
**“A INTERVENTIONAL STUDY TO KNOW THE OUTCOME OF
REAMED INTRAMEDULLARY INTERLOCKING NAIL IN THE
MANAGEMENT OF TIBIAL SHAFT FRACTURES.”**

Reg No. BL0109003

DISSERTATION

**SUBMITTED TO
KLE UNIVERSITY, BELGAUM, KARNATAKA**

**IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF**

**MASTER DEGREE
IN
ORTHOPAEDICS**

**DEPARTMENT OF ORTHOPAEDICS,
JAWAHARLAL NEHRU MEDICAL COLLEGE,
BELGAUM – 10, KARNATAKA**

MAY – 2012

KLE UNIVERSITY, BELGAUM, KARNATAKA

**ENDORSEMENT BY THE HOD, PRINCIPAL/
HEAD OF THE INSTITUTION**

This is to certify that the dissertation entitled “**A INTERVENTIONAL STUDY TO KNOW THE OUTCOME OF REAMED INTRAMEDULLARY INTERLOCKING NAIL IN THE MANAGEMENT OF TIBIAL SHAFT FRACTURES.**” is a bonafide research work done by **BL0109003**.

Dr. V. G. Murakibhavi MS Ortho, D Ortho, FAOI
Professor & Head,
Department of Orthopaedics,
J. N. Medical College,
Nehru Nagar, Belgaum – 10

Dr. V. D. Patil MD,DCH
Principal,
J. N. Medical College,
Nehru Nagar, Belgaum –10

Date:
Place: Belgaum

Date:
Place: Belgaum

ABSTRACT

BACKGROUND AND OBJECTIVES:

Many patients come to Department of Orthopaedics with tibial fractures. It is one of the common injuries occurring in adult age group. Though fracture unites with conservative treatment but associated with high morbidity. So fractures stabilization with intramedullary interlocking nail is useful to prevent morbidity. We aim to study the outcome of reamed intramedullary interlocking nail for the treatment of closed tibial shaft fractures.

METHODOLOGY:

A prospective study, including 30 cases done from January 2010 to December 2011. The cases were followed up for 6 months at intervals of 6 weeks, 3 months and 6 months. The results were evaluated by assessing their functional outcome at follow-up as per Johner and Wruh's criteria.

All required routine investigations done pre-operatively. Study performed after obtaining consent of the patients.

RESULTS AND INTERPRETATION:

Excellent results were obtained in 70% of cases, good results in 16.6%, fair in 6.7%, poor in 6.7%. Complications include 3% of infection, 6.7% of malunion, 3% of non union.

CONCLUSIONS:

Reamed intramedullary interlocking nail is the reliable, versatile and effective treatment for closed tibial fractures. It minimizes the hospital stay and reduces the economic burden and enhances early return to work.

KEYWORDS: Reamed nailing, Intermedullary nailing, tibial shaft fracture.

LIST OF ABBREVIATIONS USED

C V S	-	Cardio Vascular System
C N S	-	Central Nervous System
DOA	-	Date Of Admission
DOD	-	Date of Discharge
DOS	-	Date of Surgery
E S R	-	Erythrocyte Sedimentation Rate
Hb	-	Haemoglobin
HBsAg	-	Hepatitis B surface antigen
HIV	-	Human immunodeficiency virus
HTN	-	Hypertension
IP No.	-	Inpatient Number
IMN	-	Intramedullary Nail
INF	-	Infection
I.V	-	Intravenous
Lt	-	Left
MAL	-	Mal union
NU	-	Non union
Rt	-	Right
ROM	-	Range of movement
R S	-	Respiratory System
RTA	-	Road traffic accidents
H/O	-	History of
SI No.	-	Serial Number

CONTENTS

SL. NO.	TOPIC	PAGE NO.
1.	INTRODUCTION	1-5
2.	OBJECTIVES	6
3.	REVIEW OF LITERATURE	7-53
4	METHODOLOGY	54-65
5.	RESULTS	66-77
6.	DISCUSSION	78-82
7.	CONCLUSION	83
8.	SUMMARY	84-86
9.	BIBLIOGRAPHY	87-96
10.	ANNEXURE I – CONSENT FORM	97-100
11.	ANNEXURE II – PROFORMA	101-107
12.	ANNEXURE III – PHOTOGRAPHS	108-111
13	ANNEXURE IV – MASTER CHART	112

LIST OF TABLES

TABLE. NO.	DESCRIPTION	PAGE NO.
1	Age incidence	67
2	Sex Distribution	68
3	Mechanism of Injury	69
4	Side Distribution	70
5	AO type	71
6	Level of fracture	72
7	Associated injuries	73
8	Type of anaesthesia	73
9	Difficulties during operation	74
10	Secondary procedure	74
11	Union in relation to type of fracture	74
12	Functional result (Johner and Wruh's criteria)	76
13	Complications	77
14	Age distribution compared with other studies	81
15	Sex preponderance compared with other studies	82
16	Results compared with other studies	82

LIST OF GRAPHS

GRAPH NO.	DESCRIPTION	PAGE NO.
1	Age incidence	67
2	Sex Distribution	68
3	Mechanism of Injury	69
4	Side affected	70
5	AO type	71
6	Level of fracture	72
7	Type of anaesthesia	73
8	Time to bone union	75
9	Functional results (Johner and Wruh's criteria)	77

LIST OF FIGURES

FIGURE NO.	DISCRIPTION	PAGE NO.
1.	Tibia and fibula ligaments and tendon attachments	13
2.	Muscle attachments of leg	14
3.	Superficial muscles anterior compartment of leg	16
4.	Deep muscles anterior compartment of leg	17
5.	Superficial muscles posterior compartment of leg	18
6.	Deep muscles posterior compartment	19
7.	AO Classification	28
8.	Split patellar tendon approach	58
9.	Medial parapatellar tendon approach	58
10.	Curved bone awl entry into medullary cavity	59
11.	Point of entry on the tibial tuberosity	59
12.	Instruments and Implants for IM nailing	64
13.	Surgical technique for intermedullary nailing	64-65
14.	Clinical photographs	108-111

INTRODUCTION

“The primary objective in the management of a open fracture is union with prevention or eradication of wound sepsis”.

- Gustillo et. al.,

“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

The statement perhaps still rings true after 40 years when it was first written.

As industrialization and urbanization are progressing year to year with rapid increase in traffic, incidence of high energy trauma are increasing with the same speed.

Tibial diaphyseal fractures are the commonest long bone fractures encountered by most orthopaedic surgeons. In an average population there are about 26 tibial diaphyseal fractures per 1 lakh population per year. Males are more commonly affected than females with male incidence being about 41 per 1 lakh per year, and female incidence about 12 per 1 lakh per year. There is a bimodal distribution of tibial fractures with a preponderance of young males.¹

Fractures of the tibial shaft are important for the reason that they are common and controversial. The exposed anatomical location of the tibia makes it vulnerable to the direct blow and high energy trauma as a result of motor vehicle accidents thus

resulting in comminuted fractures, which are frequently open with significant loss of skin and soft tissues.

In contrast to the rest of appendicular skeleton, tibia has precarious blood supply due to inadequate muscular enveloped.² Tibial fractures may be associated with compartment syndrome, vascular or neural injury. The presence of hinge joints at the Knee and the ankle, allows no adjustment for rotatory deformity after fracture. Because of the high prevalence of complications associated with these fractures, management often is difficult, and the optimum method of treatment remains a subject of controversy.

There are five principle causes of tibial diaphyseal fractures; fall, sports injuries, direct blows or assaults, motor vehicle accidents and gun shot injuries.¹ The important factors in prognosis are (1) amount of initial displacement (2) degree of comminution (3) whether infection has developed and (4) severity of soft tissue injury excluding infection.²

“Every fracture is an individual problem, and the decision to treat it by internal fixation or indeed conservatively should be based on a realistic assessment of the advantages and the hazards of each method in the circumstances of that particular case .This calls for a high degree of clinical judgment which is harder to acquire or to impart than technical virtuosity in the operating theatre” – Nicoll³

Management of the fractured tibia requires the widest experience, greatest wisdom and the best of clinical judgment in order to choose the most appropriate treatment for a particular pattern of injury – Watson and Jones.⁴

Three goals must be met for the successful treatment of fractures of tibia. The prevention of infection, the achievement of bony union and the restoration of function. These goals are interdependent and usually are achieved in the chronologic order given. For example failure to prevent infection promotes delayed union or non-union and delays functional recovery of the limb. Immobilization in a plaster cast has been used most commonly in the past but it does not always maintain the length of the tibia and it leaves the wound relatively inaccessible⁵.

Open reduction and internal fixation with plates and screws has yielded unacceptably high rates of infection^{6,7,8}. This method may be selected with more severe or local injuries, associated displaced intra articular fractures of knee and ankle.

External fixation, considered the treatment of choice for the open & comminuted fractures by many traumatologists, has the disadvantages of the bulky frames and frequent pin track infections, nonunion, and malunions.^{6,9}

Charnley¹⁰ in his text closed treatment of common fractures, said that he believed the eventual solution to the tibial fractured would be reamed intramedullary nail.

The Reamed intramedullary nailing locked or unlocked has become an attractive option since image intensifier has made closed intramedullary nailing possible. Nail is a load sharing device and is stiff to both axial and torsional forces. Closed nailing involves least disturbance of soft tissue, fracture hematoma and natural process of bone healing as compared to other forms of internal fixation.

Intramedullary nails, such as Lottes and Ender nails, used without reaming, have been employed successfully in the treatment of open tibial fractures and have been associated with low rates of post-operative infection. They are, however contraindicated for comminuted fractures, as there tends to be shortening or displacement of such fractures around these small nails.^{9,11}

Among the various modalities of treatment such as conservative gentle manipulation and use of short leg or long leg cast, open reduction and internal fixation with plates and screws, intra medullary fixation (including Ender Pins, intramedullary nails, and interlocking intramedullary nails with remaining (or) without Reaming), and External fixation techniques, surgeon should be capable of using all these techniques and must weigh advantages and disadvantages of each one and adapt the best possible treatment.¹² The best treatment should be determined by a thoughtful analysis of morphology of the fracture, the amount of energy imparted to the extremity, the mechanical characteristics of the bone, the age and general conditions of the patient, and most importantly the status of the soft tissues (the skin, muscle associated neurologic and vascular structure of the leg).

The locking of intramedullary nails to the major proximal and distal fragments decreases the prevalence of malunion of comminuted fractures. Intramedullary (IM) fracture fixation serves to stabilize fracture fragments and maintains alignment, while permitting motion at the fracture site during functional activities. Acting as an internal splint, the implant serves as a load-sharing device and fracture healing progresses with the formation of peripheral callus. By allowing motion of adjacent joints, rehabilitation is concurrent with treatment, and stress-shielding is thought to be minimal using these techniques. Recently, IM nails have been introduced to widen

indications for their use based on variations in the cross-sectional geometry, length and shape of nails, interlocking designs, and surgical techniques. Although the most important mechanical factors in the design of IM nails are strength, stiffness, and rigidity, anatomic constraints and surgical technique limit nail variations. Closed nailing is preferred to open procedures to preserve periosteal blood supply and minimize surgical trauma adjacent to the fracture. Blood flow to the fractured bone is elevated in nailing experiments. However, the end result in terms of healing was similar to that of plate fixation as observed by a study done by Tar et al.^{13,14}

With introduction of reamed intramedullary interlocking nail for tibial shaft fractures has overcome some of these complications by using a bigger diameter nail and encourages the patient for early mobilization. As fracture hematoma is not disturbed, healing of fracture is good. Due to minimal exposure and minimal soft tissue handling the rate of infection is reduced.

Use of proximal and distal interlocking nails has broadened the indications for the use of the technique for the fractures that may be too difficult to maintain the alignment in plaster cast or functional brace.

This lead us to design a trial, to study the results of reamed interlocking intramedullary nails in the treatment of closed fractures of the tibial shaft and assess the functional outcome and quality of life using Johner & Wruh's Criteria in the patients.¹⁵

OBJECTIVES

1. To study the outcome of reamed intramedullary interlocking nail in fracture shaft tibia.
2. To study the complications of reamed intramedullary interlocking nailing of tibial shaft fractures.

REVIEW OF LITERATURE

Hippocrates treatise *Medicatrix naturae* provided early advice on treatment of the tibia fibula fracture.¹⁶ Rest and immobilization of the injured extremity by splinting, with fracture healing to follow in time.

In modern times, Bohler¹⁷ recommended preliminary skeletal traction for 1 to 3 weeks for difficult tibia fractures and long leg cast treatment, and approach that yielded satisfactory results.

Watson – Jones¹⁸ advocated long leg cast treatment for several months, or until the fracture had healed. His rate of non-union was very low, but it was not reported in detail. For example, he did not mention the effect of prolonged cast immobilization on joint motion and muscle atrophy.

Early in his career, Charnley produced his classic text *Closed reduction of common fractures* (1961), he meticulously described in detail how to reduce tibia – fibula fractures (making use of the periosteal sleeve) and outlined the limitations of the technique described. He recognized a problem reported recently by others, namely, the problem of the intact fibula, which allows the tibia to drift into varus and increases the incidence of delayed union.

The conservative school of treatment¹⁸⁻¹⁹ flourished for almost three decades until the early 1960s, when the Swiss Arbeitsgemeinschaft für Osteosynthesefragen (AO) group advocated open reduction and internal fixation with plating as a primary treatment of both closed and open tibia fractures. Their rationale was that prolonged cast immobilization lead to poor results. Numerous publications in the early 1970s

supported the AO approach and documented early recovery and good functional result. In this approach, however, the incidence of sepsis and non union increases considerably, particularly in the primary plating of open fractures.

Sarmiento (1967)²⁰ almost single – handedly stemmed the tide of open reduction and internal fixation of tibia fractures. He advocated closed reduction and the use of patellar tendon, bearing casts or functional bracing. His treatment of over 500 closed tibia fractures with closed reduction and functional bracing resulted in an almost unbelievable union rate of 99.3%, with 0.7% non union and no cases of infection. In 250 open tibia fractures, union rate of 96%. These results were subsequently replicated by brown and Urban (1969) and others.

In 1970 to the early 1980s,¹⁶ the AO approach to fracture treatment was further propagated by the development of creative (hands-on) educational work shops, which greatly enhanced the surgeon's ability to perform open reduction and internal fixation of tibia fractures. This aggressive surgical approach spread very quickly across North America and challenged the conservative approach to fracture management. Anatomic reduction and rigid internal fixation with early motion were the by-words in this period.

In 1974 Nicoll's,³ observations in almost 800 tibia fractures, open and closed. He outlined the major factors affecting results.

1. Degree initial displacement.
2. Fracture comminution.
3. Soft tissue damage.

Anderson L.D., et. al., (1974)¹ reported a 95% union rate in 250 open and closed fractures treated with pins and plaster method followed at 3-6 weeks by weight bearing in a long leg cast.

In 1976, Ruedi, Webb and Allgower,²¹ reported 97% excellent and good results in 323 closed fractures treated with DCP, the infection rate was less than 1%, 80% of 95 open fractures had good or excellent results. Only 12% had an infection. The patients were kept in bed for 1 week after surgery and they were allowed partial weight bearing (20 kg) until fracture healing.

Intramedullary nailing (unreamed nails) for tibia fractures was extensively reported in the United States by Lottes (1974).¹¹ In the majority of both open and closed tibia fractures cases he achieved excellent results, with a 98% union rate in closed tibia fractures and less than 1% infection. He allowed early weight bearing, and in most cases, post operative cast immobilization was not required. Infection rate in his study was 7.3% of 200 cases.

Chapman and Mahoney (1979)²² achieved a fracture healing rate of over 90% when using the Lottes nail in tibia fractures. The primary draw back of lottes nailing was its limited application to the isthmic position of the tibia (a necessity to achieve fracture stability).

Ender nail and other flexible nails have also been used with a high rate of success in closed and type I and II open fractures.

Subsequent reports by D'Olerud et al and others²³ of reamed intramedullary nailing has extended the application of intramedullary nailing to longer portions of the

shaft with locked nailing. This even included the distal and proximal thirds of tibia fractures and achieved stability.

DeBastiani and colleagues (1985)²⁴ treated 91 closed tibial fractures with the orthofix frame with a 91% union rate an average time of 3.6 months to union.

Court – Brown and Hughes (1985)²⁵ obtained worse results with a static external fixator and believed it led to a higher delayed and non unions rate than other treatment.

Complications unique to external fixation are pin tract infections and pin loosening, which occur in upto 50% of patients. Loss of frame stability is becoming a more recognized entity and may account for the higher malunions rate of upto 45% with external fixation.

Pankovich AM., et. al., (1981)²⁶ reported good results in 36 of 38 fractures with flexible nailing. Ender-type curved pins with medial and lateral entry portals for rotational control of the fracture were used. Stacking of multiple pins exert spring force to resist angulation and rotation. They require a stable fracture configuration and fracture of middle one third are best controlled.

Henlye and Colleagues (1994),²⁷ in a prospective randomized study, compared reamed locked intramedullary nails to external fixation. They reported a higher incidence of wound problems in the external fixation group (21% Vs 11%), as well as an increased of malunion of 24% with external fixation versus 5% with intramedullary nailing.

EVOLUTION OF INTERLOCKING INTRAMEDULLARY NAIL

The concept of stabilizing tibial shaft fracture by means of intramedullary technique is an old one. The first reported case of intramedullary nailing was of conquista dores in the 16th century. The Spanish archives briefly mentions that the Incas and Aztecs²⁸ used resinous wooden pegs in the medullary canal of long bones for the treatment of non unions.

Various material have been used for intramedullary nailing including ivory pegs by Birchers in 1886 and Koining of Germany in 1913. Høglund used bone instead of ivory pegs in 1947. Metal was first used by Senn, Labotte and Hey Grooves.²⁹

In the 1930s German Othopaedist Gerhard Kuntscher³⁰ invented a metallic intramedullary nail for fixation of femoral fractures.

In 1937, Rush brothers introduced metal nails, later known as “Rush nail”, which had disadvantage that it offered minimal stability. The current nails in use have evolved mainly from the work of Kuntscher in Germany and the Rush family in the USA.

Kuntscher performed the first nailing of subtrochanteric fracture in humans in November 1939.

The Biomechanical principles of intramedullary splinting were established by the intramedullary nailing technique introduced by Kuntscher in 1940.

Unquestionably, Kuntscher is the father of reamed intramedullary nailing. In 1950 he developed the technique of medullary reaming and closed insertion of an

intramedullary nail without exposing the fracture. Kuntscher together with Pohl an instrument maker and metallurgist invested a number of nails of different shapes for intramedullary fixation of a fracture. Improvements in the original designs culminated in his design of cloverleaf cross section of a slotted nail.

Kuntscher's concept of the "detensor" (1969)³¹ was the predecessor of the current concepts of interlocking, which considerably extend the indications for intramedullary nailing.

Closed intramedullary nailing came in Vogue in the 1970s with the advent of the image intensifier.

The technique of closed interlocking was popularized by the AO – ASIF during the period 1970 – 75 for the middle third for the femur and tibia.

Klemm and Schelmann in 1972, made the interlocking design following which in 1974, Grosse and Kempf from France invented the G.K. interlocking nail.

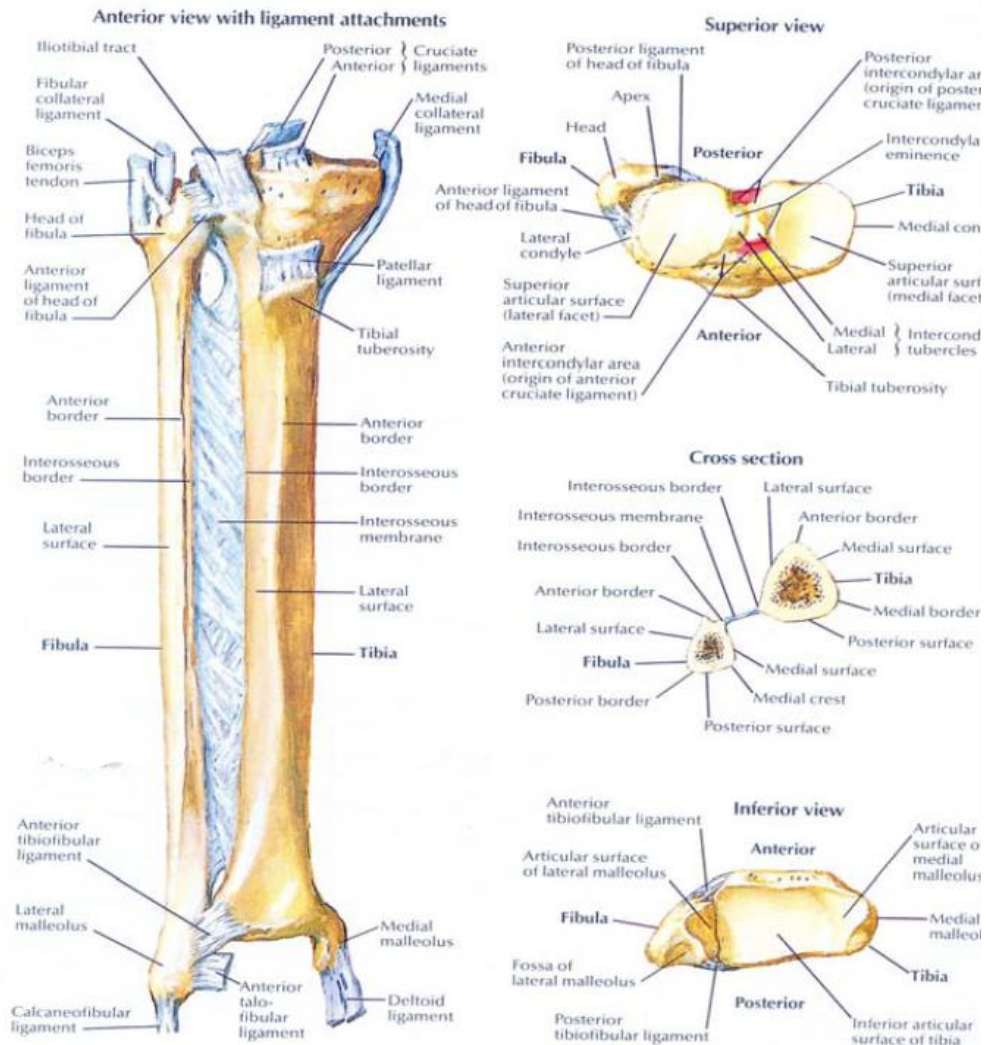


Fig. 1: Tibia and fibula ligaments and tendon attachments

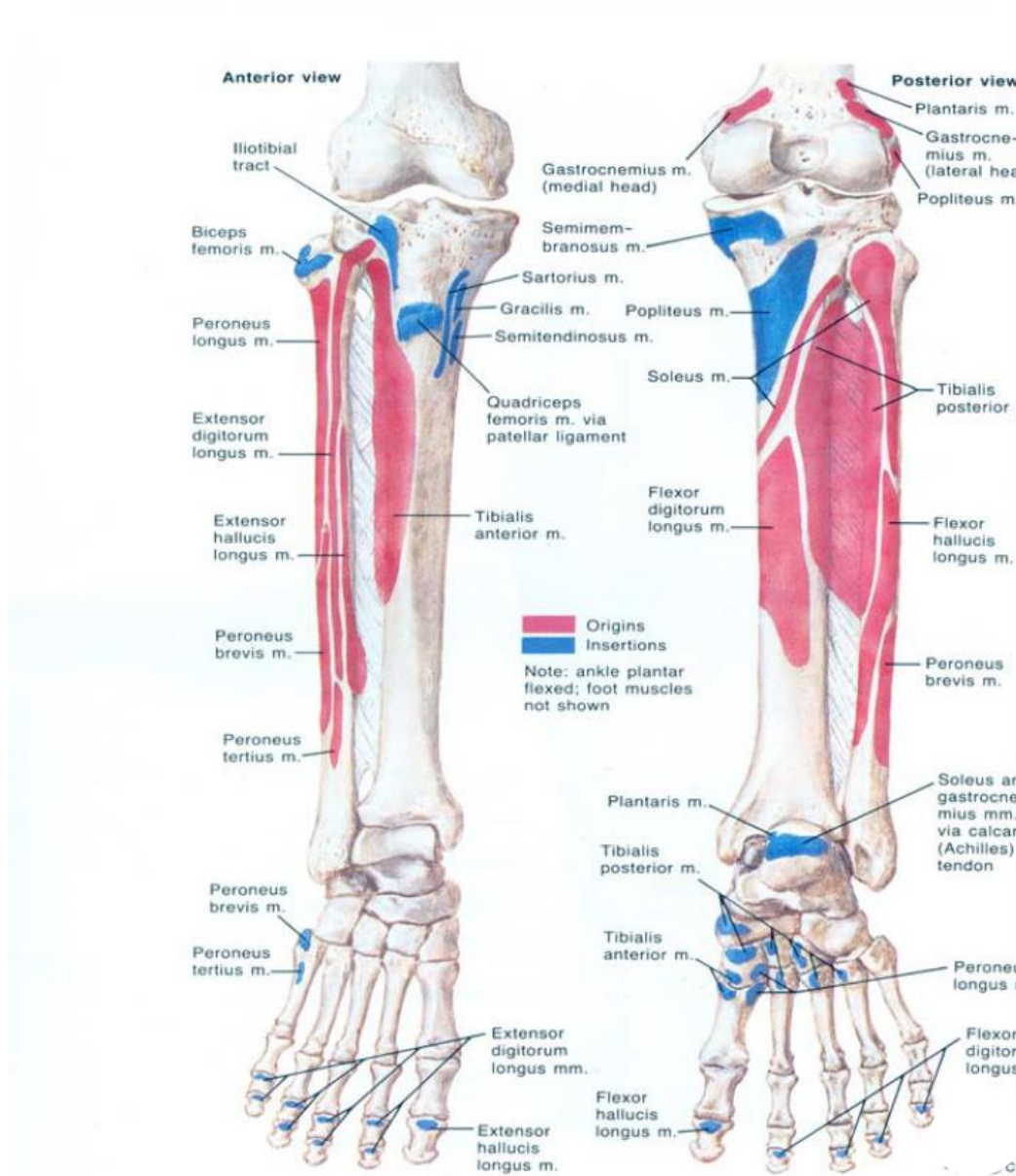


Fig. 2: Muscle attachments of leg

SURGICAL ANATOMY

The anatomy of the leg makes tibia susceptible to fractures. The Entire medial border is subcutaneous and is covered only by skin and subcutaneous tissues. It also makes a tempting target for the enthusiastic surgeon, as the surgical approach to the tibia is simple.

The anterior tibial border in the diaphyseal region of tibia is very dense and extends from tibial tuberosity prominence of tibia lends itself very readily to pin fixation due to a lack of muscles, tendons traversing the anteromedial portion.

Tibia is surrounded by muscular envelop and is divided compartments by unyielding deep fascia of the leg.

1. Anterior compartment

It contains the tibial anterior, extensor digitorum longus, extensor hallucis longus, peroneous tertious muscles. This anterior compartment also contains the anterior tibial artery and deep peroneal nerve. The tendons are close to the tibia and the fracture in this area may cause callus formation that comparatively restrict gliding of these tendons.

2. Lateral Compartment

Lateral compartment contains the muscles peroneous longus and peroneous brevis and they protect the fibular shaft except near the ankle. So isolated fractures of the fibula owing to direct trauma are uncommon, the superficial peroneal nerve is in between the peronei and the extensor digitorum longus in the intermuscular septum,

thus the nerve is rarely involved in fracture of the fibular shaft. It is at risk in fractures at fibular neck.

3. Posterior Compartment

It is further divided into a superficial and a deep compartment.

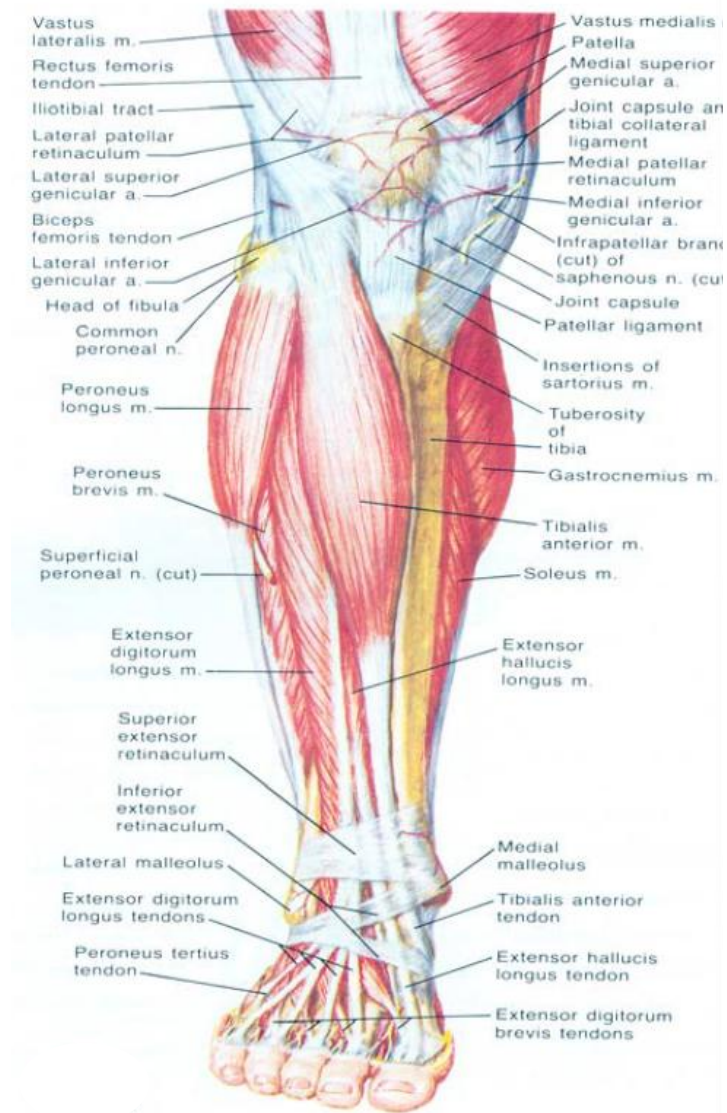


Fig. 3: Superficial muscles anterior compartment of leg

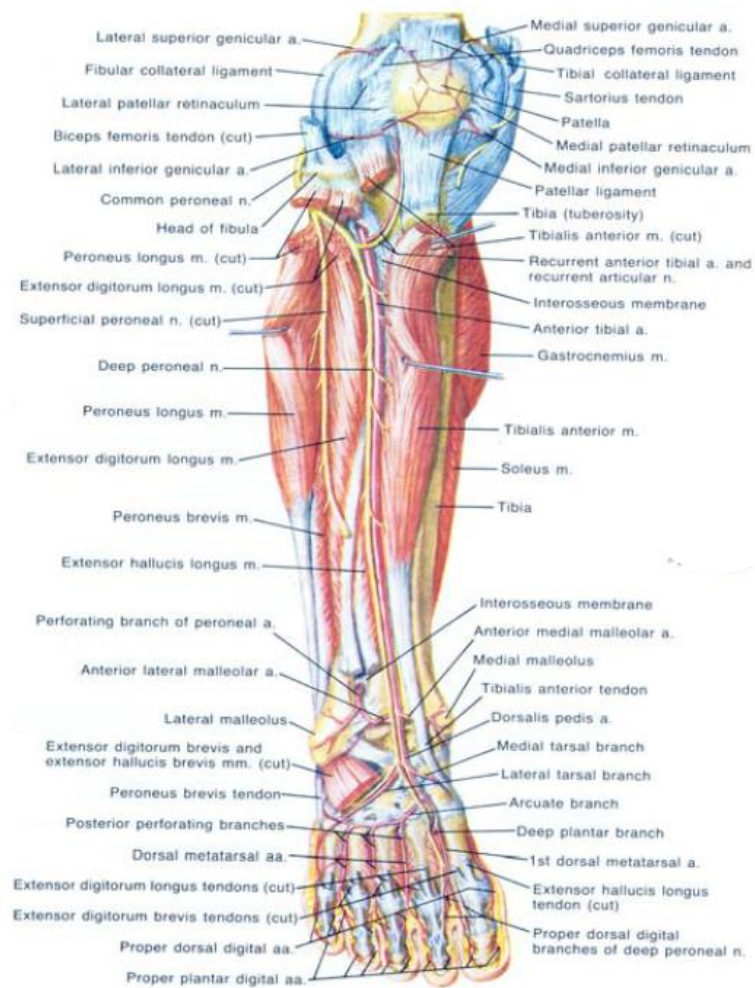


Fig. 4: Deep muscles anterior compartment of leg

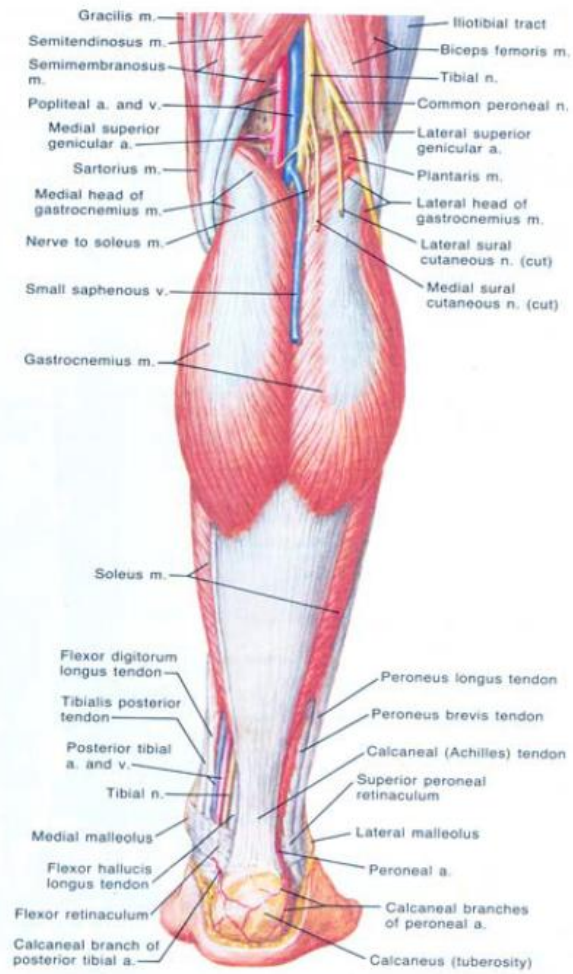


Fig. 5: Superficial muscles posterior compartment of leg

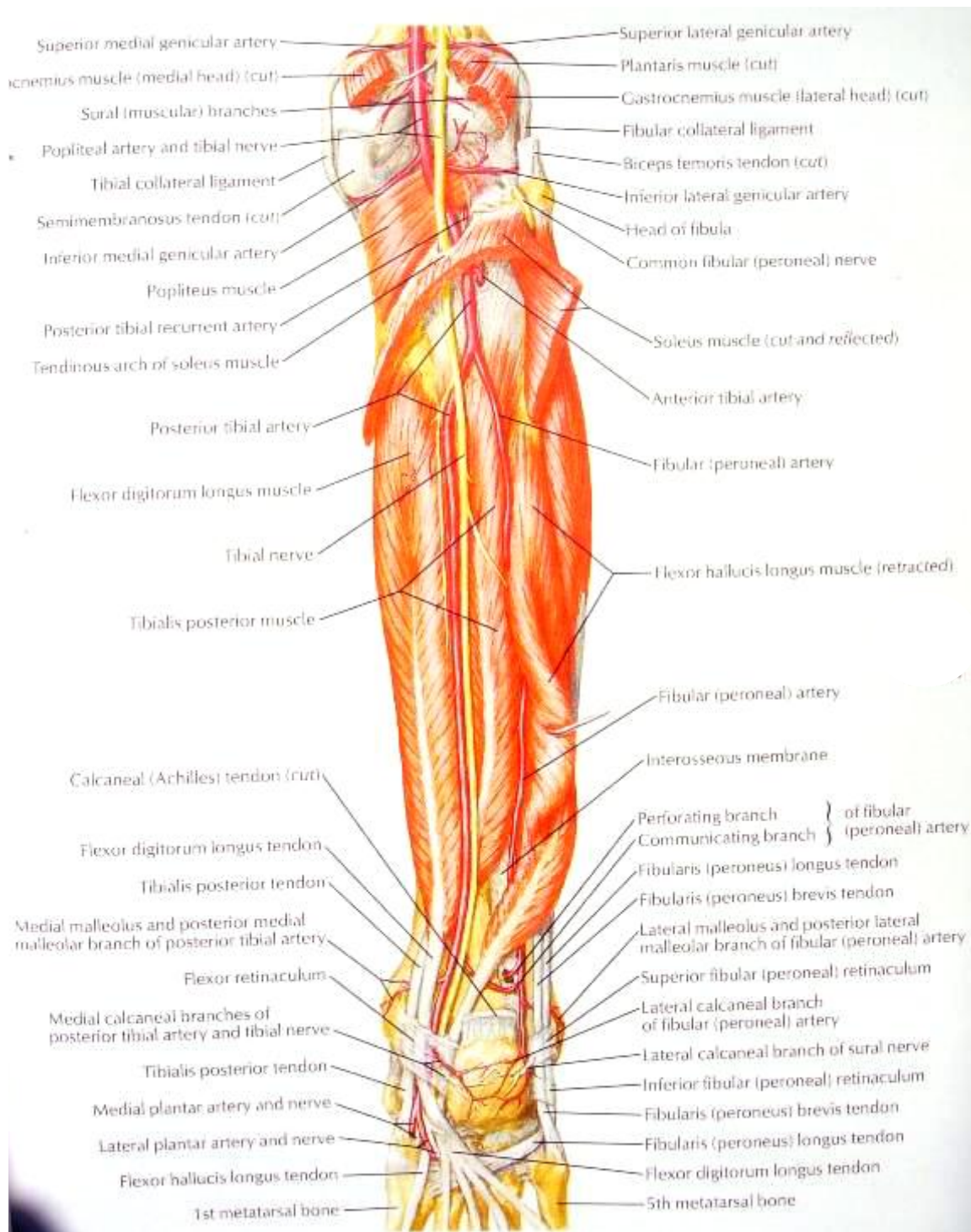


Fig. 6: Deep muscles posterior compartment

The muscles of this compartment are soleus, gastrocnemius, popliteus, tibialis posterior, flexor hallucis longus and flexor digitorum. Longus. The posterior tibial nerve, the posterior tibial artery and its large branch peroneal artery also run in the posterior compartment.

Tibial fracture in the upper third are complicated by the compartment syndrome. This may occur more commonly in the anterolateral compartment and also the posterior compartment. The superficial posterior compartment contains the gastrocnemius, soleus muscle serving as a source for local muscle flaps, which helps in covering the soft tissue defects in the proximal and middle third of tibia.

The posterior tibial artery is usually well protected. It is the major arterial supply after a severe open fracture and is a potential source for anastomosis with the free flaps for soft tissue reconstruction of the leg.

Interosseous membrane

This is a strong sheet of fibrous tissue, which closes the spaces between the tibia and fibula except at its upper end, where there is a small opening for the passage of the anterior tibial vessels in fracture it prevents the separation of the bone unless it is extensively torn. Since the majority of its fibres runs down wards and outwards, the interosseous membrane serves to distribute indirect violence acting on the tibia to the fibula.

The Blood Supply

The anterior and posterior tibia and peroneal arteries are the main blood vessels of the leg. The anterior tibial artery is one of the terminal branches of the popliteal

artery and passes forward through the opening in the interosseous membrane to reach the anterior compartment, where it passes downwards on the interosseous membrane to terminate in the dorsalis pedis artery. The posterior tibial is the direct continuation of the popliteal artery. It passes downwards in the space between the deep flexor muscle and the calf muscle to terminate in the plantar arteries. The peroneal artery passes downward in close relation to the posterior surface of the tibia.

Blood supply of tibia as with all other long bones is periosteal and endosteal. The periosteal blood supplies the outer third of the cortex, while the endosteal blood supplies the inner two-third of the cortex.

Periosteal blood supply comes from the surrounding musculature, while endosteal comes from nutrient artery which is a branch of the posterior tibial artery at the soleal line. Usually the blood flow is centrifugal, however, in case of a fracture when the endosteal blood supply is damaged, the flow is reversed and it changes from centrifugal to centripetal. When intramedullary nailing is done, the endosteal blood supply is interrupted. Newer studies have proven that endosteal blood supply is restored after several weeks of reaming. It is extremely important to preserve the soft tissue attachment. This is achieved by a closed intramedullary nailing.

The nutrient artery divides into three ascending branches which supply the proximal two-third of the tibia, and gives a smaller descending branch which supplies the distal one-third of tibia. Hence, the proximal tibia has good endosteal blood supply, while the distal tibia has poor supply. The soft tissue attachments to the distal tibia are less, making the periosteal blood supply scanty. This differential pattern of blood supply makes tibia susceptible to atrophic non union at the junction of the middle

and distal third. Unfortunately, majority of the open tibial fractures are at this junction.

Medullary canal

The medullary canal of tibia is more triangular in cross section than circular. Lack of curvature of the tibial medullary canal as against that of femur makes a longitudinal interference fit with an intramedullary nail very difficult.

Role of Fibula

When the fibula is intact the tibial fracture is stable. It is a surgeon's friend in the management of tibial fractures. It maintains length in comminuted fractures and with bone loss, it acts as an internal splint.

But, sometimes it also acts as a double – edged sword. For example, it prevents the union by preventing the collapse at the fracture site or in case of comminuted fractures, it can cause a varus angulation at the fracture site.

MECHANISM OF INJURY

For the tibial shaft to fracture, a significant amount of energy must be applied in one of 3 modes.

Torsional injuries (e.g. Skiing injuries) are more common with low energy trauma where the foot becomes fixed and the body rotates about this fixed point.

Three and four point bending forces produces short oblique and transverse fractures. As the points of bending are spread further apart and as the amount of

energy implied increases, comminution increases and even segmental fracture develops.

Direct violence or high energy trauma as a result of motor vehicle, motorcycle and other road traffic accidents. Crushing injuries can be seen in RTA and industrial injuries where high concentration of energy is applied over a small area with resulting increased damage to bone and soft tissues.

The type of fibular fracture associated with that of tibia indicates the degree of soft tissue trauma involved. Severe comminution of fibula or tibiofibular diastasis indicates an unstable fracture with relative devascularization of fracture fragments and attendant high rates of delayed, non or malunion.

Classification of Tibial Shaft Fractures

Any classification of injury is useful only if it alerts the physician / surgeon to potential dangers or helps to determine appropriate treatment. Numerous classification systems have been proposed for tibial fractures but unfortunately none have been validated for reproducibility and sensitivity.

The most important morphologic varieties in classifying tibial fractures are:

1. Anatomical location
2. Pattern of fracture lines
3. Associated injuries of fibula
4. Position and number of fragments
5. Extent of soft tissue damage

1. **Ellis**³² classified tibial fractures into three groups of severity : minor, moderate or major.
 - a. **Minor** fracture is un-displaced with only minor communication or a small open wound.
 - b. **Moderate** severity signified total displacement or angulation with a small degree of communication or a small open wound.
 - c. **Major** severity indicates complete displacement of fracture fragments with major comminution or major soft tissue damage.

2. **Nicoll (1964)**³ identified the fracture characteristics that seemed to be most indicative or prognosis in the closed treatment of tibial fractures:
 - a. Degree of initial displacement.
 - b. Comminution
 - c. Soft – tissue wounds.

He arbitrarily assigned one of three grades for each factor :

- Nil or slight
- Moderate
- Severe

From the system he was able to make reasonable prediction or outcome of particular fracture with technique of closed reduction and casting.

Although this classification system gives statistical information, they do not guide the selection of a specific treatment modality of individual fracture.

3. Gustilo Anderson's classification for open fractures (1976) :^{17,33}

Open fractures are classified into three major types (one of which has three subtypes), according to the mechanism of injury, the degree of soft tissue damage, the configuration of the fracture, and the level of contamination.

In a type I open fracture, the wound is less than one centimeter long. It is usually a moderately clean puncture, through which a spike of bone has pierced the skin. There is little soft tissue damaged and no sign of crushing injury. The fracture is usually simple, transverse, or shot oblique, with little comminution.

In type II the laceration is more than one centimeter long, and there is no extensive soft tissue damage, flap or avulsion. There is a slight or moderate crushing injury, moderate comminution of the fracture, and moderate contamination.

Type III is characterized by extensive damage to soft tissue, including muscle, skin, and neuro vascular structures, and a high degree of contamination. The fracture is often caused by high velocity trauma, resulting in a great deal of comminution and instability. Type III fractures are divided into three subtypes.

In type IIIA soft tissue coverage of the fractured bone is adequate, despite extensive laceration, flaps, or high energy trauma. This subtype includes segmental or severely comminuted fractures from high energy trauma, regardless of the size of the wound.

The type IIIB open fracture is associated with extensive injury to or loss of soft tissue, with periosteal stripping and exposure of bone, massive contamination, and severe comminution of the fracture from high velocity trauma. After debridement

and irrigation is completed, a segment of bone is exposed and a local or free flap is needed for coverage.

Type IIIC includes any open fracture that is associated with an arterial injury that must be repaired, regardless of the degree of soft tissue injury.

4. Ao classification of Tibial diaphyseal fractures :

Type A : Unifocal fractures

Group A1 Spiral Fracture

- Sub groups 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 $> 30^{\circ}$)

- Subgroups 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 line $< 30^{\circ}$)

- 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
	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
	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 fragments
	C1.2 Three intermediate fragments
	C1.3 More than three intermediate fragments
Group C2	Segmental fractures
Subgroups	C2.1 One segmental fragments
	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)

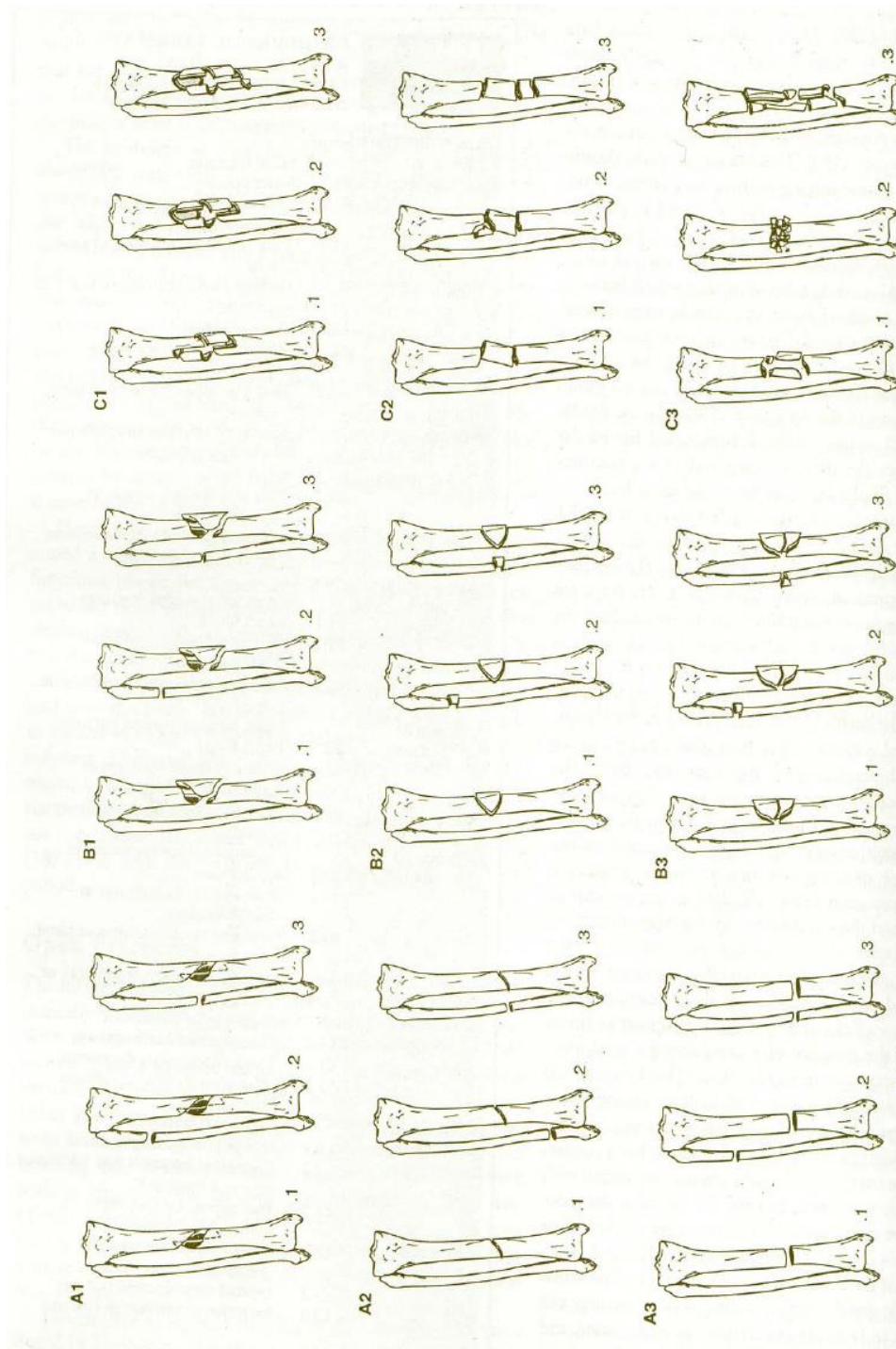


Fig. 7: AO Classification

5. Johner and Wruhs (1983) reported an alpha numeric system developed by Muller based on four major factors of prognostic significance in the outcome of tibial fractures¹⁵ :

1. Mechanism of accident / injury
2. Communion
3. Soft-Tissue injury
4. Displacement of fracture (not a reliable criterion)

Morphologically fractures were classified on the basis of communion and accident mechanism. The alphanumeric classification sub-divides fractures of the tibial shaft into three zones referenced from the diaphyseal segment. The middle segment is defined as the area with smallest medullary canal plus 1mm. The proximal and distal diaphyseal metaphyseal junction are the regions where the cortical bone narrows to the epiphyseal cortical thickness. The morphology of the fracture is represented by an alphanumeric system where the letters A B and C represent increasing degrees of communion and the numbers 1, 2 and 3 represent morphologic criteria reflected indirect or direct impact.

Group – A : Simple fractures with no communion.

Group – B : Fractures which have one butterfly fragment (one cortex is broken once other cortex several times).

Group – C : Involves those fractures in which all cortices are broken several times, it includes segmental and severely communitated fractures.

Type – 1 : Fractures include all spiral fractures produced primarily by indirect impact or torsion.

Type – 2 & 3: Include fractures produced mainly by direct impact or bending forces. Usually either three or point bending.

The simple bending fractures (with less than 30° of obliquity) in group A are subdivided into A_2 when the fractures is oblique ($> 30^{\circ}$) A_3 when it is transverse ($< 30^{\circ}$). Bending of wedge fractures with butterfly fragment in group B are classified as B_2 if there is one fragment and B_3 if there are several butterfly fragments.

Bending fractures in group C and classified C_2 if segmental fracture with circumferentially intact mid-segment and C_3 if segmentally comminuted without an intact mid-segment from crush injury or from penetrating trauma.

They further classify the fractures by location with sub-groupings 1, 2 and 3 ranging from proximal to middle to distal segments.

In their evaluation of this system they found that the most important factor in prognosis was fracture pattern with non-spiral benign fractures having worst prognosis and spiral having best prognosis.

6. Classification of soft tissue injuries : The AO/ASIF group has proposed an open fracture classification to grade soft tissue injury to be used in conjunction with the AO/ASIF alpha numeric fracture classification system. The soft tissue grade incorporates the degree of injury to the injury to the integument (IO for open injuries), muscle tendon injury (MT), and neurovascular injury (NV).³⁴

SKIN LESIONS 10 (OPEN FRACTURES) :

101 = Skin breakage from inside out.

102 = Skin breakage from outside in < 5 cm, contused edges.

103 = Skin breakage > 5cm, devitalized edges, circumscribed degloving.

104 = Full thickness contusion, abrasion, skin loss.

105 = Extensive degloving.

MUSCLE / TENDON INJURY (MT) :

MT1 = No muscle injury

MT2 = Circumscribed muscle injury, one muscle group only.

MT3 = Extensive muscle injury, two or more muscle groups

MT4 = Avulsion or loss of entire muscle groups, tendon laceration.

MT5 = Compartment syndrome / crush syndrome

NEUROVASCULAR INJURY (nv) :

NV1 = No neurovascular injury

NV2 = Isolated nerve injury

NV3 = Localized vascular injury

NV4 = Combined neurovascular injury

NV5 = Subtotal or total amputation

GUIDELINES FOR TIBIAL FRACTURE REDUCTION

Regardless of the treatment method chosen, the most important consideration is an acceptable reduction. Acceptable reduction is a position of fracture fragments that minimize angulatory, rotational and length deviation from what is normal for the patient. The primary concern is the effect malunion will have on gait and load bearing

stresses on the knee and ankle joint. Cosmetic and radiographic appearance are of minimal concern and are not by themselves indications for operative treatment. Nicoll, E.A. (1964)³ stated that more than 10° angulation in any plane and shortening more than 2 cms was unacceptable. Dehne et. al. (1961),¹⁹ Sarmiento A (1976) and Brown. P.W. et. al., (1969) reported satisfactory function when angulation was less than 10°. None of the authors advocated reoperation for symptoms of malunion of 10° or less. Rockwood and Green³⁵ prefer to set goal of 5° for varus and valgus angulation, 10° for anterior and posterior angulation and 10° or less for rotation and 1 cm or less for leg length discrepancy, however, more deformity have to be accepted to obtain union but it is preferable to prevent a malunion than to correct it later. The most commonly used clinical guide for reduction is the alignment of the antero-superior iliac spine with the middle of patella and the second toe in the antero-posterior plane. Rotation and lateral alignment are best determined by comparison to opposite extremity.

Although tibial shaft fracture may heal with 100% displacement, delayed and non – union are more common in adults with this degree of displacement. No distraction should be tolerated because as little as 5 mm of distraction may increase healing time of tibial fracture to 8 – 12 months.

BIOLOGY OF FRACTURE HEALING WITH INTRAMEDULLARY

NAILING

Intramedullary fixation offers many advantages in fracture healing when compared to other methods. Union is usually rapid because unlike rigid plate fixation external callus is seldom completely suppressed. This is due to the fact that a nail can

never be completely rigid. Movement at the fracture site along with axial micro-motion in dynamically locked nails promotes the external bridging callus. This may also be due to the fact that as the medullary blood supply is lost the periosteal vascular supply increases.

Intramedullary nailing avoids “Stress Protection Osteopenia” and so the risk of late refracture after nail removal is uncommon. Evidence favors the use of intramedullary nails to stabilize diaphyseal fractures of the tibia³⁶⁻³⁷. However, the choice between reamed or unreamed intramedullary nailing of tibial fractures remains controversial³⁶⁻³⁸. Unreamed nailing preserves the endosteal blood supply and may therefore improve fracture-healing and decrease the risk of infection. Reamed nailing but increase in rate of malunion. With use of larger nails, while destructive to the endosteal blood supply, affords greater stability³⁹⁻⁴⁹. A number of prospective, randomized controlled trials have compared the effects of reamed and unreamed intramedullary nailing of lower extremity fractures. Meta-analyses of these trials have suggested reduces the risk of nonunion and helps in early fracture to heal, in association with the use of reamed intramedullary nailing (relative risk, 0.44; 95% confidence interval, 0.21 to 0.93)^{37,38,50,51}.

Court and Brown et, al. reported that reaming produces an internal bone graft locally which appears to stimulate fracture union and reduces the need for bone grafting.¹²

Anglen et, al. reported reamed nails have faster healing time.⁵²

Court Brown et, al, and Wiss have found that reaming promotes fracture healing in non-union compared with insertion of unreamed nails.⁵³

BIO-MECHANICS OF INTER LOCKING INTRA MEDULLARY NAILS

All the intramedullary nails, regardless of their types, act as flexible internal splints providing stability for the fracture fragments from within.

It is a load sharing device in which stress shielding is minimal due to the fact that is situated close to the neutral axis of the bone where strain is minimal. The strain induced is now considered the most important factor in later stage of fracture callus remodeling.

Intramedullary locked nails, in addition to 3 point fixation and elastic impingement mainly provide stability by anchorage of the bone both proximal and distal to the fracture site by interlocking screws / bolts.

The mechanical behaviour of I.M. nails depends on both material and geometry of the design.

MATERIAL

Venable and Stuck in 1934 discovered an inert alloy of chromium, molybdenum and nickel and named it Vitallium. Then came 18/12 S.M.O. stainless steel. Titanium and then Super alloys. Most of the Orthopaedic nails are made of 316 L stainless steel.

The bending rigidity depends on the moment of inertia of the design which is proportional to the fourth power of the radius and the quantity of the material, that is to say that the bending stiffness increases as the diameter and thickness of the nails increases. A 25% increase in diameter of the nail will double its bending strength.

The rotation stiffness depends on the configuration of the cross section of the nail. Abolishing the open slot in the cross section increases the rotational stiffness approximately 50 times, when compared to nails with open slot.

Clinically, bending strength the stiffness can be increased by using unslotted thick nail with large diameter and reaming helps in applying a larger diameter nail.

When a implant is loaded to failure, the resulting load deflection curve would show the structural properties of the implant.

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.

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.

STRESS STRAIN CURVE

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.

Ex. 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.

STRENGTH

Is the stress at which 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 intramedullary implants are : Strength ‘ Stiffness ; Rigidity.

Fatigue failure occurs when an implant is cyclically loaded to a certain stress level.

Intramedullary nails are designed to share the load with the bone for a limited period, as the fracture heals. They are designed to bear significant loads for few million cycles, until fracture unites.

Results of the 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 length⁴³ is defined as the length of a nail 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 the 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.

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 bending in fixation of a transverse fracture than in stabilizing a comminuted fracture. Two techniques which modify the working length are medullary reaming and interlocking. Medullary reaming prepares a uniform canal and improves nail-bone fixation towards the fracture, thus reducing the working length. Interlocking screws also modify the working length in torsion by fixing the nail to the bone at specific points. The torsional stability is substantially improved by this technique and is directly related to the distance between the two fixation points. Weight bearing with an interlocked nail further improves the nail-bone contact as the nail bends under axial load, reducing the working length and adding to the overall stiffness of the fixation.

Interlocking nail can be locked in two modes –Dynamic and Static.

Dynamic Locking : refers to transfixation only in the shorter fragment which is susceptible to rotational instability and allows intermittent compression of the fracture site during early weight bearing. It is indicated in fractures of the lower third and upper third of the shaft with no comminution and the contact area between the two major fragments is at least 50% of the cortical circumference.

Indications :

- a. Proximal and distal fractures
- b. Non union
- c. Mal union

Static locking refers to the placement of transfixing screws above and below the fracture. It controls the riation, bending and axial loading. It is indicated when the fracture is comminuted, unstable to compression or subject to rotational forces.

Indications :

- d. Significant communication
- e. Bone loss
- f. Lengthening osteotomies.

Dynamization means removal of either the proximal or distal locking screws to allow increased axial loading of the tibia. There is no certain time interval when dynamization should occur. However, a general guide line would be 6-8 weeks postoperatively if no signs of fractures healing on X-ray. Ultrasound can help for the early diagnosis of fracture healing.³¹

Dynamization is not indicated if it will compromise the tibial construct. In a nail locked statically, we should decide on which screws, either proximal or distal, it depends upon the decide which screw if removed might production angulation or rotational deformity.

Closed Intramedullary Nailing

The rewards for mastering this technique are many like

1. Decreased risk of infection
2. Absence of additional soft tissue or vascular damage inherent in open reduction.
3. Minimal blood loss
4. Early mobilization
5. Early joint motion
6. Less muscular atrophy
7. Less joint stiffness
8. Higher rate of union and overall reduced morbidity.

Design of Reamed Tibial Nails :

1. AO Tibial Nails :

It is made of a tube with 1.2 mm wall thickness and a cloverleaf cross-section. It has a continuous longitudinal slot on the dorsal aspect, formed as a keystone at the proximal end. The inner conical thread of the proximal end has the same configuration for all nail sizes. This allows the same insertion / extraction instruments to be used for all nail diameters.

The anterior aspect of the proximal end is beveled to prevent irritation of the overlying soft tissue and patellar tendon. The two notches accept the lung of the insertion handle, positioning the handle for right or left leg insertions. The nail has a bend at the transition between the middle and the proximal third. This bend takes into account the anatomical angle of about 11° formed by the axis of the access canal and that of the medullary canal. The bend greatly facilitates insertion. The tapered tip of the nail ensures sliding of the nail along the guide road without penetration of the posterior cortex.

For locking of the nail, there are three holes both proximally and distally. The proximal three holes are used for mediolateral locking. The middle, slotted one is used for dynamic locking, and the two 5 mm diameter round holes for static locking. Two of the distal holes, the most distal and the most proximal, are orientated mediolaterally, and the middle, hole anterior – posteriorly. The antero – posterior (AP) holes is used if medial soft tissue coverage is inadequate or if the proximal mediolateral hole is too close to the fracture site. The most distal mediolateral hole is 20 mm from the nail end, and the second mediolateral hole 30 mm from the first hole.

2. Indian Nail

It is interlocking nail which is hollow and tubular. It is circular in cross section and flares at the top. It has positioning solts to lock the jig and has anterior flattened lip to decrease anterior knee discomfort. It's 2 mm wall thickness gives the nail a certain flexibility or bending and torsion, necessary for fracture healing.

The nails conical proximal end has threads on the inner-side for attachment of jig and extractor. Positioning grooves, precisely align the jig. The observation of stress distribution during insertion has suggested the curvature of 11 degree at the junction of the proximal third and distal $\frac{2}{3}$ rd of the nail. The nail has 2 proximal holes for locking in mediolateral direction and 2 distal holes in the antero – posterior direction. The hole diameter is 5 mm for 9 mm and 10 mm tibial nails and 4 mm for 8 mm nails. The nails available length from 240 mm to 420 mm in 10 mm increments.

- The locking bolts are self – tapping.
- For 8 mm tibial nails 3.9 mm diameter locking bolts are used.
- For 9, 10, 11 mm nails, 4.9 mm diameter locking bolts are used.
- Locking bolt available length from 18 mm to 50 mm in 2 mm increments

3. Gross & Kempf small Diameter Nails :

They have the same cloverleaf cross section and wall diameter as the standard nail, but without the partial posterior slot. They are available in diameter of 9 and 10 mm for tibia. All the nails are flared proximally to provide extra strength for insertion. There are 2 proximal locking holes for 4.5 mm shaft crews. The most proximal hole is directed antero – posteriorly, all the other holes are aligned in the coronal plane.

4. Russel – Taylor Delta Tibial Nail :

It is a close sectioned stainless steel nail available in shaft diameters of 8.9 and 10 mm. The nail has a 15 deg anterior bend 45 mm from the top to allow the nail to enter the proximal portion of tibia. It has a 3 degree anterior bend in the distal 64 mm of the nail, which serves as a ‘ramp’ during insertion to reduce chance of posterior cortical comminution. The proximal end of the nail is tapered to 12 mm to give extra strength for nail insertion. There are 4 locking holes, all in the coronal plane. 4.5 mm screw is used.

METHODS OF TREATMENT

In the past 25 years, tibia fibula fracture has been the most challenging problem of all long bone injuries. Due to progress in the management of this injury, we can now save limbs that would have been amputated 20 years ago.

In dealing with tibia fractures, these are the essential steps to be taken (listed in the order in which they are taken)^{16,54}

1. Treat the open tibia fracture as an emergency. A delay of over 8 hours can allow a contaminated fracture to become infected.

2. Start intravenous antibiotic treatment before debridement and irrigation. Given cefazolin for type I fractures. Cefazolin and an aminoglycoside for type II and type III fractures. For farm injuries or any type of soil contamination, add 10 million units of penicillin. If the patient is allergic to penicillin and cephalosporin, prescribe clindomycin or vancomycin.
3. Perform adequate debridement and irrigation. The goal is to convert a contaminated wound to a relatively clean wound. Repeat debridement in 48 to 72 hours is a must in type III open fractures.
4. Stabilize the fracture.
5. Begin early rehabilitation.
6. Recognize and effectively treat complications, e.g., compartmental syndrome, wound sepsis, and gas gangrene.

Every fracture of the tibial shaft must be assessed individually, and it can be dangerous to establish fixed routines of treatment.

1. Closed reduction and Plaster immobilizations

For closed fractures and low energy open fractures, (Stable fractures) closed reduction is done by simple manipulation under anaesthesia. A long leg cast with adequate padding over the malleoli, back of the head and neck of the fibula is applied with 15 – 20 of flexion at the Knee for 4 – 6 weeks. Later sarmiento cast (patellar tendon bearing cast) is applied for about 8 weeks. It does not always maintain the length of the tibia.

2. Pins and Plaster¹

Unstable and open fractures can be treated with plaster casts incorporating transfixion pins. Here two steinmann pins are inserted in the proximal end and distal end of tibia. Closed reduction is done and below knee plaster cast is applied. Care has to be taken not to distract the fragments when the cast is applied and provided the pins are removed after 3 to 6 weeks. This method has been valuable for distal tibial fractures, including those with joint extension, especially the rotation type pilon fractures.

3. Fixation by Plate and Screws:

Fixation with plates is most appropriate for closed tibial fractures ,open fractures (Gustilo's type I) with good soft tissue coverage. Both standard AO plates with the external compression device and dynamic compression plates function quite satisfactorily. Most often we use Dynamic compression plates for fresh fractures and standard AO plates with the external tensioning device for non unions. Greater degrees of impaction of the irregular bone ends of the non unions are achievable with the later. A plate with 9 holes occasionally is sufficient for transverse fractures, but plates with eight or more holes are necessary more often for short oblique fractures or those with comminution.

Plating has its own disadvantages, it is a load bearing device and hence may lead to delay in union and breakage of implant. The difficulty in closure of skin, is a major problem encountered in the leg. The stripping of soft tissue required for application of a plate, however, has led to an unacceptable rate of infection in patients who have an open tibial fractures. Also, after plate removal a period of about 3

months should be allowed for obliteration of screw holes before strenuous activity can be undertaken.

Most authors now recommend plating for tibial shaft fractures associated with displaced intra articular fractures of the Knee and ankle.

4. External Skeletal Fixation

The popularity of external skeletal fixation for the treatment of open fractures has waxed and waned throughout the middle and later parts of the 20th century. Today external fixation is most often indicated for type IIIB and IIIC open fractures of tibia and fibula⁵⁵. More recently the introduction of ring fixators using highly tensioned Kirschner wires by Ilizarov and others and half pin or hybrid ring fixators by Green and others have expanded the usefulness of external fixators.

External fixators provide rigid fixation with a relatively low rate of deep infection, but they have the disadvantages of frequent pin – tract infections and malunions, a poor appearance and loss of reduction after removal and this technique has long learning curve and has a higher complication rate than intramedullary fixation.^{24,25, 56}

INTRAMEDULLARY NAILING:

This is most accepted surgical treatment of modality. Healing is rapid with abundant callus. These are load sharing devices hence implant induced osteopenia is not encountered

Intramedullary nails, such as Lottes and Ender nails, used without reaming, have been employed successfully in the treatment of open tibial fractures and have

been associated with low rates of post operative infection. They are, however, contraindicated for comminuted fractures, as there tends to be shortening or displacement of such fractures around these small nails. The locking of intramedullary nails to the major proximal and distal fragments decreases the prevalence of malunion of comminuted fractures.

Larsen et, al.(2004) showed that The average time to fracture healing was 16.7 weeks in the reamed group and 25.7 weeks in the unreamed group and Unreamed nailing in patients with tibial shaft fractures may be associated with higher rates of secondary operations and malunions compared with reamed nailing⁵⁷.

Busse JW et, al (2005) suggests that, from an economic standpoint, reamed intramedullary nailing is the treatment of choice for closed and open grade I tibial shaft fractures⁵⁸.

Kowalski D et, al (2007) carried out an investigation on 24 patients (17 male and 7 female) based on measuring the pressure in the deep posterior compartment during tibial intramedullary nailing with reaming. The pressure was checked in each part of the operation. The mean increase of the pressure was 7% (+ 1.6 mmHg) and didn't cause any risk of compartment syndrome. And opined that the intramedullary nailing might be consider as a safe procedure⁵⁹.

Lam SW, Teraa M, et, al.(2010) conducted a systematic search in Pubmed, Embase, and the Cochrane Library and the results showed that reamed IMN led to reduction of nonunion rate compared to unreamed IMN in closed tibial shaft fractures (risk difference ranging 7.0-20%, number needed to treat ranging 5-14), while the difference between compared treatments for open tibial shaft fractures was not

clinically relevant. The evidence showed a consistent trend of reduced nonunion rate in closed tibial shaft fracture treated with reamed compared to unreamed IMN⁶⁰.

Kuzyk PR, Li R; et, al. (2011) conducted the study to relate the extent of reaming to angiogenesis and bone formation occurring around a critical-sized defect in the tibia for two scenarios, namely, when the bone defect is left empty and when the bone defect is treated with autograft; and The results suggest that limited reaming may be beneficial to the acute management of tibial shaft fractures with a bone defect⁶¹.

COMPLICATIONS OF FRACTURE SHAFT OF THE TIBIA

Complications are common after fractures of the tibia and fibula and may be related to the fracture or to its management. Many different treatment modalities for tibial fractures are devised to avoid the complications. Following are the usual complications.

1. Infection:

The incidence of infection of the wound in patients who have an open fracture correlates directly with the extent of soft tissue damage. For Type – I fractures, the rate of infection has ranged from 0-2 percent; for Type-II, from 2 to 7% ; for Type-III over all, from 10-25 percent.⁶²

For Type – III A, 7%

For Type – III B, from 10-50%

For Type – III C, from 25-50%

2. Compartment Syndrome:

The possibility that a compartment syndrome may develop after a fracture of the tibia should not be overlooked. Decompressive fasciotomies of patient in whom the clinical diagnosis of compartment syndrome is made.

3. Delayed Union and Nonunion:

Several factors have been implicated in the cause of delayed union and nonunion, most of which are inherent in the nature of the fracture. High – velocity, open fractures with skin or bone loss and fractures with 100% displacement are more likely to become nonunions than are low velocity injuries.

There is an increased incidence of nonunion in fractures that develop an infection after either open fracture or open reduction.

Distraction at the fracture site and an intact fibula that prevents weight bearing in the cast have also been suggested as causes of delayed union and non union. Inadequate external or internal fixation that allows excessive motion at the fracture site is an other contributing factor.

Clinically, delayed union and nonunion are characterized by pain and motion at the fracture site. Radiographically, there is an absence of bridging callus and persistence of the fracture lines. In hypertrophic nonunion, sclerosis and occasionally flaring of the bone ends are noted at 6 months. In atrophic nonunion, osteopenia at the fracture site and an absence of callus formation may be the only radiographic findings³⁵.

4. Bone defects

Autogenous cancellous bone grafting is most frequently used to create a synostosis between the tibia and fibula, especially when there is anterior tibial bone loss with the posterolateral approach, as described by Harmon⁶³

The Ilizarov⁶⁴ technique using a circular tensioned wire external fixator has been advocated to induce regeneration of bone to fill defects. In this procedure, a corticotomy is performed away from the nonunion site and a segment of bone is transported distally or proximally. The created defect away from the original fracture site gradually fills in with new bone.

5. Malunion and shortening

The four most important criteria for judging alignment of the tibia are angulation in the anteroposterior and mediolateral planes, shortening, rotational malalignment, and displacement.³⁵

Malalignment more than 15 to 21⁰ may require corrective osteotomy if clinically symptomatic with ankle or knee pain. More external rotation is acceptable than internal rotation. Internal rotation of more than 10⁰ may cause gait disturbances, whereas external rotation of as much as 20⁰ usually does not cause a significant gait disorder.

A relatively high malunion rate has been reported for proximal third fractures of the tibia treated with interlocking intramedullary nails. Lang and coworkers⁶⁴ experienced an 84% malunion rate in proximal third tibial fractures treated with intramedullary nails with angulation of 5⁰ or greater in the frontal or sagittal plane. Nineteen of the 32 fractures (59%) and 1 cm or more displacement at the fracture site. In 8 fractures (25%), there was loss of fixation, most commonly associated with placement of a single proximal locking screw.

Shortening of some degree is common with tibial fractures, and many authors believe that physiologic shortening allows impaction of the fracture site and promotes union, especially in early weight bearing protocols.

6. Amputation:

Amputation done above or below the knee after tibial fracture is associated with massive soft tissue injuries resulting directly from the trauma that caused the fracture. Most of these amputations are the result of open wounds and severe soft tissue crushing injuries from motorcycle or motor vehicle – pedestrian accidents.³⁵

Hansen⁶⁵ recommends consideration of primary amputation when open type III B and III C tibial fracture are associated with an insensitive foot or major bony and soft tissue injuries of the foot. Amputation may be a life – saving measure in the severely traumatized patient or in very elderly patient with poor renal and immunologic reserves. Several authors have called attention to improve quality of life by early amputation in severe open fracture and importance of return to gainful employment.^{66,67}

7. Vascular Injuries

Vascular injuries rarely occur at the time of tibial fracture, except in high energy trauma that causes comminuted, markedly displaced, and often open tibial fracture. The most frequent site of vascular injury is the upper portion of the tibia, where the anterior tibial artery passes from behind through the interosseous membrane. The artery may be lacerated by a fracture fragment or occluded by direct pressure from the bone or soft tissue swelling. Irreparable vascular damage may require primary amputation at the level of the injury.

8. Nerve Injury

Primary nerve injury from direct trauma is uncommon in fractures of the tibial or fibular shaft. High energy trauma causing proximal tibial or fibular fractures with gross varus displacement of the distal fragment or direct trauma to the fibular neck may rarely injure the peroneal nerve. Secondary nerve dysfunction, however, is not uncommon and function of the posterior tibial, deep peroneal and superficial peroneal nerves should be evaluated immediately. After fracture reduction, the foot and toes usually can be actively dorsiflexed and plantar flexed. Sensation of the foot and leg should be evaluated, especially in the first dorsal web space.

9. Joint Stiffness and Ankylosis

Bony or fibrous ankylosis is uncommon after tibial fracture, but joint stiffness may involve the knee, ankle, or subtalar joint. Opinion is divided as to the cause of this joint stiffness; some believe it results from prolonged immobilization, while others believe it results from the initial soft – tissue injury or from secondary infection.

10. Traumatic Arthritis:

Traumatic arthritis is unusual unless there is intra-articular extension of the fracture.

11. Reflex Sympathetic Dystrophy:

Reflex sympathetic dystrophy (Sudek's atrophy) is most common after tibial fractures in patients who cannot bear weight early and in those who are immobilized in casts for long periods. These patients usually have severe fractures with significant

soft tissue damage. The massive sympathetic response in the leg and foot is manifested initially by swelling and pain and later by atrophy of the limb. Radiographically, reflex sympathetic dystrophy appears as spotty areas of demineralization in the bones of the foot and distal tibia. Gradual remineralization occurs as weight bearing progress.

Reflex sympathetic dystrophy generally can be treated by gradual weight bearing. Sympathetic nerve blocks may also be of benefit. In patients with deformity of the foot, usually equinovarus, a double upright ankle foot orthosis with a lateral T-strap may be helpful.

12. Refracture

An inadequately healed fracture may refracture if the cast is removed too soon or if unusually heavy stress is applied to a healed but still weaker – than normal tibia. This is particularly likely in younger patients engaged in athletic activities. Contact or stress sports should not be resumed until the musculature of the involved leg regains normal strength and the tibial intramedullary canal has remodeled, which may require 9 to 24 months.

Osteopenia beneath the compression plate has been a frequently reported complication of rigid fixation with compression plates.

13. Claw – Toe Deformity:

Claw – toe deformity rarely causes significant disability after tibial fracture but may be severe if caused by ischemia of the posterior compartment muscles. Tethering of the long extensor tendons by callus on the anterior aspect of the tibia is a rare cause of claw toe deformity. Frequent flexion and extension of the toes should be

encouraged, regardless of the treatment modality selected, and passive stretching should be done at least once a day.⁶⁸

14. Fat Embolism:

Fat embolism can occur after tibial fracture, with signs and symptoms the same as after other fractures. Ganong has recorded an incidence of 19% in isolated tibial fractures from healthy young skiers.³⁵

15. Anterior knee pain:

The main complication of intramedullary nailing is knee pain. This was documented by Keating et al,⁶⁹ who reported that 61 (57%) of 107 patients developed knee pain in the vicinity of the nail insertion site. The pain was activity related in 55 (92%) patients and exacerbated by kneeling in 50 (83%) patients. They also showed statistical correlation between pain and a tendon-splitting approach.

Court-Brown et al⁷⁰ documented similar results reporting 56.2% knee pain in a group of 169 patients. They did not find a positive correlation with a tendon-splitting approach but did find that the patients with pain were significantly younger than the patients without pain.

In a prospective, randomized comparison of the paratendinous or transtendinous approach to the proximal tibia, Toivanen et al⁷¹ failed to show any difference between the two approaches. About 70% of patients reported knee pain, and the approach made no difference to the frequency of knee pain during kneeling, squatting, climbing or descending stairs, sitting, walking, running, or at rest.

METHODOLOGY

I intend to do this study in the department of orthopaedics and casualty in KLE's Prabhakar Kore Hospital and Medical Research Centre, Belgaum, Karnataka. I intend to study over a period of 12 months from January 2010 to December 2010 with sequentially selected 30 cases. I intend to study on the patient attending orthopaedic out patient department and casualty.

Inclusion Criteria :

1. Participant giving consent to enroll in the study.
2. Age > 18 yrs with fracture shaft tibia
3. Patient with closed fracture shaft tibia
4. AO classification used to classify the fractures.
5. Johner & Wruh's Criteria
6. Both males and females

Exclusion Criteria :

1. Participant not willing to enroll in the study.
2. Age <18 yrs
3. Fracture extending into tibial condyle
4. Fractures extending into ankle
5. Duration of the fracture > 3 weeks
6. Pathological fractures
7. Compound fractures of the tibia with extensive soft tissue damage.
8. Old fractures with complications like infection, delayed union, nonunion and malunion.

On admission general condition of the patient was assessed with regards to hypovolemia, associated orthopaedic or other systemic injuries and resuscitative measures taken accordingly. All patients received analgesics in the form of I.M. injections, Tetglob 500 I.V. intramuscularly and antibiotics intravenously. A thorough clinical examination was performed including detailed history relating to age, sex, occupation, mode of injury, past and associated medical illness and the limb was immobilized in the form of above knee plaster of paris posterior slab (or) Thomas splint. Limb elevation over a pillow was given in all the patients.

Routine investigations were done for all patients. All patients were evaluated clinically and radiographically to assess for any injuries. X ray were taken in two planes, anteriorposterior view and lateral view, and importance is given, and other serious injuries like head injuries.

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 subtracting 3 to 4 cm from measurement taken from the knee joint line to tip of the medial malleolus clinically and medullary canal is measured at the isthmus on X-rays. Accordingly a stock of interlocking nails 2 cm above and below the measured length and 1 mm above and below the required diameter were always kept.

Pre operative Preparation of Patients :

- Patients were kept NBM for 8 – 10 hours before surgery.
- IV Fluids are per the need were given.
- Adequate amount of compatible blood if needed was arranged.

- Preparation of whole extremity, private parts and back was done.
- Written and informed consent was taken.
- Soap water enema in night
- Tranquilizers HS
- IV antibiotics half an hour before surgery.

Surgical Technique :

Patients were operated under spinal / general anaesthesia. Patient is placed in supine position over a radiolucent operating table. The injured leg is positioned freely, with knee flexed 90° 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.

AO pneumatic tourniquet / Esmarch rubber 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 10% 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.

Determination of Nail Length :

Hold the radiographic rule parallel to the tibial shaft in such a way that the proximal end comes to lie at the level of the insertion point. Mark the skin at the appropriate point. Position the image intensifier over the distal tibia. Align the measuring rule at the skin marking with correct reduction, we can now read off the

required nail length on the image intensifier picture at the level of former epiphyseal cartilage.

In another way to measure the length of nail is if using the Hollow and Tubular nails, the exposed length of the guide road and sub tract this from its total length of 950 mm.

Determination of Nail Diameter :

The marking on the radiographic ruler may be used to determine the diameter of the medullary canal. Position the square marking over the isthmus. If the transition to the cortex is still visible both to the left and right of the markings, the corresponding nail diameter may be used.

Make a vertical patellar tendon splitting incision over skin extending from central of the inferior pole of patella to the tibial tuberosity about 5 cm long. Split the patellar tendon vertically in its middle and retract it to reach the proximal part of tibial tuberosity. Next step is to determine the point of insertion, essential for the success of the procedure is the correct choice of the insertion point. As a general rule, the insertion point should be slightly distal to the tibial plateau, slightly medial and exactly in line with the medullary canal. If the insertion point is too distal, there is a danger of fracturing the distal cortex of the main proximal fragment.

On the other hand, inserting too far proximally bears the risk of opening the knee joint, patella comes in the way of jig or removal of nail may be difficult. After selecting the point of insertion curved bone awl is used to breach the proximal tibial cortex in a curved manner, so that from perpendicular position its handle comes to be

parallel to the tibial shaft. In the metaphyseal cancellous bone create a entry portal, making sure it is in line with the center of medullary canal.

Point of entry is widened with curved tibial awl.

After widened the medullary canal of proximal 1/3, the ball tip guide wire of 3 mm diameter x 950 mm length passed into the medullary canal of proximal fragment and reduce the fracture fragments under image intensifier by maintaining longitudinal traction in the line of tibia.

After reduction, the tip of guide wire adjusted to pass in the distal fragment upto 0.5 – 1 cm above the ankle joint under image intensifier. Confirm its containment with in the tibia by anteroposterior and lateral views. Next step is to ream the medullary canal. Remaining is done with the help of flexible reamers. Normally we start from 8.0 mm and increase by increments of 0.5 mm. The medullary canal is reamed 1 mm more than the diameter of measured at isthmus an X-ray lateral view.



Fig. 8 : Split patellar tendon approach



Fig. 9 : Medial parapatellar tendon approach



Fig. 10 : Curved bone awl entry into medullary cavity

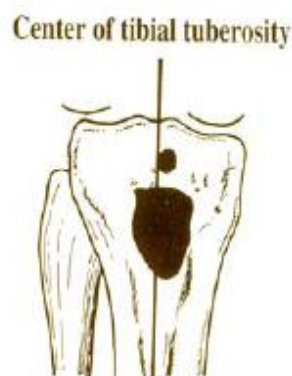


Fig. 11: Point of entry on the tibial tuberosity straight line indicates mid point of tibial tuberosity

Procedure for intramedullary nail(IMN) :

Insert the connecting screw through the insertion handle and coupling block then screw this assembly into the proximal end of the selected nail. Ensure that the notches of the insertion hand fit into the grooves of the coupling block. The coupling blocks ensure a torque – resistant connection between insertion handle and nail. The insertion handle guides the nail and control rotation during insertion. Applied the insertion handle to the medial side of the tibial for insertion and proximal locking. Tighten the whole assembly with combination wrench. Checked that the assembly is firmly screwed together. Over tightening was not done.

Screw the inserter / extractor onto the proximal end of the connecting screw.

Now introduce the (IMN) as far as possible manually into the medullary canal with the help of the mounted insertion instruments. Used the image intensifier to

check passing of the fracture line. Insertion can be aided by gentle blows with the slotted hammer. Insert the nail until it is slightly counter sunk in the bone. Confirm the placement of nail in-situ under image intensifier in both AP and lateral planes.

Routinely we prefer proximal locking carried out first, but if gap present at the fracture site we carried out distal locking first, it enables the use of the rebound technique to prevent diastasis.

The insertion handle is used to locate the holes for proximal locking bolts. The insertion handle of the insertion instrument is in the medial position. The skin is incised insert the trocar into the protection sleeve and push it down onto the insertion handle. Remove the trocar and insert the drill sleeve. To prevent the drill bit from sliding off the tibial surface, ensure that the drill guide is sitting firmly on the bone and is not deflected by skin or soft tissue.

Drill through both cortices using the drill bit. Determine the required length of the locking bolt by reading it directly by measuring with the depth gauge. We added 2 mm to the measurement found so that the bolt can find purchase in the opposite cortex.

Insert the locking bolt with the hexagonal screw drive. Inserted the second locking bolt in the same way. After screwing the insertion handle off (IMN) insert the sealing screw into the proximal end. This prevents in growth of tissue and thus facilitates later implant removal.

Incised wound washed with betadine and normal saline, patellar tend on sutured with delayed absorbable sutures and skin is sutured.

Next step is dislocking locking, several distal dislocking options are available to the surgeon. Using free hand technique with an imageintensifier provides a convenient method for targeting the distal locking holes.

The leg is extended over the table from its flexed position. The IMN, three distal locking holes present two medial lateral plane and middle anteroposterior plane. In our study all cases we locked mediolateral hole. The image intensifier is placed in the radiolateral position with the beam exactly at lateral aspect of the tibia with foot head in neutral position. Adjust the image intensifier until the most distal hole is clearly visible and appears completely round.

Place a scalpel on the skin with the top of the blade over the center of the hole to determine the stab incision point. Make a stab incision in addition, it also ensures that the surgeon's hand remain outside the central radiation field of the image intensifier. Place the tip of the 2.5 mm 'K' wire centered in the locking hole image. Adjust it until the K- wire is in line with the X-ray beam and appears as radio opaque solid circle in the center of the outer ring, hit the K-wire into the bone. The DCP drill sleeve passed over the K wire holds sleeve firmly over the bone. The K wire removed and hole drilled through both cortices with drill bit. Measure the hole with depth gauge for locking bolts. Add 2 mm to this reading to ensure that the locking bolt will engage the far cortex. Insert the locking bolt and tighten with the hexagonal screwdriver. Position of the screw is again confirmed under image intensifier. The entire leg and the fracture site visualized finally in both views for the proper placement of nail. Incised wound is washed with betadine and normal saline skin is sutured. Sterile dressings applied over the wound. Compression bandage given. Tourniquet is deflated. Capillary filling and peripheral arterial pulsations checked.

Post Operative Care :**Immediate :**

- NBM 4-6 hours post operatively
- IV fluids / blood transfusions
- IV antibiotics
- IM analgesics
- Tranquilizers HS
- 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.

Postoperatively elastocreepe 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 anaesthesia. 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 10th – 12th 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 is done at 6 weekly intervals i.e., at 12 and 24 weeks and each patient is individually assessed clinically and radiographically according to the proforma.



Fig. 12: Instruments and Implants for IM nailing

Fig. 13: Surgical technique for intermedullary nailing:



Position of the patient



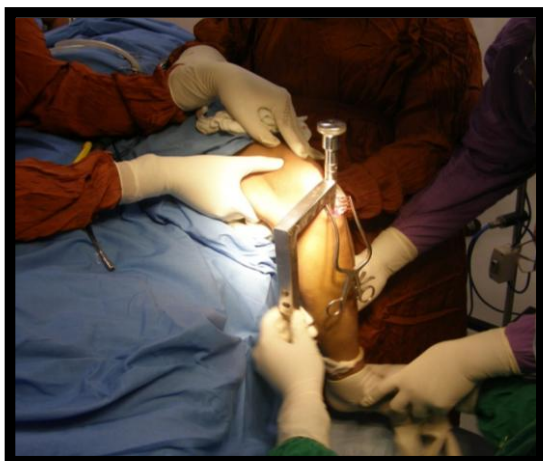
Split patellar approach with awl insertion



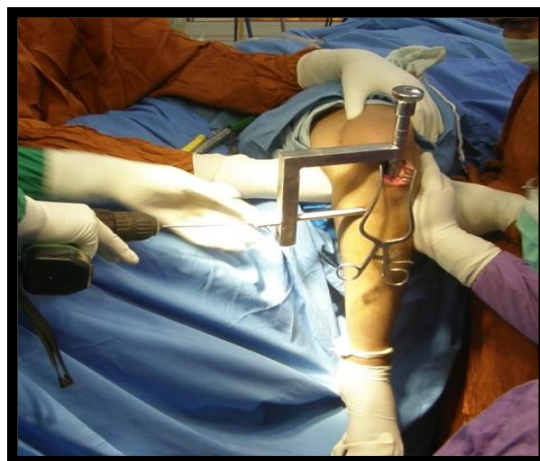
Insertion of the guide-wire



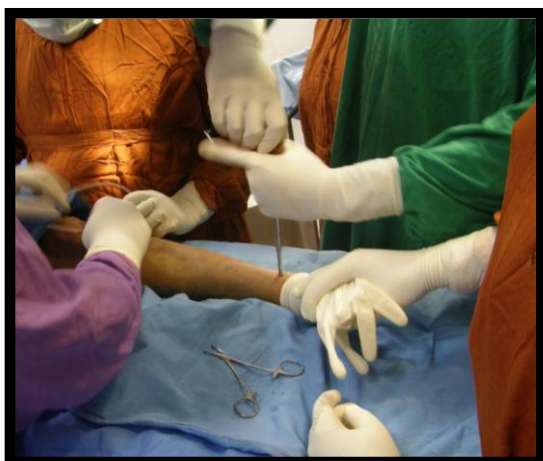
Reaming



Nail insertion



Proximal locking



Distal locking



Wound Closure

RESULTS

The present study includes 30 closed fractures of the tibial shaft surgically treated with closed interlocking intramedullary nailing from october 2009 to october 2011 in the Department of Orthopaedics at KLE's Prabhakar Kore's Hospital and Medical Research Center. The patient have followed up for atleast 8-10 month. All these patients were available for follow up.

The end results of all 30 cases have been summarized here. All the cases had a follow up between 8 to 10 months.

Results were evaluated at every 6, 12 and 24th weeks from the date of discharge.

One of the essential aspect of closed reduction and internal fixation with interlocking intramedullary nailing is the ability to mobilize the patient early. 27 of the patients were mobilized by active knee, bending and quadriceps exercises were initiated after over come from anaesthesia. 3 patients associated with other injuries mobilization was delayed

Table No. 1: Age incidence

Age in years	No. Of cases	Percentage
18-28	9	30
28-38	6	20
38-48	6	20
48-58	6	20
58-68	3	10

Majority of the patients were in the age group of 18 to 48 years(70%). The youngest was 24 year old and the oldest was 66 year old.

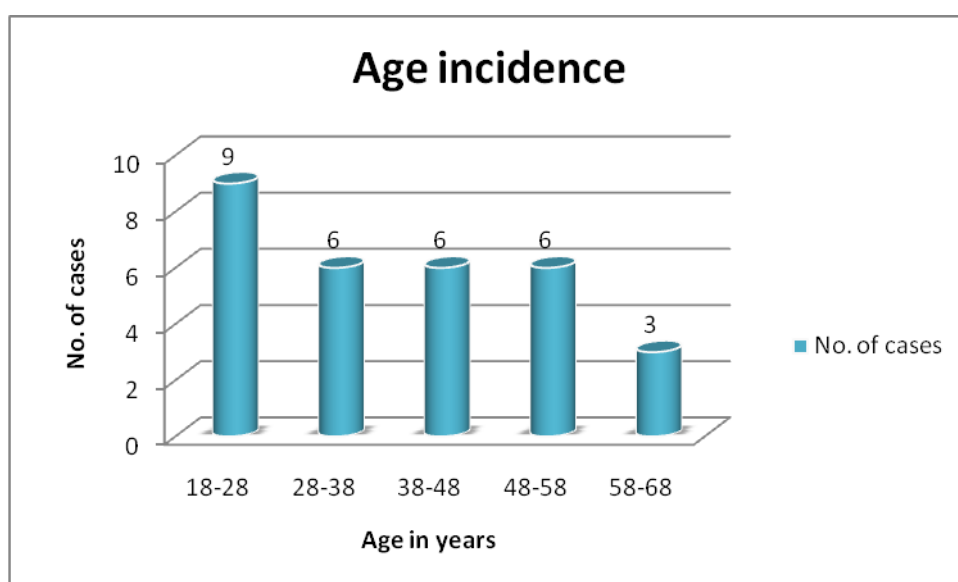
Graph No. 1: Age incidence

Table No. 2: Sex Distribution

Sex	No. Of cases	Percentage
Male	24	80
Female	6	20

Majority of the patients are male 80% and only 20% are female patients.

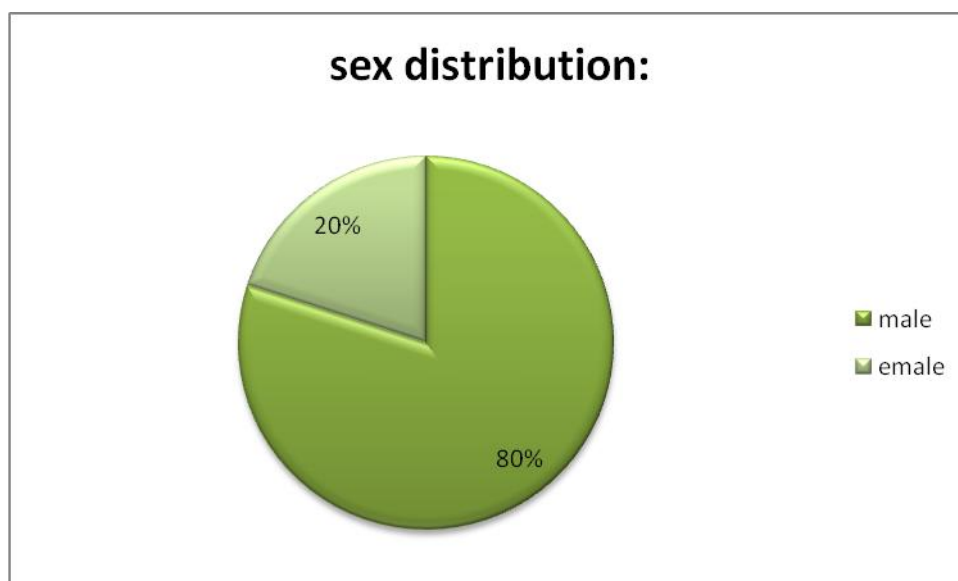
Graph No. 2: sex Distribution

Table No. 3: Mechanism of Injury

Type of Trauma	No. Of cases	Percentage
H/O of Fall	6	20
RTA	24	80

The major causes of fracture in our study was road traffic accident 80%

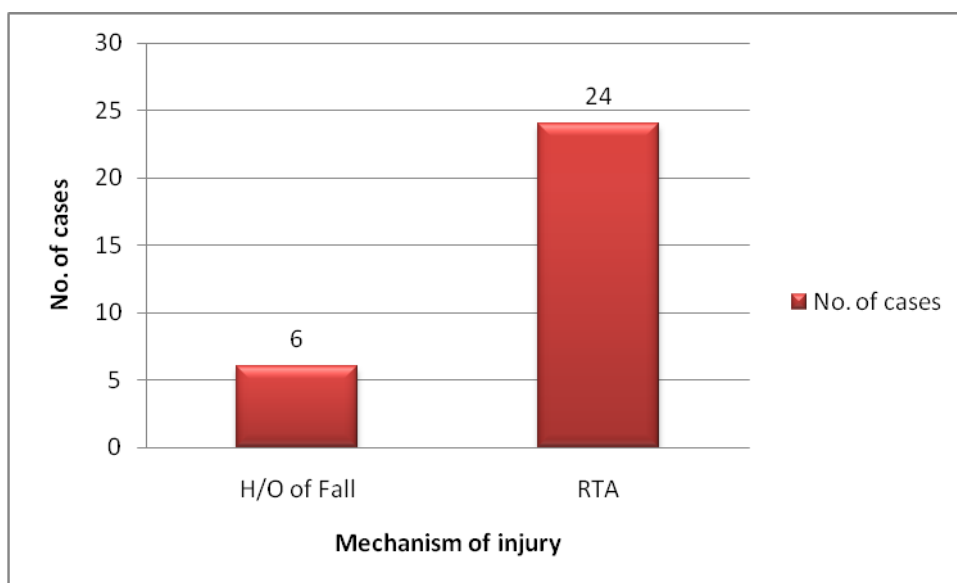
Graph No. 3: Mechanism of Injury

Table No. 4: Side affected

Side	No. Of cases	Percentage
Right	21	70
Left	9	30

In most of the patients Rt side was affected.

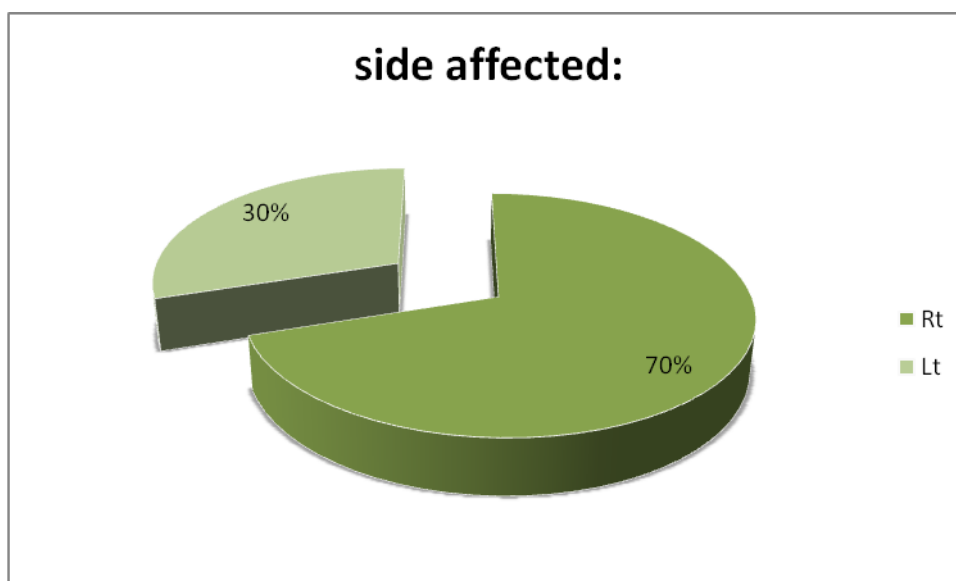
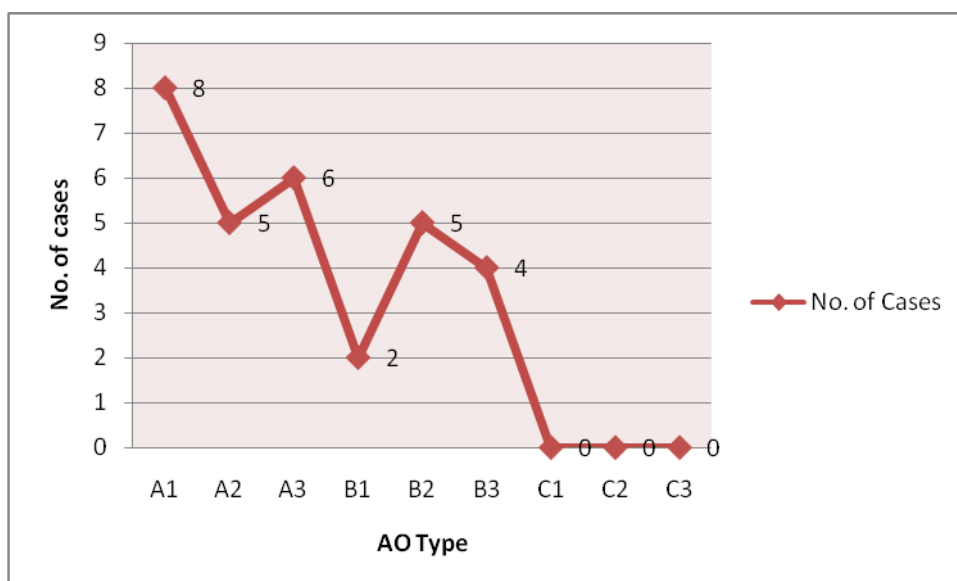
Graph No. 4: Side affected

Table No. 5 : AO type

Type of fracture	Type A			Type B			Type C		
	A1	A2	A3	B1	B2	B3	C1	C2	C3
No. Of cases	8	5	6	2	5	4	-	-	-
Percentage	27	17	20	7	17	12	-	-	-

Graph No. 5 : AO Type



- The predominant tibial fracture pattern was Type A1 (27%).
- In our study most of the cases were associated with fibula fracture.

Table No. 6: Level of fracture:

Level of fracture	No. Of cases
Proximal 1/3	1
Middle 1/3	18
Lower 1/3	11

- Majority of fracture occurred at middle and distal third (97%) in our study.

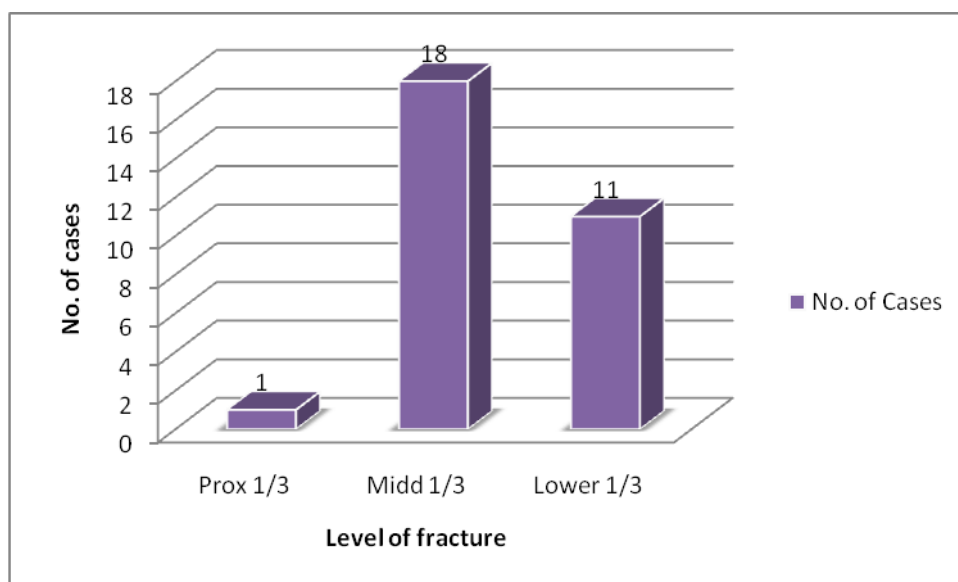
Graph No. 6 : Level of fracture

Table No. 7 : Associated injuries

Associated injuries	No. Of cases	Side affected		Treatment given
		Rt	Lt	
Head injury	6	-	-	Consevatively treated
Clavicle fracture	3	1	2	Consevatively treated
Distal radius	3	2	1	Consevatively treated

Table No. 8 : Type of anaesthesia

Anaesthesia	No. Of cases	Percentage
Spinal	27	90
General	3	10

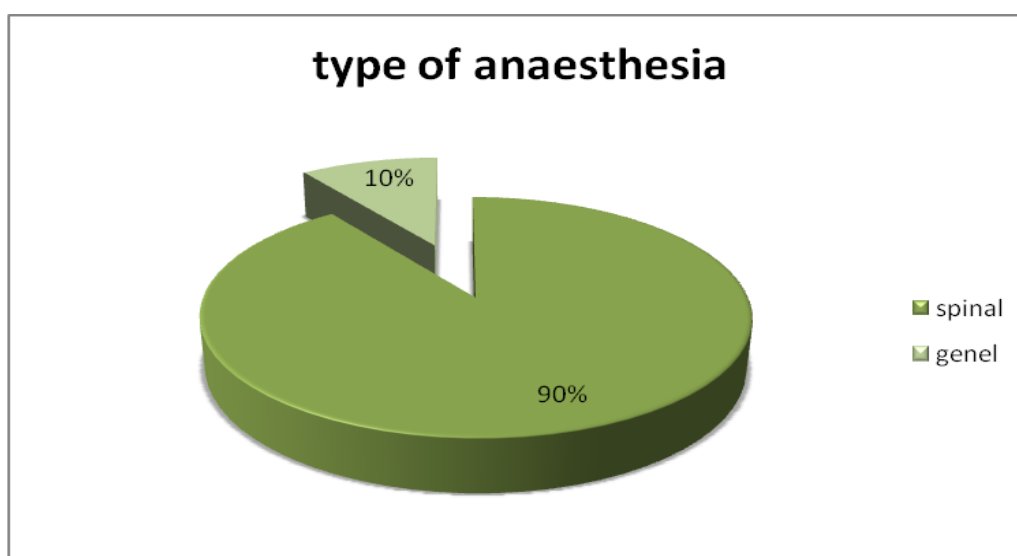
Graph No. 7 : Type of anaesthesia

Table No. 9: Difficulties during operation

Difficulties	No. Of cases	Percentage
Drill bit breakage	3	10
Locking bolt outside of holes (distal)	3	10

Table No. 10: Secondary procedure

Procedure	No. Of cases	Percentage
Dynamization	4	13

In 4 cases dynamization was done between 16-20 weeks.

Table No. 11: Union in relation to type of fracture

Duration in weeks	A1	A2	A3	B1	B2	B3	Total
0-12	0	0	0	0	0	0	0
13-16	8	1	4	0	2	2	17
17-20	0	4	2	2	2	1	11
>20	0	0	0	0	1	0	1
NU	0	0	0	0	0	1	1

Union was defined as the presence of bridging callus on two radiographic views and the ability of the patients to bear full weight on the injured extremity, if other injuries allowed. 28 of the thirty fractures united. The time to union ranged from

three to eight months, with an average of 4 months. 28 fractures healed before 20 weeks, and 1 fractures healed between 21 weeks to 31 weeks. And there was 1 case of non union.

Graph No. 8: Time to bone union

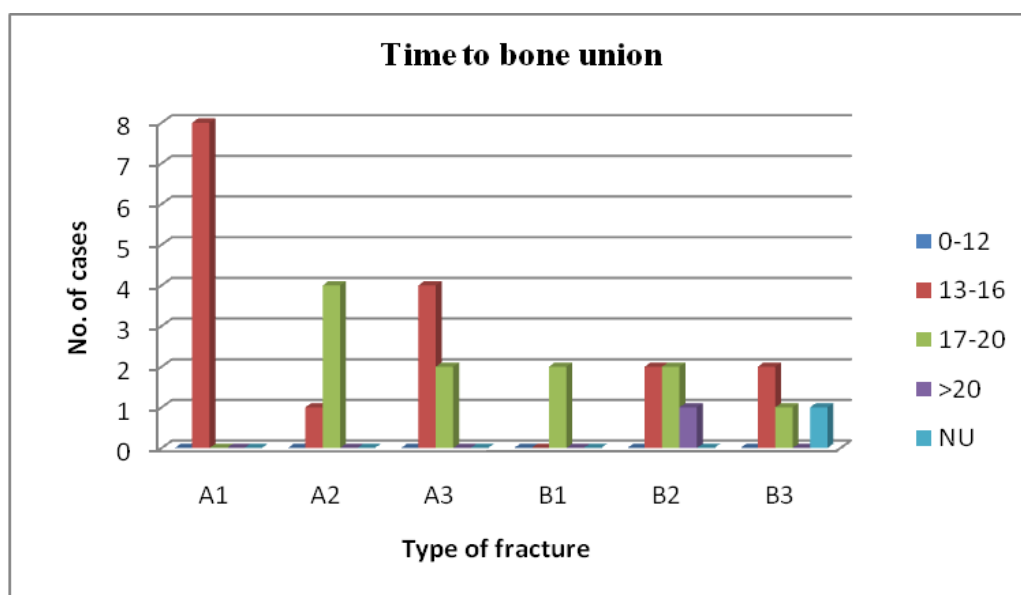
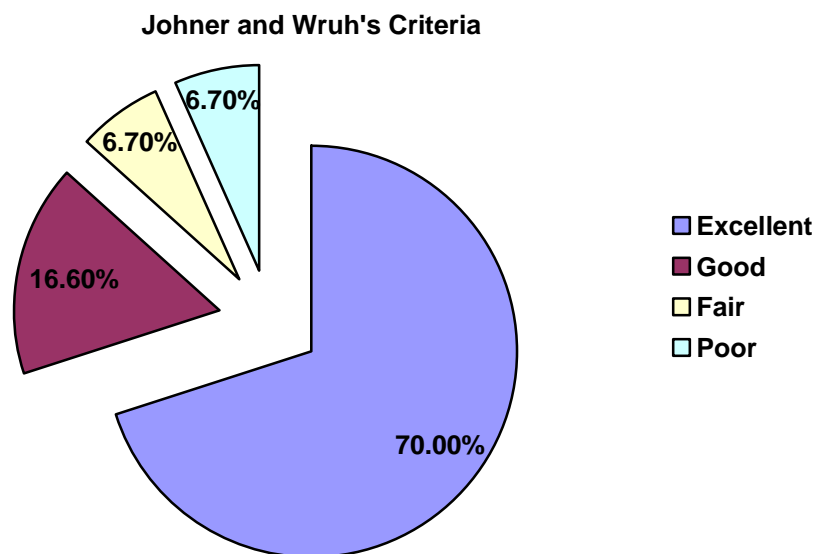


Table No. 12: Functional results (Johner and Wruh's criteria)

	Excellent	Good	Fair	Poor
Non union, Osteitis, amputation	None	None	None	Yes
Neuro-vascular disturbances	None	Minimal	Moderate	Severe
DEFORMITY				
Varus / Valgus	None	2°-5°	6°-10°	>10°
Anteversion / recurvation	0°-5°	6°-10°	11°-20°	>20°
Rotation	0°-5°	6°-10°	11°-20°	>20°
Shortening	0-5mm	6-10 mm	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
sternous activities	Possible	Limited	Severly limited	Impossible
No. Of cases	21	5	2	2

Detailed analysis of function of the patient was done on the basis of the following criteria by Johner and Wruh²⁸ .

Graph No. 9: Functional results (Johner and Wruh's criteria)

The results of this grouped under the above categories are as follows. 21 cases (70%) had excellent results. 5 cases had good results (16.6%), 2 fair (6.7%) and two case (6.7%) poor result.

Table No. 13: Complications

Complications	No. of cases	Percentage
Infection	1	3
Non-union	1	3.3
Knee Pain	6	20

DISCUSSION

The optimal management of tibial shaft fractures continues to be a problem with several unanswered questions. Those fractures, usually caused by high energy trauma, have numerous problems resulting from the poor soft tissue coverage and limited vascular supply of the tibia, cause malunion, non-union, infection and some times resulting in amputation.

There are two major factors related to the lesion that alter the final out come in tibial shaft fractures. The first is the severity of the fracture, characterized according to Nicoll³ by the degree of initial displacement, comminution and soft tissue injury. Accordingly, the more severe the fracture, the higher the rate of complications, and the longer the periods of healing will be, whatever the method of fixation used.

Unstable and open fractures can be treated with plaster casts in incorporating transfixion pins.¹ This method has been valuable for distal tibial fractures, including those with joint extension, especially the rotation type Pilon fractures. The method has an advantage of maintaining the length, prevention of rotation and allows the mobilization of knee. This has the disadvantage of severe pin tract infection and pivoting of the bone and angulation of the fracture site.

Plate osteosynthesis provides rigid fixation of an unstable fracture, and that reduces the problems of non union. The stripping of soft tissue required for application of plate, however, has lead to an unacceptable rate of infection in patients who have an open tibial fractures.

In current series 30 cases of closed fracture of shaft of the tibia were treated by closed reamed interlocking intramedullary nailing over a period of two years.

They were followed up for an average of 10 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 Distribution

The average age of all cases in this series was 40.7 years. The fracture is more common in the age group of 18 – 48 years.

The average age in a study of 50 fractures of tibia conducted by Whittle et. al., showed that the average age was 34 years.

In a study of 43 fractures of tibia conducted by Singer and Kellam, the average age was 36 years.

In another study of 72 fracture of tibia conducted by Borratus et. al., the average age was 30.3 years. (Table No. 14)

Sex Distribution:

There were 24 male and 6 female patients showing male predominance.

The sex distribution in a study by Bonatus et al., showed that there were 52 men and 19 women. In a study by Singer and Kellam, there were 30 males and 11 females (Table No. 15).

Nature of violence

Majority of the cases sustained fractures from road traffic accidents. 6 patients who sustained fracture after a fall. Among R.T.A. motor vehicle accidents 28 cases (80%) was most common mode of injury in present series.

Results

In our series 29 (97%) fractures united within 4 months of injury, is comparable with the other series as well (Table No. 16)

The delay in union was noticed in 1 patient which was infected. And there was one case of non union.

The physiological and stable fixation with reamed interlocking intramedullary nailing should lower the rates of infection and mal union and expand the use of intramedullary locked nails to the tibial fractures with any degree of comminution and soft tissue injury.

A malunion was defined as angulation in a coronal plane (varus – valgus) $> 5^{\circ}$, sagittal plane (anterior – posterior) angulation of $> 10^{\circ}$ or $10 > \text{mm}$ of shortening. In our series, 4 cases of malunion occurred (15%).

These results comparable with the early results of reamed interlocked intramedullary nailing of closed tibial fractures from other centers. (Table No.15).

In our series no implant failure was observed.

On the basis of this study, we are now recommend dynamization of most statically locked nails at 8-12 weeks if callus is not evident to promote fracture union and to avoid fatigue fracture of the inter locking screws.

In our series, 21 patients (70%) full range of knee motion, in 21 patients (70%) full range of ankle motion at 12 weeks of injury (Table No. 12).

In our study 6 patients (20%) noticed pain at the knee joint. Similar results were found by Keating et, al., Court and Brown et, al. and Toivanen et, al.⁶⁹⁻⁷¹

Patzakis et. al., (1996) recommends removal of nail after fracture healed to avoid the risk for reactive of infection.

In our series, no patients developed fat embolism, compartment syndrome, peroneal nerve palsy and reflex sympathetic dystrophy.

Table no. 14: Age distribution compared with other studies.

Authors	Average age in years
Bonatus et. al., ⁶	30.3
Duwelius et. al. ⁷²	40.5
Singer and Kellam ⁷³	36.0
Whittle et. al., ¹⁴	34.0
Present study	40.7

Table no. 15: Sex preponderance compared with other studies.

Authors	Male	Female
Bonatus et. al., ⁶	52	19
Duwelius et. al. ⁷²	12	06
Singer and Kellam ⁷³	30	11
Whittle et. al., ¹⁴	34	13
Present study	24	06

Table no. 16: The results of reamed intramedullary nailing in the treatment of closed tibial fractures.

Authors	No. Of patients	Union (weeks)	Infection (%)	Non-union(%)	Mal-union(%)
Court-Brown et. al., ²⁵	25	15.4	0	0	0
Blachur et. al., ⁵	73	18	2	4	4
Bone et. al., ^{7,8}	47	18	0	2	2
Present study	30	16.89	3.3	3.3	4

CONCLUSIONS

1. Closed reamed interlocking intramedullary nailing with the help of image intensifier seems feasible in diaphyseal fractures of the tibia.
2. Early mobilization of the patient which helps in healing of the fracture and prevent joint stiffness.
3. Minimal blood loss.
4. Minimal risk of infection.
5. Promotes early union as it does not disturb the anatomy and physiology of vasculatiry at the fracture site.
6. Simpler follow-up, escaping repeated visits, plaster changes, wedging and check radiographs.
7. Strict adherence to technical principles during nailing might have prevented some of the complications that developed in this series.
8. Minimal hospital stay and early returns to activities.
9. Acceptable complications rate as compared to other modalities of treatment.
10. Overall reduce morbidity.
11. Cost effective as per reduced need for out patients care, earlier return to work and cessation of sick benefit compensation.

SUMMARY

Thirty patients who had closed fractures of the tibial shaft were treated with reamed interlocking intramedullary nailing with reaming during the period from January 2010 to December 2010 at KLE's Prabhakar Kore Hospital and Medical Research Centre. All the cases were fresh fractures and were traumatic in nature.

They were followed for a period of 8-10 months.

Our aim was to treat these fractures by reamed intramedullary interlocking nailing, early mobilization and to assess the outcome of interlocking nailing in the treatment of these fractures using Johner and Wruh's criteria.

The mean age of patients with these fractures was 40.7 years and the maximum patients were in the age group of 18-48 years. Males predominated in our study.

Road traffic accidents are the main cause of these fractures followed by fall.

In our series most of them were type A1 (27%) of AO classification. Most of the fractures occurred at the junction of middle-distal third of tibia. 40% of 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 was 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. Most of the cases surgery was performed in 2-4 days of trauma.

In all the cases midline patellar tendon splitting approach was used for nail insertion site. In three cases there was guide wire bending during nail insertion. In 3 cases drill bit was broken, while drilling the proximal holes. Our mean operating time was 90 minutes (Range 100 min to 150 min).

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

28 fractures had united with in 4 months of injury and 1 cases of delayed union, which united with 8 months. There was one case of non union.

In 21 patients (70%) full range of knee motion at 12 weeks, in 5 cases more than 80° of knee motion, in two cases more than 75° of knee motion and in 2 cases less than 75° of knee motion. In 21 patients (70%) full range of ankle motion at 12 weeks, more than 75° of ankle motion in 5 cases (17%). In two cases more than 50° of ankle motion (6%) and in 2 cases there was less than 50% loss of ankle range of motion.

In two case varus angulation were noticed between 6° - 10° and in two patient more than 10° anterior angulation of 7° - 5° . Shortening noticed in four patients, more than 1 cm of shortening.

One patients developed superficial infection which was healed with antibiotics.

21 cases (70%) had excellent results. 5 cases had good results (17%), 2 fair (6%) and two case (7%) poor result.

Closed intramedullary interlocking nailing is feasible in fracture of shaft of tibia. Image intensifier has revolutionized the treatment of tibial shaft fractures by making the technique easier.

The present series shows that closed fractures of the tibial shaft, managed with reamed interlocking intramedullary nailing, involves minimal surgical trauma and negligible blood loss. It provides the advantages of early ambulation, lower rates of infection, delayed union, non-union and malunion compared to other treatment modalities. To achieve these goals, we recommended early stabilization with reamed interlocked nail. Fracture should be dynamized at 8 –10 weeks, if union does not progress to prevent the unwanted complication of non-union or delayed union.

A significant advantage of interlocking in addition to early joint motion, early weight bearing allows earlier return to work.

In our series we found that reamed interlocking nailing in fractures of tibial shaft is feasible as showed excellent and good results in 87% patients with minimal complications.

BIBLIOGRAPHY

1. Anderson LD., Hutchens WC., Wright PE., and Disney JM. Fractures of the tibia and fibula treated by casts and transfixing pins. Clin Orthop 1974; 105 : 179-191.
2. Bach AW., and Hansen Jr. S.T. Plates versus external fixation in severe open tibia shaft fractures : A randomized trial. Clin Orthop 1989; 241 : 89-94.
3. Nicoll EA. Fractures of the tibial shaft : A survey of 705 cases. J Bone Joint Surg 1964 ; 46 B : 373-387.
4. Watson – Jones. Injuries of the leg. Chapter – 32 in “Watson-Jones fractures and joint injuries”, 6th Edn, Wilson JN (Ed)., B.I. Churchill Livingstones: New Delshi 1998, 1071pp
5. Blachur PA, O’Brien PJ. Meek RN, et. al., Interlocking intramedullary nailing with and without reaming for the treatment of closed fractures of the tibial shaft. J Bone Joint Surg 1997 ; 79 A : 640-646.
6. Bonatus T, Olson SA., Lees and Champman MW. Non reamed locking intrameduallary nailing for open fracture of the tibia. Clin Orthop 1997; 339: 58-64.
7. Bone LB., Johnson KD. Treatment of tibial fractures by reaming and intramedullary nailing. J Bone Joint Surg (Am) 1989; 68 : 877-887.

8. Bone LB, Sucato D, Stegemann PM et. al., Displaced isolated fractures of the tibial shaft treated with either a cast or intramedullary nailing. *J Bone Joint Surg* 1997 ; 79A : 1336-1341.
9. Brown PW. Urban JG. Early weight bearing treatment of fractures of the tibia “ An end result of 63 cases. *J Bone Joint Surg* 1969; 51 A : 59-75.
10. Chapman MW. The role in intramedullary fixation in open fracture. *Clin Orthop* 1986 ; 212 : 26-34.
11. Lottes JO. Medullary nailing of the tibia with the triflange nail. *Clin Orthop* 1974; 105 : 253.
12. Court Brown DM, Will E., Chirstile J, et. al., Reamed or un-reamed nailing for closed tibial fractures. *J Bone Joint Surg* 1996; 78 B : 580-583.
13. Schmidt AH, Finkemeier CG, Tornetta P. Treatment of closed tibial fractures. *3rd Instr Course Lect* 2003;52:607-22.
14. Rhinelander FW. Tibial blood supply in relation to fracture healing. *Clin Orthop* 1974; 105 : 34-81.
15. Johner R., and Wruhs O. Classification of tibial shaft fractures and correlation with results after rigid internal fixation. *Clin Orthop* 1983; 178:7
16. Gustillo R.B. Fractures of the tibia and fibula. Chapter-27, Fractures and dislocations, Edt. Gustillo RB., Kyle RF., and Templemen DC., Mosby, Philadelphia 1992; 901 pp.

17. Gustillo RB., Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones. Retrospective and prospective analysis. *J Bone Joint Surg* 1976; 58 A : 453-458.
18. Watson-Jones R., Coltart WD. Slow union of fractures iwht a study of 804 fractures of the shaft of the tibia and femur. *J Bone Joint Surg* 1942; 30 : 260.
19. Dehne E, Metzcow, Deffer PA., et. al. Non operative treatment of the fractured tibia by immediate weight bearing. *J Trauma* 1961; 1 : 514.
20. Sermiento A. Functional below knee cast for tibial fractur. *J Bone joint Surg (AM)* 1967; 49 : 855.
21. Ruedi T., Webb JK., and Allgower M. Experience with the dynamic compression plate (DCP) in 418 recent fractures of tibial shaft. *Injury* 1976 ; 7 : 252-257.
22. Chapman MW., Nmahoney M., The role of internal fixation in the management of open fractures. *Clin Orthop* 1979; 138 : 120-131.
23. Olerud S, Strömberg L. Intramedullary reaming and nailing: its early effects on cortical bone vascularization. *Orthopedics* 1986; 9:1204-8.
24. DeBastiani G., Aldegheri R., and Renzi Brivio L. The treatment of fractures with a dynamic axial fixator. *J Bone Joint Surg* 1984; 66 : 538-546.
25. Court Brown CM., and Hughes SPF. Hughes external fixator in treatment of tibial fractures. *J Soc Med* 1985; 78 : 830-837.

26. Pankovich AM., Tarbisky IE., and Yelda S. Flexible intramedullary nailing of tibial shaft fracture. Clin Orthop 1981; 160 : 185-195.
27. Henley MB., Chapman JR., Agel J., et. al. Comparison treatment of grade II and III open tibial shaft fractures. Orthop Trans 1994 ; 19 : 143-144.
28. Venkat S. Interlocking nails. A new era in fracture management. Chapter-7 in “Recent advances in orthopaedics-2”, 1st Edn, Kulkarni GS (Ed), Jayapee Brothers : New Delhi; 1997, 152 pp.
29. Watson – Jones. Operative reduction of fracture. Chapter-16 in “Watson-Jones fractures and joint injuries”, 16th Edn, Wilson JN (Ed), B.I. Churchill Livingstone: New Delhi; 1998, 387 pp.
30. Thakur AJ, (Ed) : “Intramedullary nailing” chapter 5 in “The elements of fracture fixations”, Churchill Livingstone: New York; 1997, 81 pp.
31. Weller S., and Hontsch. D. Medullary nailing of femur and tibia. Chapter-4 in “Manual of internal fixation, Techniques recommended by the AO-ASIF group”, 3rd Edn, Muller ME., Allogwer M (Ed)., Mosby: NewYork; 1998, 2067-2094pp.
32. Ellis H. The speed of healing after fracture of the tibial shaft. J Bone Joint Surg 1958; 40B : 42-46.
33. Gustillo RB., Mendoza RM., Williams DN. Problems in the management of type III (severe) open fractures : A new classification of type III open fractures. J. Trauma 1984; 24 : 742-746.

-
34. Ruedi TH., Border RJU., and Allgower M. Classification of soft tissue injuries. In manual of internal fixation, techniques recommended by the AO-ASIF group, 3rd Edn., Edt., Muller ME., and Allgower M., Springer – Verlag : New York; 1990 : 151 pp.
 35. Ressel TA. Fractures of the tibia and fibula. Chapter-30, Rockwood and Green's Fractures in adults, 4th Edn., Edt. Rockwood DA., Green DP., Bucholz RW., Heckman., Lippincott-Raven: Philadelphia; 1996 : 2127 pp.
 36. Bhandari M, Guyatt GH, Swiontkowski MF, Schemitsch EH. Treatment of open fractures of the shaft of the tibia. *J Bone Joint Surg Br* 2001; 83: 62-8.
 37. Bhandari M, Guyatt GH, Tong D, Adili A, Shaughnessy SG. Reamed versus nonreamed intramedullary nailing of lower extremity long bone fractures: a systematic overview and meta-analysis. *J Orthop Trauma* 2000; 14:2-9.
 38. Forster MC, Bruce AS, Aster AS. Should the tibia be reamed when nailing? *Injury* 2005; 36:439-44.
 39. Rhinelander FW. Tibial blood supply in relation to fracture healing. *Clin Orthop Relat Res* 1974; 105:34-81.
 40. Rhinelander FW. The vascular response of bone to internal fixation. In: Browner BD, Edwards CC, editors. *The science and practice of intramedullary nailing*. Philadelphia: Lea and Febiger; 1987. p 25-9.
 41. Klein MP, Rahn BA, Frigg R, Kessler S, Perren SM. Reaming versus non-reaming in medullary nailing: interference with cortical circulation of the canine tibia. *Arch Orthop Trauma Surg* 1990; 109:314-6.

42. Hupel TM, Aksenov SA, Schemitsch EH. Cortical bone blood flow in loose and tight fitting locked intramedullary nailing: a canine segmental tibia fracture model. *J Orthop Trauma* 1998; 12: 127-35.
43. Schemitsch EH, Turchin DC, Kowalski MJ, Swiontkowski MF. Quantitative assessment of bone injury and repair after reamed and unreamed locked intramedullary nailing. *J Trauma* 1998; 45:250-5.
44. Schemitsch EH, Kowalski MJ, Swiontkowski MF. Soft-tissue blood flow following reamed versus unreamed locked intramedullary nailing: a fractured sheep tibial model. *Ann Plast Surg* 1996; 36:70-5.
45. Utvåg SE, Grundnes O, Reikerås O. Effects of degrees of reaming on healing of segmental fractures in rats. *J Orthop Trauma* 1998; 12:192-9.
46. Grundnes O, Utvåg SE, Reikerås O. Restoration of bone flow following fracture and reaming in rat femora. *Acta Orthop Scand* 1994; 65:185-90.
47. Fairbank AC, Thomas D, Cunningham B, Curtis M, Jinnah RH. Stability of reamed and unreamed intramedullary tibial nails: a biomechanical study. *Injury* 1995; 26:483-5.
48. Whittle AP, Wester W, Russell TA. Fatigue failure in small diameter tibial nails. *Clin Orthop Relat Res* 1995; 315:119-28.
49. Bhandari M, Schemitsch EH. Bone formation following intramedullary femoral reaming is decreased by indomethacin and antibodies to insulin-like growth factors. *J Orthop Trauma* 2002; 16:717-22.

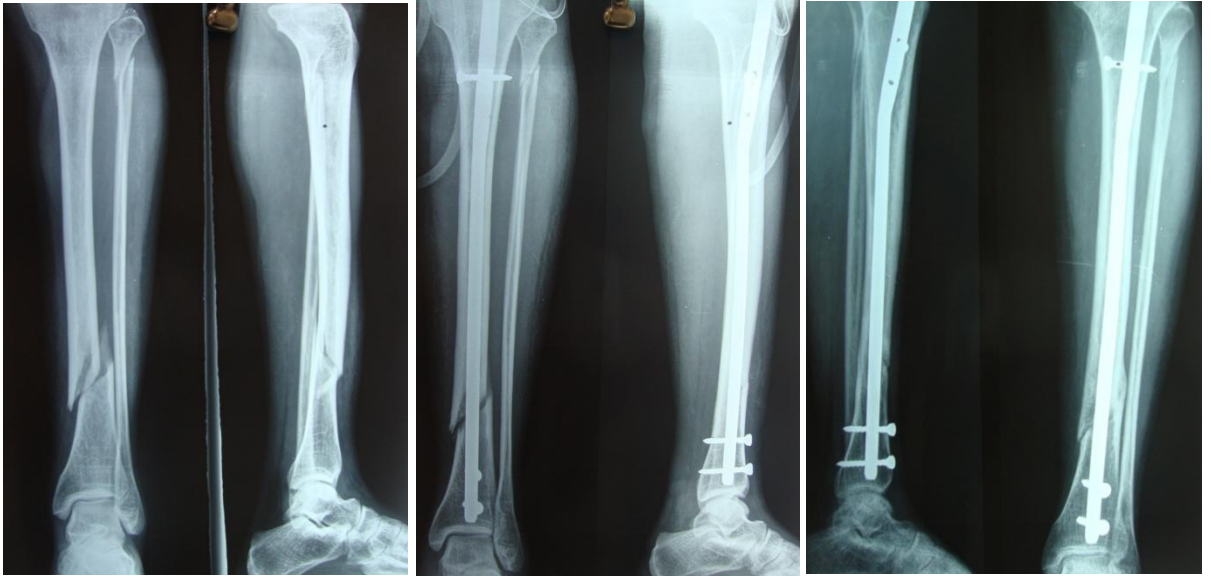
50. Littenberg B, Weinstein LP, McCarren M, Mead T, Swiontkowski MF, Rudicel SA, Heck D. Closed fractures of the tibial shaft. A meta-analysis of three methods of treatment. *J Bone Joint Surg Am* 1998; 80:174-83.
51. Coles CP, Gross M. Closed tibial shaft fractures: management and treatment complications. A review of the prospective literature. *Can J Surg* 2000; 43:256-62.
52. Anglen JO, Blue JM,. A comparison of reamed and unreamed nailing of tibia. *J of Trauma* 1995; 39: 351-355.
53. Wiss DA, Stetson WN, Unstable fractures of tibia treated with reamed intramedullary interlocking nail. *Clin Orthop Rel Res* 1995; 315:56-63
54. Templeman DC., Gulti Benjamin., Tsukayama DT and Gustilo RB. Update on the management of open fractures of the tibial shaft. *Clin Orthop* 1998 ; 350: 18-25.
55. Whittle AP. Fracture of lower extremity. Chapter-47 in “Campbell’s operative orthopaedics”, 9th Edn., Canale ST (Ed)., Mosby : NewYork; 1998, 2067-2094pp.
56. Holbrook JL., Swiontkowski MF., Sanders R. Treatment of open fractures of the tibial shaft : Ender nailing versus external fixation : A randomized prospective comparison. *J Bone Joint Surg* 1989 ; 71 A : 1231- 1238.
57. Larsen et, al. Should insertion of intramedullary nails for tibial fractures be with or without reaming? A prospective, randomized study with 3.8 years' follow-up. *J Orthop Trauma* 2004 Mar; 18(3):144-9

58. Busse JW, Bhandari M, Sprague S, Johnson-Masotti AP, Gafni A. An economic analysis of management strategies for closed and open grade I tibial shaft fractures. *Acta Orthop*. 2005 Oct;76(5):705-12.
59. Kowalski D, Orłowski J, Rylski W, Pomianowski S, Zakrzewski P. Effect of intramedullary nailing of tibial shaft fractures on the pressure in the deep posterior compartment of the leg; *Chir Narzadow Ruchu Ortop Pol* 2007 Nov-Dec;72(6):415-7.
60. Lam SW, Teraa M, Leenen LP, van der Heijden GJ. Systematic review shows lowered risk of nonunion after reamed nailing in patients with closed tibial shaft fractures. *Injury* 2010 Jul; 41(7):671-5. Epub 2010 Mar 11.
61. Kuzyk PR, Li R, Zdero R, Davies JE, Schemitsch EH. The effect of intramedullary reaming on a diaphyseal bone defect of the tibia. *J Trauma* 2011 May; 70(5):1248-56.
62. Gustillo RB., Merkow RL., and Templeman D. Current concepts review the management of open fractures. *J Bone Joint Surg* 1990 ; 72 A : 299-304.
63. Harmon PH. A simplified approach to the posterior tibia for bone grafting and fibular transferal. *J. Bone Joint Surg* 1945; 63 A : 921-931.
64. Ilizarov GA. Clinical application of the tension – stress effect for limb lengthening. *Clin Orthop* 1945; 250 : 8-26.
65. Hansen ST., Jr. Over view of the Severely traumatized lower limb reconstruction versus amputation. *Clin Orthop* 1989 ; 243 : 17-19.

66. Pozo JL., Powell B., Andrews BG., Hutton PAN and Clarke J. The timing of amputation for lower limb trauma. *J Bone Joint Surg* 1990 ; 72 B : 288-292.
67. S. Sidharthan, A. Sujith, A. K. Rathod & R. H. Pathak. Management Of High Energy Tibial Fractures Using The Ilizarov Apparatus. *The Internet Journal of Orthopedic Surgery* 2005; 2(2):1-5.
68. Clawson DK. Claw toes following tibial fracture. *Clin Orthop* 1974; 103 : 47.
69. Keating JF, Orfaly R, O'Brien PJ. Knee pain after tibial nailing. *J Orthop Trauma* 1997; 11:10–13.
70. Court-Brown CM, Gustilo T, Shaw AD. Knee pain after intramedullary tibial nailing: its incidence, etiology and outcome. *J Orthop Trauma* 1996; 11:103–105.
71. Toivanen JAK, Väistö O, Kannus P, et al. Anterior knee pain after intramedullary nailing of fractures of the tibial shaft. *J Bone Joint Surg Am* 2002; 84:580–585.
72. Duwelius PJ., Schmidt AH., Rubinstein RA., and Green JM. Non reamed interlocked intramedullary tibial nailing one community's experience. *Clin Orthop* 1995 ; 315 : 104-113.
73. Singer RW., Kellam JF. Open tibial diaphyseal fractures : Results of unreamed locked intramedullary nailing. *Clin Orthop* 1995; 315 : 114-118.
74. Charnley J. Fractures of the shaft of the tibia. The closed treatment of common fractures, Edinburgh: Churchill Livingstone; 1961 : 209-249 pp.

75. Lang GJ., Cohen BE., Bosse MJ., and Kellam JF. Proximal third tibial shaft fractures should they be nailed? *Clin Orthop* 1995; 315 : 64-74.
76. Moed BR., Watson JT., Goldschmidt P., and Holsbeeck MV. Ultrasound for the early diagnosis of fractures healing after interlocking nailing of the tibia without reaming. *Clin Orthop* 1995; 310 : 137-144.
77. Smith JE, 1974 : “Results of early and delayed internal fixation for tibial shaft fractures : A review of 470 fractures”. *J Bone Joint Surg (Br.)* 56-B : 469-477.
78. Velasco A., White Side TE, Jr., and Fleming LL. Open fractures of the tibia treated with the Lottes nail. *J Bone Joint Surg (AM)* 1983; 65 : 879-885.
79. Whittle AP and Wood II GW. Fractures of the lower extremity. Chapter 51 in *Orthopaedics Terry Canale S (Ed), Campbells Operative Orthopaedics, Volume 3, 11th Edition, USA Philadelphia: Mosby; 2003; 3085-95.*
80. Whittle AP., Russell TA., Taylor JC., Lavelle DG. Treatment of open fracture of the tibial shaft with the use of interlocking nailing without reaming”. *J Bone Joint Surg* 1992 ; 74 A : 1162-1171.

EXCELLENT RESULTS



Preoperative X-ray AP-Lateral

Immediate Postoperative X-ray AP-Lateral

X-ray AP-Lateral after 6 months



Full range of knee and Ankle movements

GOOD RESULTS



Preoperative X-ray AP-Lateral



Immediate Postoperative X-ray
AP-Lateral



X-ray AP-Lateral after 6 months



Knee > 80% and ankle 75% movements

FAIR RESULTS



Preoperative X-ray AP-Lateral



Immediate Postoperative X-ray AP-Lateral



X-ray AP-Lateral after 6 months



Knee 75% and Ankle 50% movements

POOR RESULTS



Preoperative X-ray AP-Lateral



Immediate Postoperative X-ray AP-Lateral



X-ray AP-Lateral after 6 months



Knee <70% and Ankle <50% movements

ANNEXURE I

INFORMED CONSENT

TITLE OF THE STUDY: “A INTERVENTIONAL STUDY TO KNOW THE OUTCOME OF REAMED INTRAMEDULLARY INTERLOCKING NAIL IN THE MANAGEMENT OF TIBIAL SHAFT FRACTURES”.

Principle Investigator : BL0109003

INTRODUCTION AND PURPOSE:

Intramedullary interlocking nailing is the preferred operative technique, for the treatment of tibial shaft fractures in patient owing to its good range of movements, early mobilisation and the stability which it provides the subject following surgery.

The main purpose of the current study is to, assess the functional outcome and complications of these patients with tibial shaft fractures fractures treated with Intramedullary interlocking nailing, with regard to functional mobility, stability and the range of movements using Johner and Wruh’s criteria.

PROCEDURE

If you CONSENT to be in this study, the relevant data is collected as per the proforma, and the final diagnosis is confirmed after correlating both clinical and radiological evidences. The subject is then posted for the proposed surgery after obtaining the fitness for surgery. Following this the patient is operated wherein the participant is placed in the supine position with affected limb bent at 90° and entry into the proximal metaphysis is done and then the medullary cavity is reamed. Correct size of intramedullary interlocking nail are fixed taking all aseptic precaution. After 1

week partial weight bearing advised using a walker. Subject discharged on day 14 and advised to continue exercises to strengthen muscles around the knee and ankle. Follow up of the patient carried out at 6weeks, 3 months and 6 months.

BENEFITS

1. Early mobilisation
2. Avoids all decubitus problems.
3. Maintains the tibial length
4. Prevents recurrence of deformity.

RISKS

1. Infection.
2. Non union
3. Joint stiffness

ALTERNATIVES:**VOLUNTARY PARTICIPATION/WITHDRAWAL:**

Taking part in this study is voluntary. I may choose not to take part in this study, or if I decide to take part I can later change my mind and withdraw from the study. My decision will not change the present or future health care or other services that I receive. The study doctor or the sponsor may stop my participation in this study. I will tell of any important new findings that may change my willingness to continue to take part. If I choose not to take part in the study I will receive the standard treatment for patients with my condition.

COSTS : Each DHS implant will cost around Rs 1500/- to 2500/-.

COMPENSATION: As the subject voluntarily consents to be a part of the study, no compensation will be given.

CONFIDENTIALITY:

All information collected about the subject during the course of the study will be kept confidential to the extent permitted by the law. The code numbers will identify the subject in this research record. Information from this study may be published but the subjects identity will be confidential in any publication.

QUESTION:

If any enquiries in the future or in case of study related injury or illness, you may contact the principle investigator.

CONSENT TO PARTICIPATE IN RESEARCH STUDY:

I voluntarily agree to take part in this study by signing below. I may withdraw at any time. I am not giving up any of my legal rights by signing this form. My signature below indicated that I have read this entire consent form or it has been read to me, and had all my questions answered. I will be given a copy of this consent form.

Signature of the Participant or legally authorized representative.

Participant's Name :

Signature :

Name of the legally authorized representative :

Signature :

Witness's Name :

Signature :

Investigators name and Signature :

Date and Place :

ANNEXURE II**“A INTERVENTIONAL STUDY TO KNOW THE OUTCOME OF
REAMED INTRAMEDULLARY INTERLOCKING NAIL IN THE
MANAGEMENT OF TIBIAL SHAFT FRACTURES”.**

Sl. No:

IP No:

Name:

Age:

Sex:

Occupation:

Address:

DOA:

Complaints:

Nature of trauma:

1. RTA
2. Sports injuries
3. Fall from height
4. Trivial

Mechanism of injury:

1. Direct
2. Indirect

Duration since injury:

1. < 1 Week
2. > 1 Week

Significant past history:

a. History of diabetes, hypertension, asthma, epilepsy:

1. Yes
2. No

b. Previous history of fractures

1. Yes

2. No

General physical examination:

a) Pulse Rate:

b) Blood Pressure:

c) Respiratory Rate:

Pallor:

Cyanosis

Icterus

Clubbing

Pedal edema

Lymphadenopathy

Respiratory system examination:

Cardio vascular system examination:

Per abdominal examination:

Central nervous system examination:

Presence of any associated injury:

1. Yes

2. No

If yes specify:

Local examination:

ON INSPECTION

LOWER LIMB INVOLVED	RIGHT	LEFT

ATTITUDE

SWELLING

DEFORMITY

ON PALPATION

TENDERNESS

CREPITUS

ABNORMAL MOBILITY

NEUROVASCULAR DEFICITS

1. Yes
2. No

SKIN

ANY OPEN WOUNDS

1. Yes
2. No

PUNCTURE WOUNDS

1. Yes
2. No

RELEVANT INVESTIGATIONS:

1- Yes

2- No

a) x-ray full length tibia– AP view

b) x-ray full length tibia- lateral view

c) blood: hb%, tc ,dc ,esr.

d) urine: albumin ,sugar, microscopy

DIAGNOSIS:**X-RAY**

AO CLASSIFICATION X	TYPE – A			TYPE - B			TYPE – C		
	A1	A2	A3	B1	B2	B3	C1	C2	C3

TREATMENT:

First aid: (1- Yes , 2 – No)

a) Immobilisation of the injured limb in posterior POP slab:

b) Analgesics:

c) Antibiotic started

d) Wound irrigation debridement

Definitive treatment:

a) Relevant investigations and medical fitness for surgery

1. Yes

2. No

b) Anaesthesia

Spinal / General

c) Intra Medullary Interlocking Nail

- Nail length
- Diameter of the nail
- Type of the nail

d) Interlocking screws - length

- Distal
- Proximal

e) Antibiotic therapy- (1- Yes, 2-No)

Pre – operative:

Post –operative:

e) Analgesics (1-Yes, 2- No.)

COMPLICATIONS:**a. Intraoperative: (1- Yes , 2- No)**

- Difficulty in reduction
- Excessive bleeding
- Wrong placement of implant
- Occurance of any fracture of the proximal shaft during insertion

b. Postoperative:

a) Immediate: (1- Yes, 2- No)

• Bleeding • Infection

Duration of stay in hospital :

Range of movements at discharge

Advise at discharge regarding weight bearing

FOLLOW UP:

Date:

Serial no. Of follow up:

Time since surgery:

Clinical union:

	1 ½ months	3 months	6 months	1 year
Range of movements (Knee/ ankle/ subtalar)				
Tenderness at the fracture site				
X-ray findings				
Any other complications				

Final deformity:

Angulation

Varus/ Valgus

Anterior / Posterior

Rotation

Shortening

Final result : Excellent/ Good/ Fair/ Poor

Johner & Wruh's Criteria after rigid internal fixation

	Excellent (Lt=Rt)	Good	Fair	Poor
Non union, Osteitis, amputation	None	None	None	Yes
Neuro-vascular disturbances	None	Minimal	Moderate	Severe
DEFORMITY				
Varus / Valgus	None	2°-5°	6°-10°	>10°
Anteversion / recurvation	0°-5°	6°-10°	11°-20°	>20°
Rotation	0°-5°	6°-10°	11°-20°	>20°
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
sternous activities	Possible	Limited	Severely limited	Impossible

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

MASTER CHART

S.No	name	I.P. No.	Age	Sex	Mode of injury	DOA	DOS	DOD	side	AO type	level of #	associated fib #	associated injuries	complications	secondary procedure	time for bony union	ROM knee	ankle	subtalar	results	gait	shortening
1	rachappa	329348	59	M	RTA	1/1/2010	1/3/2010	1/12/2010	LT	A2	Midd 1/3	present		none		17	N	N	>75%	E		
2	balkrishna	332294	42	M	RTA	1/5/2010	1/6/2010	1/15/2010	RT	A3	Midd 1/3	present		none		18	N	N	>75%	E		
3	sunita	332565	55	F	H/o of fall	1/11/2010	1/14/2010	1/23/2010	RT	A3	low 1/3	present		none		19	>80%	>75%	>50%	G	4mm	
4	basavraj	335954	28	M	RTA	1/12/2010	1/13/2010	1/22/2010	RT	A1	low 1/3		head injury/distal rad f	none		16	N	N	>75%	E		
5	pavan raj	345000	25	M	RTA	1/14/2010	1/16/2010	1/25/2010	LT	B2	Midd 1/3	present		none		20	N	N	>75%	E		
6	chandrakant	350833	45	M	RTA	1/20/2010	1/22/2010	2/2/2010	RT	A1	low 1/3			none		16	N	N	>75%	E		
7	shamroa	351974	24	M	RTA	2/1/2010	2/2/2010	2/12/2010	RT	B1	midd 1/3	present		none		19	>80%	>75%	>50%	G	6mm	
8	geeta	354049	36	F	RTA	2/15/2010	2/17/2010	2/27/2010	LT	A2	midd 1/3	present		none		18	N	N	>75%	E		
9	damodar	355609	27	M	RTA	3/3/2010	3/4/2010	3/14/2010	LT	A3	low 1/3	present		none		15	N	N	>75%	E		
10	nanasaheb	356709	27	M	RTA	3/8/2010	3/10/2010	3/20/2010	RT	B3	Midd 1/3			none	dyn	20	>75%	>50%	<50%	F	12mm	insig limp
11	bharati	358097	40	F	RTA	3/18/2010	3/20/2010	3/29/2010	RT	B2	low 1/3	present	head injury/lt clavicle	none		16	N	N	>75%	E		
12	ismail	358512	50	M	H/o of fall	3/22/2010	3/24/2010	4/4/2010	LT	B1	Midd 1/3	present		none		17	N	N	>75%	E		
13	manoj	360824	36	M	RTA	4/7/2010	4/10/2010	4/20/2010	LT	A1	Midd 1/3	present		none		15	N	N	>75%	E		
14	balu	361940	36	M	RTA	4/20/2010	4/24/2010	5/5/2010	LT	B2	low 1/3	present		INF	dyn	31	<75%	<50%		P	16mm	sig limp
15	fakirrapa	360912	50	M	RTA	4/22/2010	4/24/2010	5/4/2010	RT	A3	Midd 1/3			none		16	N	N	>75%	E		
16	tukaram	360103	58	M	RTA	4/24/2010	4/26/2010	5/7/2010	RT	B2	prox 1/3	present		none	dyn	18	>75%	>50%	<50%	F	11mm	insig limp
17	shivanand	364361	25	M	RTA	5/4/2010	5/7/2010	5/17/2010	LT	A1	Midd 1/3			none		14	N	N	>75%	E		
18	dundappa	364069	50	M	RTA	5/5/2010	5/7/2010	5/17/2010	RT	B3	low 1/3	present		none		16	>80%	>75%	>50%	G	5mm	
19	siddama	365630	65	F	RTA	5/12/2010	5/14/2010	5/25/2010	RT	A3	Midd 1/3	present	head injury/distal rad l	none		15	N	N	>75%	E		
20	dhananjay	366437	24	M	RTA	5/19/2010	5/20/2010	5/28/2010	LT	A2	Midd 1/3		head injury/lt clavicle	none		17	N	N	>75%	E		
21	baburoa	370139	48	M	RTA	6/14/2010	6/16/2010	6/26/2010	RT	B3	low 1/3		head injury	NU	dyn		<75%	<50%		P	18mm	sig limp
22	pradeep	371323	29	M	H/o of fall	6/28/2010	6/30/2010	7/10/2010	RT	A3	low 1/3	present	hjury/distal rad Rt/rt c	none		14	N	N	>75%	E		
23	maruti	374193	56	M	h/o of fall	7/11/2010	7/13/2010	7/23/2010	RT	B3	Midd 1/3	present		none		14	>80%	>75%	>50%	G	7mm	
24	shivanand	374287	37	M	H/o of fall	7/12/2010	7/13/2010	7/23/2010	RT	A1	Midd 1/3	present		none		16	N	N	>75%	E		
25	ravindra	374513	48	M	RTA	8/22/2010	8/24/2010	9/4/2010	RT	A2	low 1/3	present		none		15	N	N	>75%	E		
26	nagangouda	381968	25	M	RTA	9/15/2010	9/16/2010	9/26/2010	RT	B2	Midd 1/3	present		none		14	>80%	>75%	>50%	G	4mm	
27	pandurang	324850	34	M	RTA	9/16/2010	9/18/2010	9/25/2010	RT	A1	Midd 1/3			none		16	N	N	>75%	E		
28	bhaiya	325814	28	F	H/o of fall	9/20/2010	9/21/2010	9/28/2010	RT	A2	midd 1/3			none		17	N	N	>75%	E		
29	gulam hussai	327177	50	M	RTA	10/3/2010	10/6/2010	10/15/2010	RT	A1	midd 1/3	present		none		16	N	N	>75%	E		
30	mahadev	326409	66	F	RTA	10/10/2010	10/12/2010	10/22/2010	RT	A1	low 1/3	present		none		15	N	N	>75%	E		