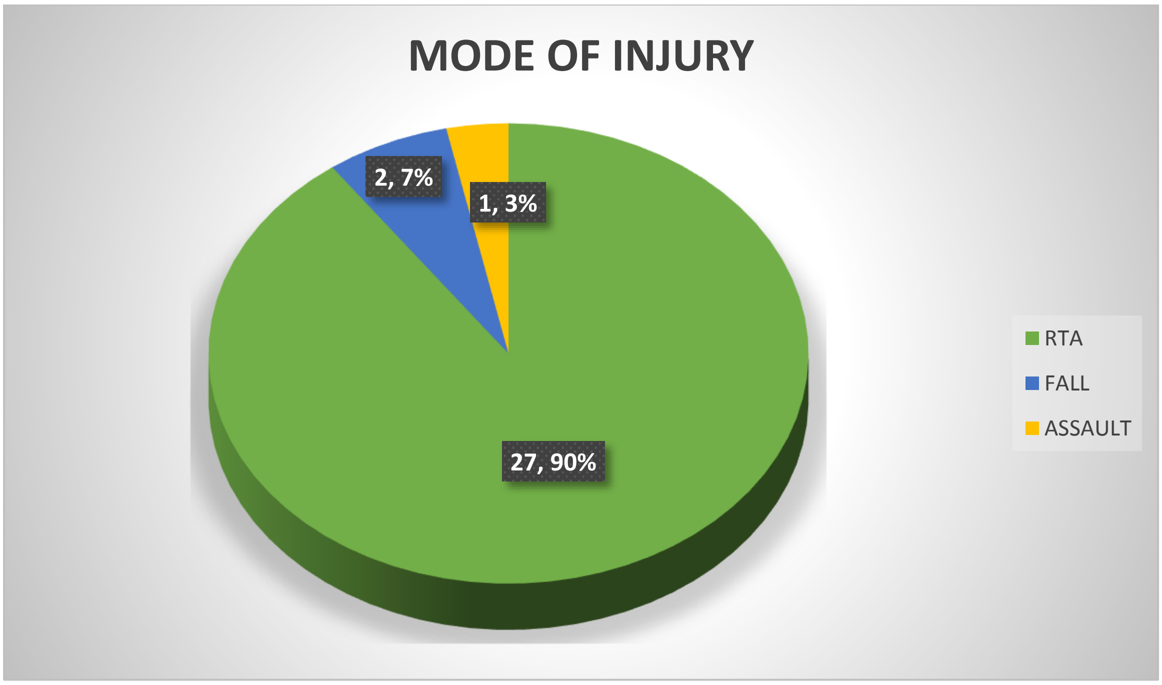
In our series, there were 21 Closed fracture out of 30 cases (70%), 4 open Type I fractures (13%) and 5 open Type II fractures (17%).

5. Mode of injury

Table 5: Mode of injury

MODE OF INJURY	NO. OF CASES	PERCENTAGE
RTA	27	90 %
FALL	2	6.6 %
ASSAULT	1	3.3 %
TOTAL	30	100 %

Figure 25: Mode of injury



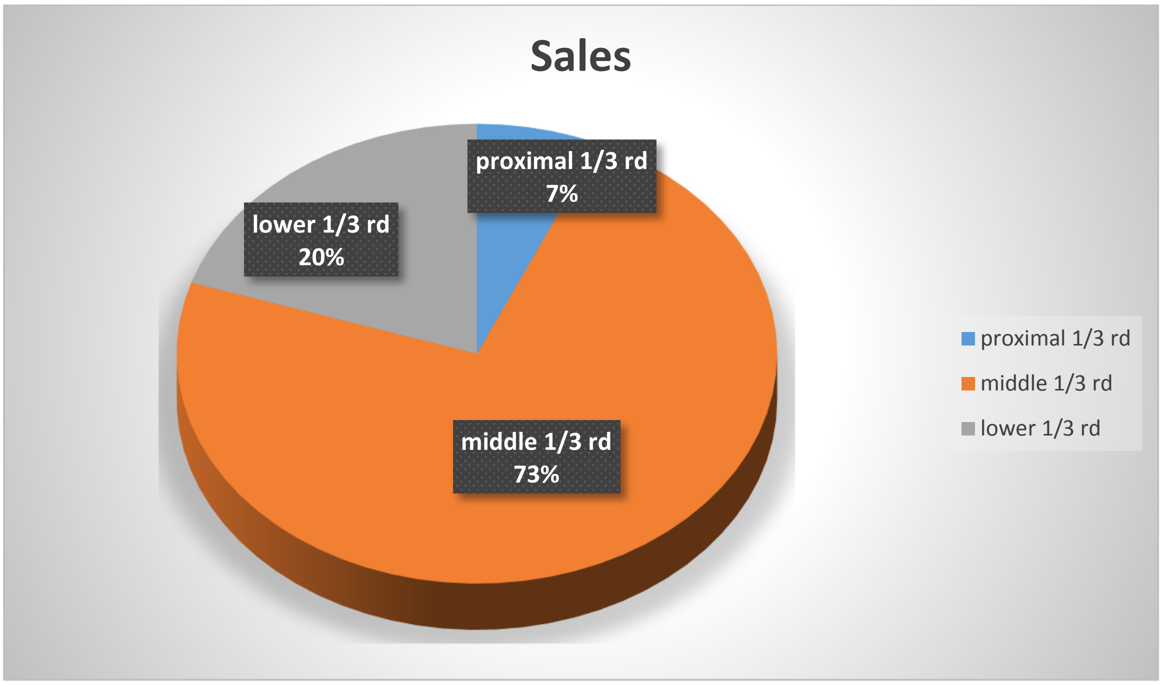
In our study, road traffic accident was the major cause for tibial fracture and it constituted 90% of cases. Second common mode of injury was fall from height and it was 7%, and third type was assault which was 3%.

6. Level of fracture

Table 6: Level of fracture

LEVEL	**NO OF CASES**	PERCENTAGE
proximal 1/3 rd.	2	6.7
Middle 1/3 rd.	22	73.3
distal 1/3 rd.	6	20
TOTAL	30	100

Figure 26: Pie chart showing level of fracture



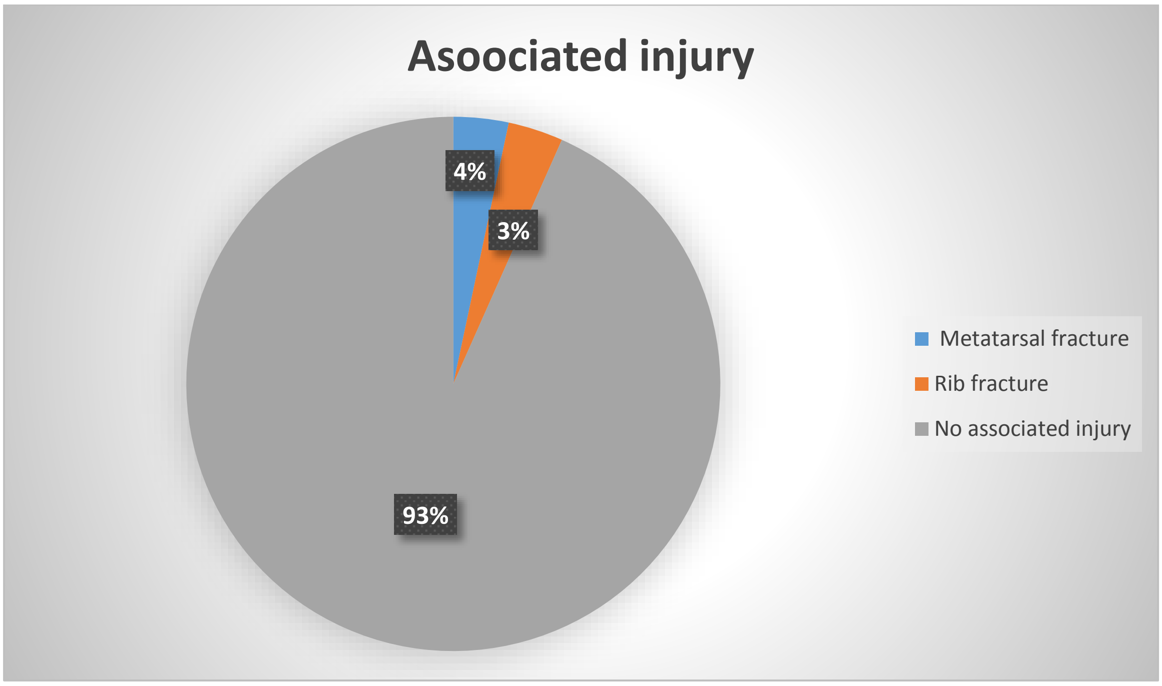
Most of the cases are middle one-third fractures (73%). Next common level of fracture in tibia in our study is lower one-third (20%). Upper one-third is 7%.

7. **Associated injuries**

Table 7: Associated injuries

ASSOCIATED INJURY	**NO. OF CASES**	**PERCENTAGE**
Metatarsal	1	3.3
Rib fracture	1	3.3
No associated injury	28	93.3

Figure 27: Chart showing associated injuries



In our study, one had opposite side metatarsal fracture which was fixed with k wire, another one had rib fracture treated conservatively, Rest 28 patients had no associated injuries.

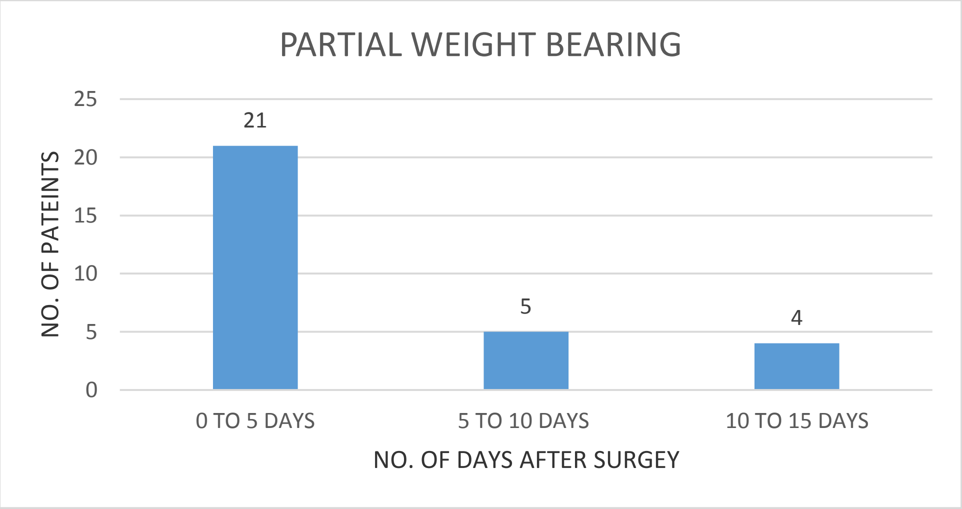
8. Commencement of Partial Weight Bearing (PWB)

Table 8: Commencement of PWB

PWD (DAYS)	NO. OF CASES	PERCENTAGE
0 TO 5	21	70%
5 TO 10	5	16.7%
10 TO 15	4	13.3%
TOTAL	30	100%

In our study most of the cases are mobilized (Partial weight bearing with crutch walking) on next day after operation. Majority of the patients, 21 out of 30 (70%) started partial weight bearing with help of walker within 5 days from date of surgery, 5 patients out of 30 (17%) started partial weight bearing between 5 and 10 days because of pain at operated site, 4 patients out of 30 (13%) started partial weight bearing after 10 days because of stability of fracture (communited) and patient noncompliance.

Figure 28: Commencement of PWB

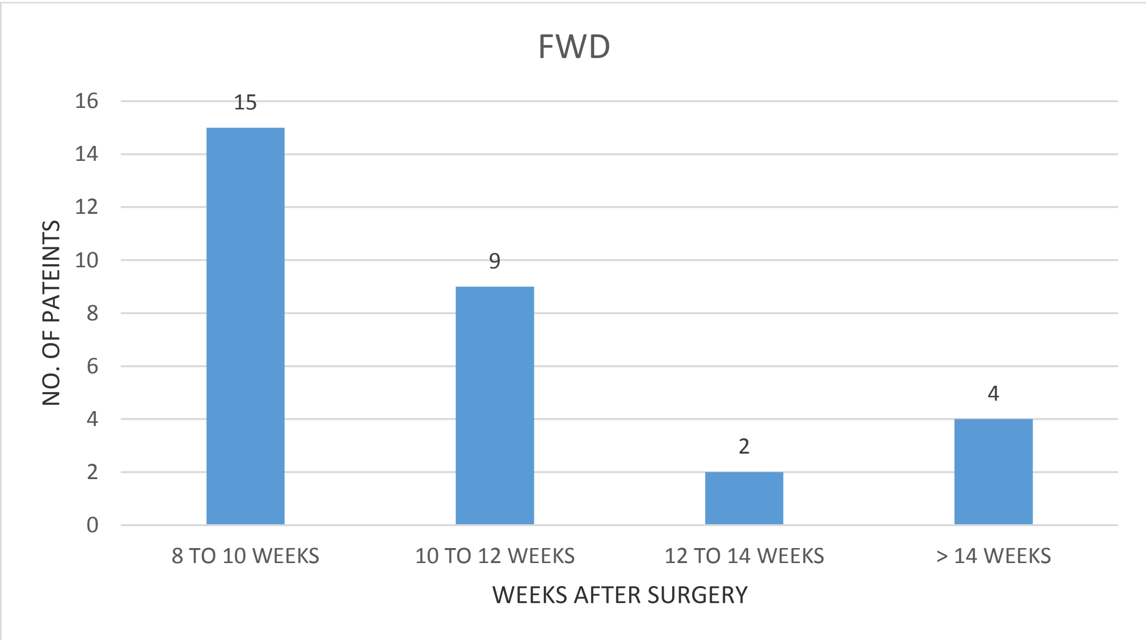


9. Commencement of full weight bearing (FWB)

Table 9: Commencement of full weight bearing

FWD (WEEKS)	NO. OF CASES	PERCENTAGE
8 TO 10	15	50%
10 TO 12	9	30%
12 TO 14	2	6.7
>14	4	13.3
TOTAL	30	100

Figure 29: Commencement of full weight bearing



Most of the patients 27 (90%) in our study commenced protective FWB between 8 and 14 weeks. Four patients (10%) commenced FWB after 14 weeks. In these 2 patients, there were no signs of union radiologically and clinically. So FWB was delayed. Two patients had deep infection with infected non-union.

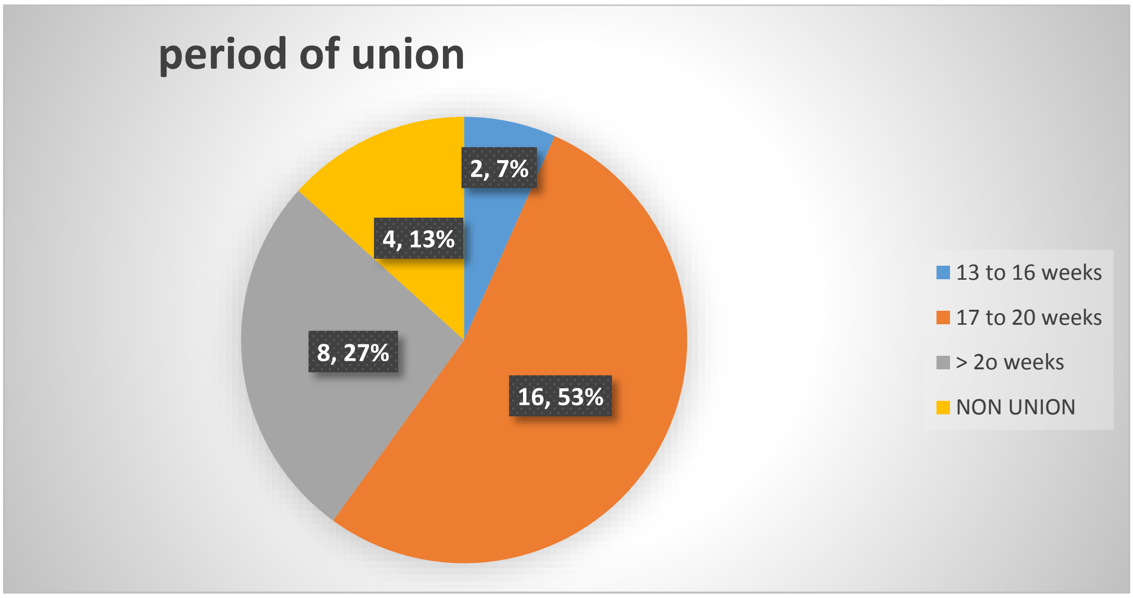
10. PERIOD OF UNION

TABLE 10: Union in relation to type of fracture

Duration in weeks	Closed	Open type 1	Open type 2	Total
O TO 12 WEEKS	0	0	0	0
13 TO 16 WEEKS	2	0	0	2
17 TO 20WEEKS	16	1	0	17
> 20 WEEKS	3	3	1	7
NON UNION	0	0	4	4

Union[45] is defined as the presence of bridging callus on three or more cortices of radiographic views and the ability of the patient to bear full weight on the injured extremity. 26 of 30 fractures united, so percentage of union rate in our study was 87%. The time for union ranged from 4 -9 months with an average of 5 months. 17 fractures healed before 5 months (20 weeks), 7 fractures healed between 5 and 8 months (20 to 32 weeks). 4 fractures failed to unite after 9 months.

Fig 30: period of union



11. DELAYED UNION

Delayed union[45] was defined when there was no adequate callus formation even after 20 to 24 weeks and patients inability or difficulty in partial or full weight bearing. In our study 7 out of 30 cases went for delayed union which is around 23%. All delayed union were managed successfully with secondary dynamization and bone marrow injection.

12. NON-UNION

US Food and Drug Administration Panel defined non-union as "established when a minimum of 9 months has elapsed since injury and the fracture shows no visible progressive signs of healing for 3 months". This criteria cannot be applied to every fracture. However, a fracture of the shaft of a long bone should not be Considered as a non-union until at least 6 months after the injury because often union requires more time, especially after some local complications such as an infection.

Open fractures with severe soft tissue injury had developed infection and, which was the cause for nonunion. In the present study 4 cases went for non-union. Majority of nonunion cases were elderly with open type 2 fractures, these patients are also having co – morbidities of diabetes mellitus and hypo-proteinuria. Initial displacement can also be the reason for nonunion. All these cases are managed with antibiotics based on culter sensitivity from wound site, once infection controlled secondary dynamization and bone grafting was advised.

13. RANGE OF MOTION

One of the essential aspects of closed reduction and internal fixation with Interlocking intramedullary nailing is the ability to mobilize the joints early.

a. Knee motion

In 26 out of 30 patients had full range of knee motion ($0 – 130^0$) gained at 12 weeks. In 3 patients > 80% of knee range of motion (up to 105^0) was noted, in 1 patients >75% of knee range of motion (up to 95^0) was noted.

b. Ankle motion

In 21 out 30 patients had full range of ankle motion (Dorsiflexion $0 - 20^0$, plantar flexion $0 – 50^0$) gained at 12 weeks, in 9 patients > 75% range of ankle motion was noted.

14. INFECTION

Two patients developed superficial infection. This healed with oral antibiotics, four patients developed deep infection and treated with antibiotics based on pus culture sensitivity. All four fractures had gone into non-union

In our study, 4 patients had poor results. These 4 patients were Type II open fractures treated with primary intramedullary nailing. Open fracture had led to chance of infection which has gone into nonunion and along with fracture pattern.

Because of infection patients were delayed for partial weight bearing and full weight bearing. So they developed quadriceps wasting and their knee and ankle range of movements are also restricted.

15. FAILURE OF IMPLANT

In current study no failure of implant was observed.

16. KNEE PAIN

In our study, 8 out of 30 patients (26%) developed anterior knee pain. In our study cause for knee pain was unclear. But the probable causes were nail prominence above the proximal tibial cortex, damage to the infrapatellar nerve.

17. COMPLICATIONS

Complications	No of cases	Percentage
Infection	4	13.3%
Non union	4	13.3%
Anterior knee pain	8	26.7%
Delayed union	7	23.3%

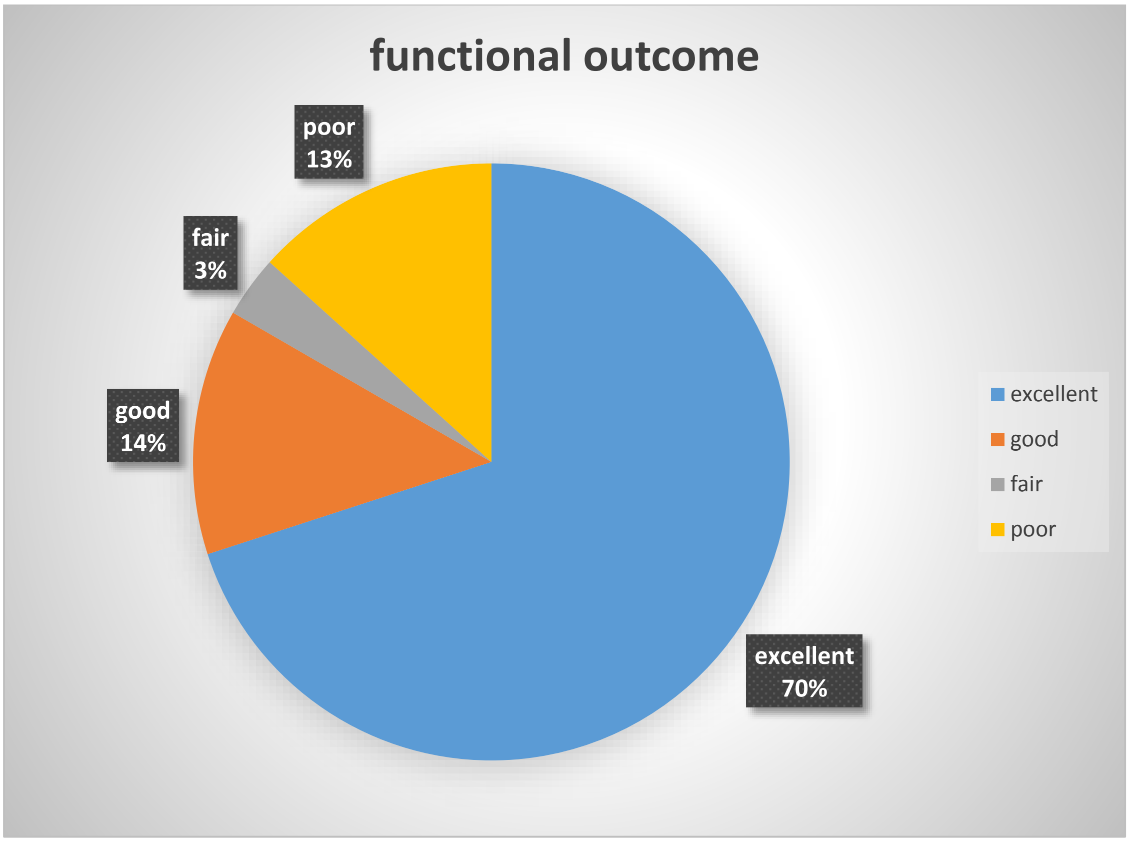
FUNCTIONAL RESULTS (JOHNER AND WRUH'S CRITERIA)

Detailed analysis of function results of patients were done at end 6 months on the basis of following criteria by Johner and Wruh's

Table 11: Functional results (Johner and Wruh's criteria)

	Excellent	Good	Fair	Poor
Nonunion, Ostetitis, amputation	None	None	None	Yes
Neuro-vascular disturbances	none	minimal	moderate	Severe
DEFORMITY				
Varus / Valgus	None	2^0-5^0	6^0-10^0	>10^0
Anteversion / recurvation	0^0-5^0	6^0-10^0	11^0-20^0	>20^0
Rotation	0^0-5^0	6^0-10^0	11^0-20^0	>20^0
Shortening	0-5 mm	6-10 mm	11-20 mm	>20 mm
MOBILITY				
Knee	Normal	>80%	>75%	<75%
Ankle	Normal	>75%	>50%	<50%
Subtalar joint	>75%	>50%	<50%	
Pain	None	Occasional	Moderate	Severe
Gait	Normal	Normal	Insignificant limp	Significant limp
sternuous activities	Possible	Limited	Severely limited	Impossible
No of cases	21	4	1	4

Fig 31: Graph showing Functional results (Johner and Wruh's criteria)



In our present series, 21 out 30 patients had excellent results which correspond to around 70%, 4 patients had good results around14%, 3 patient had fair results around 3%, and 4 patients had poor results around 13%.

DISCUSSION

Our study highlights the importance of intramedullary nailing for the treatment of isolated tibial shaft fractures in midst of various other modalities of treatment which include functional cast bracing, external fixation, internal fixation of plates & screws.

In current series 30 cases of fracture of shaft of the tibia were treated by closed reamed interlocking intramedullary nailing. They were followed up for an average of 6 months. The purpose of this study was to evaluate the end results of treatment in these patients. These cases were of different age groups, occurred in both sexes, and the fracture were of different types and at different levels.

AGE: The average age of all cases in this series was 34.7 years. The fracture is more common in the age group of 18- 39 years. The average age in a different studies as shown in table

Table 12: comparison of age in different studies

Sl.no	Studies	Average Age (years)
1	Lawrence et al[5]	34.9
2	Kelly .A et al[17]	34.4
3	Ferguson et al[16]	33
4	Bonnevialle et al[9]	28
5	Present study	34.7

Active young individuals were the major sufferers.

Sex: There were 27 male and 3 female patients showing male predominance of 90 % in our Series of 30 cases

Table 13: comparison of sex ratio in different studies

Studies	Male	Female
Lawrence et al[5]	56%	44%
Kelly et al[17]	77%	23%
M. Ferguson et al[16]	78%	22%
Bonnevialle et al[9]	73%	27%
Mohan et al[8]	80%	20%
Present study	90%	10%

Working men with outdoor activities are majority**.**

Mode of injury:

27 patients sustain fracture following road traffic accident, 2 patients sustained fracture after a fall, and 1 patient had fracture following assault. Road traffic accidents about 90% are cause for tibial fractures in present series.

Table 14: comparison of mode of injury in different studies

Studies	RTA	FALL
M. Ferguson et al[16]	45%	33%
Bonnevialle et al[9]	66%	5.2 %
Present study	90%	6.6%

High velocity, road traffic accident is the major cause of injury.

Level of fracture: In the present study 22 (73.3 %) of cases were middle one third fractures, followed by 6 (20 %) at level of distal one third and 2 (6.7%) fractures at proximal one third tibial.

Table 15: comparison on level of fracture in different studies

Studies	Proximal 1/3rd	Middle 1/3rd	Distal 1/3rd	Other
M. Ferguson et al[16]	10%	26.6%	56.7%	6.7%
Kelly. et al[17]	o	71.4%	28.6%	-
Bonnevialle et al[9]	5.2%	55.2%	39.4%	-
Present study	6.7%	73.3%	20%	-

Mid diaphyseal fractures were the most commonly involved site.

Union: In present series, 26 out of 30 cases have united with average of 19.2 weeks (16 weeks to 32 weeks), so percentage of union in our study was 87%, In Mohan et al average period of union was 36 weeks, In M.Ferugson et al average period of union was 35.8 weeks

Table 16: comparison on union in different studies

sly no.	**study**	**union (mean)**
1.	Ferguson et al[16]	35.8 weeks
2.	Mohan et al[8]	36 weeks
3.	Present study	19.2

Table 17: comparison table of age, sex, mode of injury & level of injury.

Sl no	**Studies**	**Average Age (years)**	**Sex**		**Mode of injury**		**Level of injury**			**Union** (Mean)
			MALE	FEMALE	RTA	FALL	Proximal 1/3rd	Middle 1/3rd	Distal 1/3rd	
1.	Lawrence et al[5]	34.9	56%	44%	-	-	-	-	-	-
2.	Mohan et al[8]	-	80%	20%	-	-	-	-	-	36 Weeks
3.	Bonnevialle et al[9]	28	73%	27%	66%	5.2%	5.2%	55.2%	39.4%	-
4.	Ferguson et al[16]	33	78%	22%	45%	33%	10%	26.6%	56.7%	35.8 weeks
5.	Kelly .A et al[17]	34.4	77%	23%	-	-	0	71.4%	28.6%	-
6.	Present study	34.7	90%	10%	90%	6.6%	6.7%	73.3%	20%	19.2 weeks

CONCLUSIONS

Active young individuals were the main sufferers in leg fractures, working men with outdoor activities are majority in tibial shaft fractures. High velocity road traffic accidents is the major cause of these fractures among which mid diaphyseal fractures are common site.

Closed intramedullary interlocking nailing is effective mode of treatment in isolated tibial shaft fractures in closed and open type 1 injuries. Isolated tibial shaft fractures with Undisplaced or mini displaced fractures have united well, more displaced factures have gone into delayed union.

Immediate post-operative partial weight bearing and subsequent full weight bearing helps in fracture union.

Open injuries with severe soft tissue injury was the main cause for nonunion, after inter locking nailing. Proximal end of nail prominence above cortex is the major cause for anterior knee pain.

Overall functional results are good with closed intramedullary interlocking nailing for tibial diaphyseal fractures. Intramedullary interlocking nails are the current choice of treatment for isolated tibial shaft fractures which are Undisplaced or minimally displaced fractures as it shows better union rates and early mobilization.

SUMMARY

30 patients who had Isolated Tibial Shaft fractures were surgically treated with closed intramedullary interlocking nailing during period from July 2013 to December 2015 in the Department of Orthopaedics, R.L.J Hospital attached to Sri Devaraj Urs medical college and Research Centre, kolar, Karnataka.

All the cases were fresh fractures and were traumatic in nature. All the patients were available for follow-up for period of 6 to 8 months

Our aim was to treat these fractures by closed interlocking intramedullary Nailing with early mobilization to assess the outcome of interlocking nailing in the treatment of these fractures using Johner and Wruh's criteria and to know whether intact fibula was a good or worst prognostic factor.

The mean age of patients with these fractures was 34.7 years and the maximum patients were in the age group of 18-39 years. Males predominated in our study. Motor vehicle accidents are the main cause of these fractures followed by fall. Most of the fractures occurred at middle 1/3rd of tibia. Only 2 patients had other associated injuries.

All the patients were examined clinically and radiologically, including detail history of pre morbid status and occupation, at the time of admission. Patients fulfilling the inclusion criteria were only included in the study. Patients were operated as early as possible once the general condition of the patient is stable and fit for surgery. For all cases surgery was performed within 2-4 days of trauma.

In all the cases midline patellar tendon splitting approach was used for nail insertion site. Our mean operating time was 90 minutes (Range 100 min to 150 min).

All the patients were mobilized and partial weight bearing was started post operatively as early as possible depending upon the fracture stability, general condition, associated injuries and tolerance of the patient.

19 fractures had united within 5 months of injury and 7 cases of delayed union, which united within 8 months. There was 4 cases of non-union.

In 24 out of 30 patients had full range of knee motion (0 – 130^0) gained at 12 weeks. In 3 patients > 80% of knee range of motion (>105^0) was noted, 1 patient had >75% of knee range of motion (>95^0) was noted.

In 21 out 30 patients had full range of ankle motion (dorsiflexion 0 – 20^0, plantar flexion 0 – 50^0) gained at 12 weeks, 9 patients had > 75% range of ankle motion was noted.

None of the patient had shortening present in our study.

In our study, 4 patients had poor results. These 4 patients were Type II open fractures treated with primary intramedullary nailing. Open fracture had led to chance of infection which has gone into nonunion, along with comminution at fracture site.

LIMITATIONS:

The long term results of surgical management of isolated tibial shaft fractures with closed intramedullary interlocking nail were could not be assessed because of duration of study was less and follow up was done at an average period of 8 months only , further studies are needed to evaluate the long term functional outcomes.

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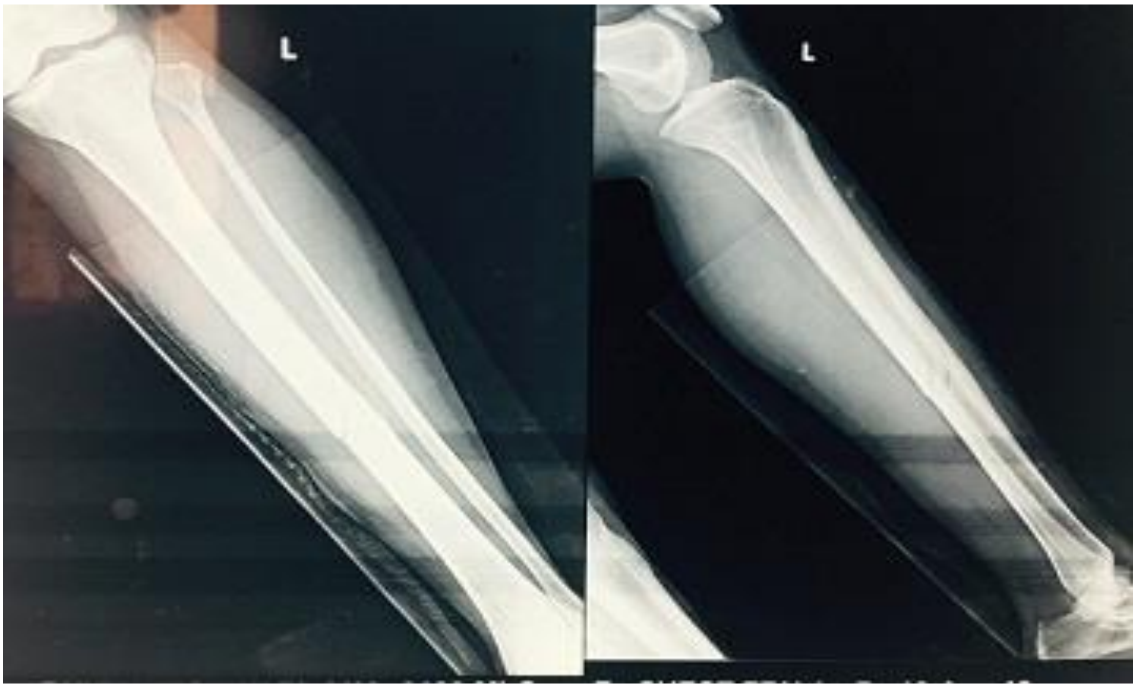
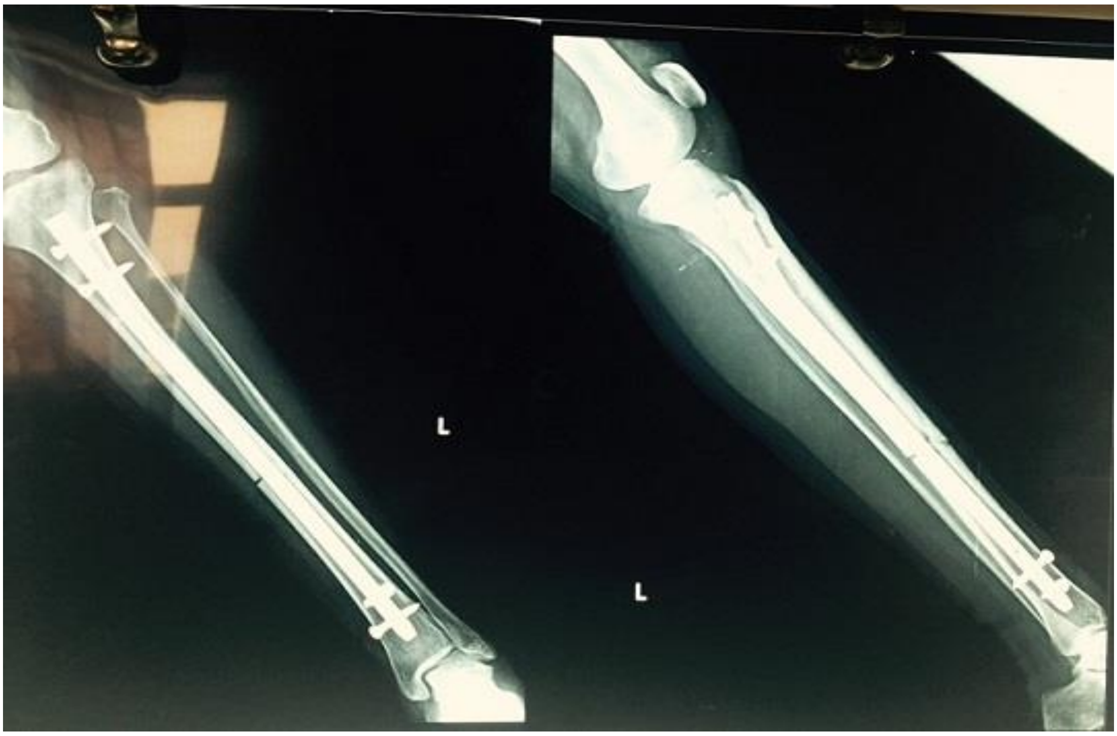
CASE ILLUSTRATIONS

CASE NO 1 – X RAY PICTURES



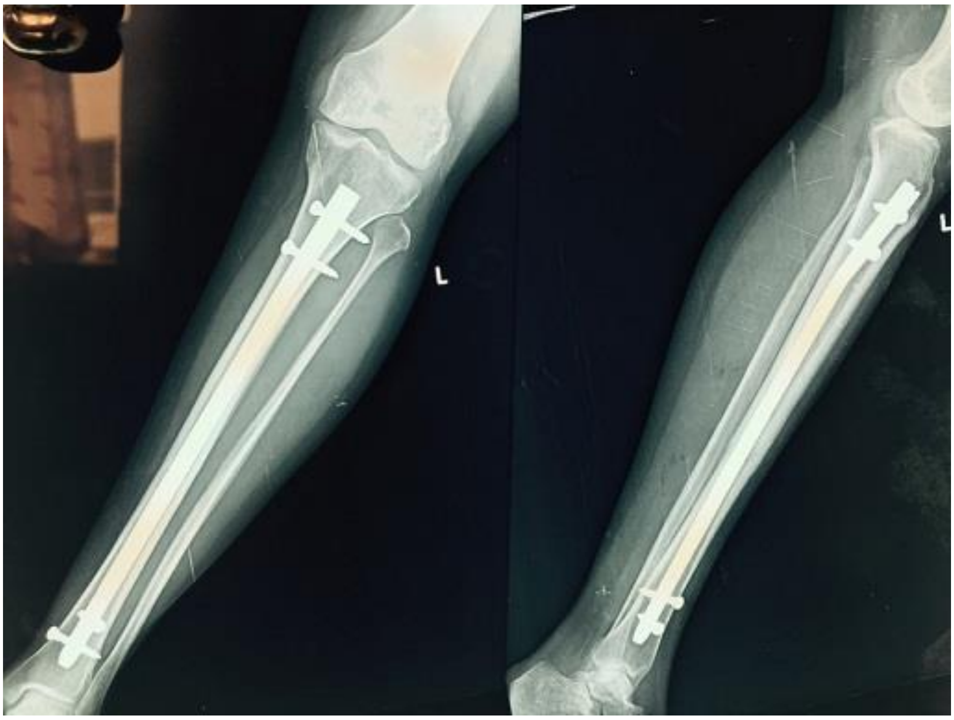
PRE OPERATIVE X RAY



IMMEDIATE POST OPERATIVE X RAY

CASE NO 1- FOLLOW UP XARYS

6 MONTHS FOLLOW UP



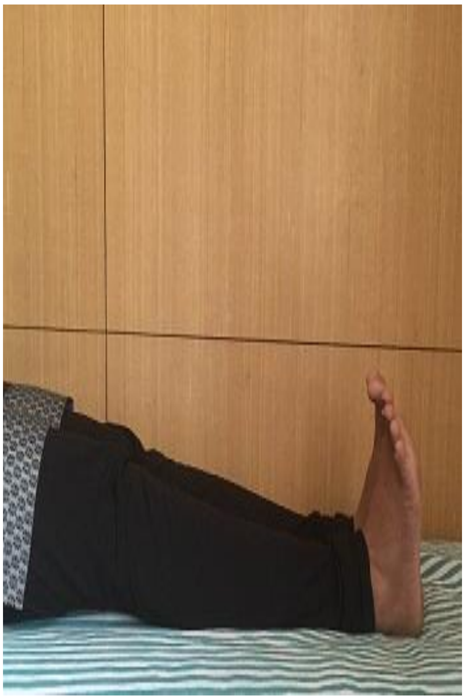
1 YEAR FOLLOW UP

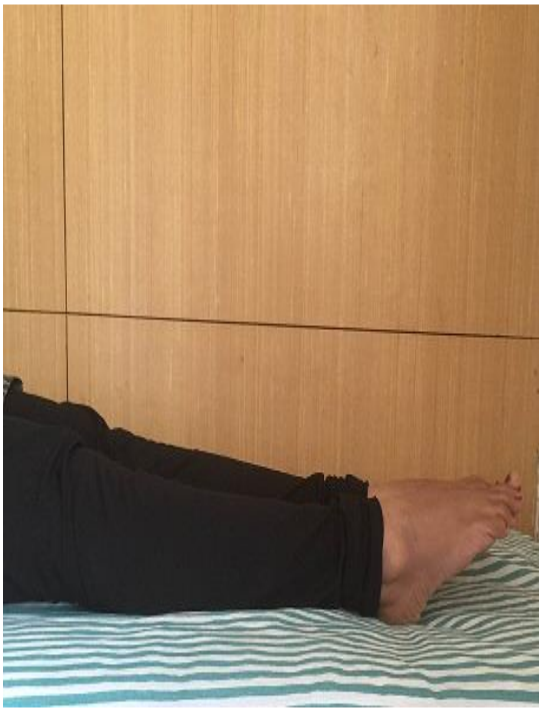
CASE NO 1- AFTER 1 YEAR , IMPLANT REMOVAL X RAYS

IMPLANT REMOVAL AP VIEW

IMPLANT REMOVAL LATERAL VIEW

CASE NO 1- CLINICAL PHOTOS

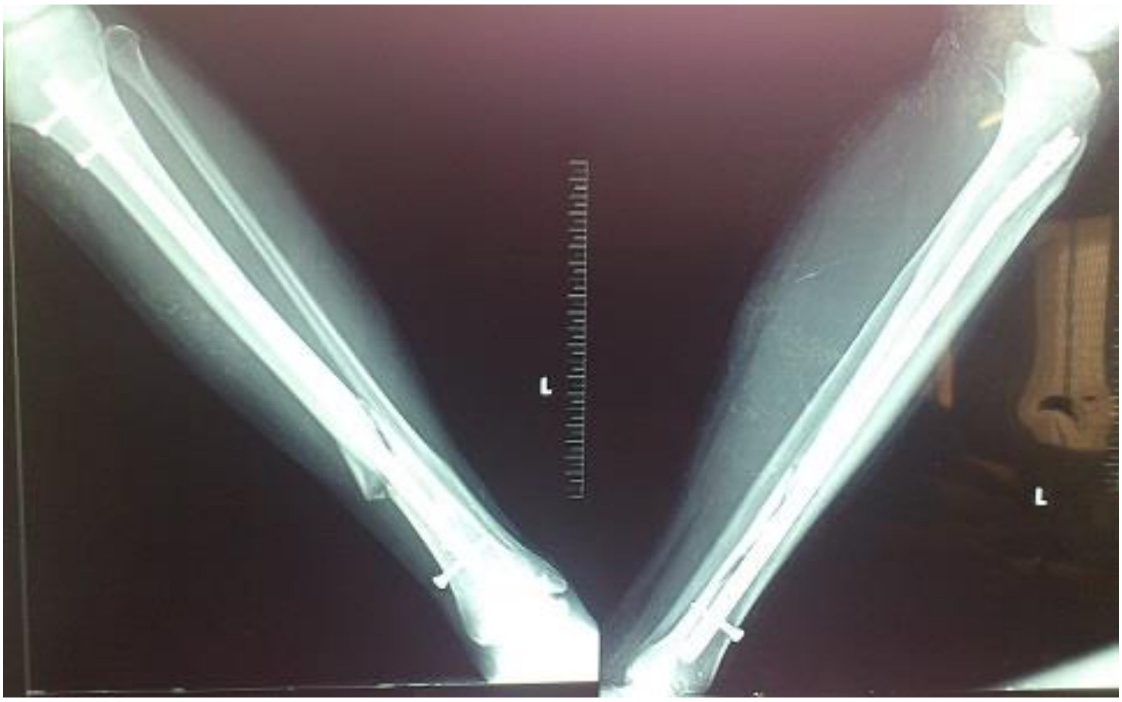




FULL RANGE OF KNEE AND ANKLE MOVEMENTS AT END OF 6 MONTHS

CASE NO -13

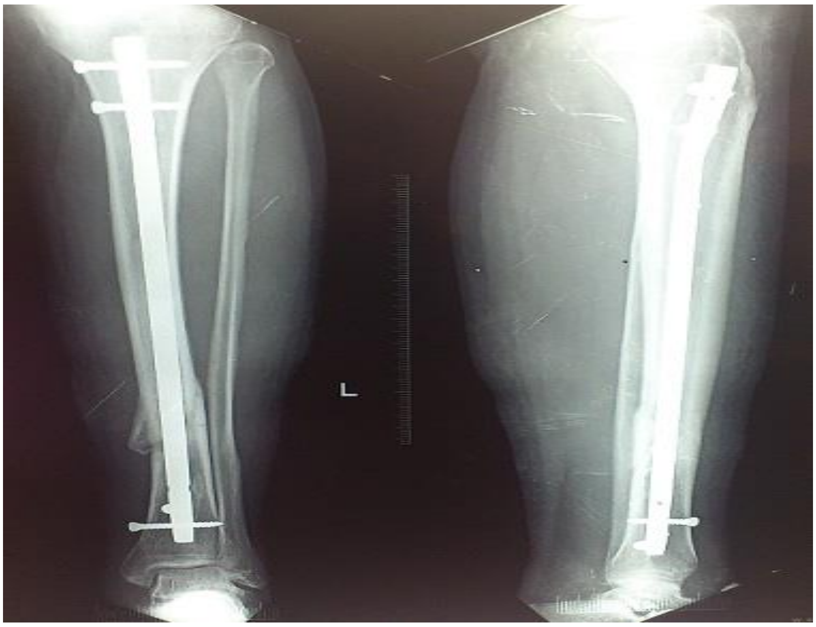
PRE OPERATIVE X RAYS



IMMEDIATE POST OPERATIVE X RAY

CASE NO 13 –FOLLOW UP X ARYS

3 MONTHS FOLLOW UP



6 MONTHS UP

CASE 13- CLINICAL PHOTOS

Knee ROM > 80 %(UPT0 100^0) and ankle ROM 75%

CASE NO – 16

PRE OPERATIVE X RAYS

IMMEDIATE POST OPERATIVE X RAYS

CASE 16- FOLLOW UP X RAYS

3 MONTHS FOLLOW UP X RAYS

6 MONTHS FOLLOW UP X RAYS

CASE 16- CLINICAL PHOTOS

KNEE AND ANKLE ROM FULL AT END OF 6 MONTHS

CASE NO 21- X RAYS

PRE OPERATIVE X RAYS

POST OPERATIVE X RAYS

CASE NO 21- FOLLOW UP X RAYS

3 MONTHS FOLLOW UP X RAY

6 MONTHS FOLLOW UP X RAY

PROFORMA

"SURGICAL MANAGEMENT OF ISOLATED TIBIAL SHAFT FRACTURES WITH CLOSED INTRAMEDULLARY INTERLOCKING NAIL.

PG: DR. K.V.RANGANATH ***THESIS GUIDE: PROF. ARUN.H.S***

NAME: HOSP. NO:

AGE: D.O.A:

SEX: D.O.S:

OCCUPATION: D.O.D:

ADDRESS:

MODE OF INJURY: RTA/ASSAULT/DOMESTIC/OCCUPATIONAL/MISC.

TIME PERIOD BETWEEN INJURY AND ARRIVAL TO HOSPITAL:

PAST HISTORY:

FAMILY HISTORY:

EXAMINATION:

GENERAL PHYSICAL EXAMINATION:

BULIT AND NOURISHMENT:

GLASGOW COMA SCALE:

PULSE: BLOOD PRESSURE:

PALLOR: CYANOSIS: CLUBBING

SYSTEMIN EXAMINATION:

Cardiov ascular system:

Respiratory system:

Per abdomen:

Cns:

LOCAL EXAMINATION:

INSPECTION:

-DESCRIPTION OF WOUND:

-ATTITUDE:

-SWELLING:

-DEFORMITY:

PALPATION

-TENDERNESS:

-CREPITUS:

-ABNORMAL MOBILITY:

-PERIPHERAL NEURO VASCULAR EXAMINATION:

-OTHER INJURIES:

INTIAL TREATMENT (DONE IN CAUSALTY):

-INITIAL STABILIZATION MEASURES:

-INITIAL ANTIBOITICS STARTED:

-WOUND IRRIGATION AND DEBRIDEMENT:

-IMMOBILIZATION:

X-ray of the part of including a joint above and a joint below - AP and lateral view.

a. SIDE AFFECTED: Right / Left / Bilateral

b. SITE OF FRACTURE: Upper 1/3, Middle 1/3, Lower 1/3

c. TYPE OF FRACTURE: Transverse/Oblique/Communited/Spiral/Segment

FINAL DIAGNOSIS:

INVESTIGA TIONS: (PRE-OP ASSESSMENT)

Hb: PCV: TC: DC: ESR:

RBS: B.UREA: S.CREAT: BT: CT:

HIV: HBsAG:

OTHERS: CXR: ECG:

TREATMENT:

PROCEDURE:

TYPE OF ANAESTHESIA:

Nail size

TYPE OF FIXATION DONE:

1. Static
2. Dynamic

POSTOPERATIVE MANAGEMENT:

ANTIBIOTICS:

Check X-RAY:

CULTEURE/SENSTIVITY FROM OPEN WOUND:

COMPLICATIONS: INFECTION:

PHYSIOTHERAPY

- Active toe and ankle movements

- Static quadriceps exercise

- Mobilization of knee and hip

- NWB /partial weight bearing crutch walking

DURATION OF HOSPITAL STAY:

RANGE OF MOVEMENTS AT DISCHARGE:

ADVICE AT DISCHARGE:

Quadriceps exercise

Mobilization of knee and hip

Active toe and ankle movements

- NWB /partial weight bearing crutch walking

POST-OP FOLLOW UP:

	6 weeks	12 weeks	18 weeks	24 weeks
ROM KNEE: ANKLE:				
TENDERNESS AT FRACTURE SITE				
X-RAY FINDINGS				
ANY OTHER COMPLICATIONS				

FINAL DEFORMITY: ANGULATION: VARUS/VALGUS

ROTATION: ANTERIOR/POSTERIOR

SHORTENING:

FUNCTIONAL ASSESSMENT BY JOHNER & WRUH'S CRITERIA

	Excellent	**Good**	**Fair**	**Poor**
Nonunion, Ostetitis, amputation	None	None	None	Yes
Neuro-vascular	None	Minimal	Moderate	Severe
DEFORMITY				
Varus / Valgus	None	2^0-5^0	6^0-10^0	$>10^0$
Anteversion / recurvation	0^0-5^0	6^0-10^0	11^0-20^0	$>20^0$
Rotation	0^0-5^0	6^0-10^0	11^0-20^0	$>20^0$
Shortening	0-5mm	6-10mm	11-20mm	>20mm
MOBILITY				
Knee	Normal	>80%	>75%	<75%
Ankle	Normal	>75%	>50%	<50%
Subtalar joint	>75%	>50%	<50%	
Pain	None	Occasional	Moderate	Severe
Gait	Normal	Normal	Insignificant limp	Significant limp
sternuous activities	Possible	Limited	Severely limited	Impossible
Result				

Signature of examiner **Signature of patient** **Signature of Guide**

ANNEXURE – II

CONSENT FORM FOR OPERATION/ANAESTHESIA

I__________ Hosp. No.______ in my full senses hereby give my complete consent for ______ or any other procedure deemed fit which is a diagnostic procedure / biopsy / transfusion / operation to be performed on me / my son / my daughter / my ward _____ age under any anesthesia deemed fit. The nature and risks involved in the procedure have been explained to me to my satisfaction. For academic and scientific purpose the operation/procedure may be televised or photographed.

Date:

Signature/Thumb Impression of Patient/Guardian

Name:

Designation:

Guardian Relationship:

Full address: