# ANALYSIS OF FUNCTIONAL OUTCOME OF EXTRA ARTICULAR PROXIMAL THIRD TIBIAL FRACTURES TREATED BY INTRAMEDULLARY NAILING

Dissertation submitted to

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY

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This is to Certify that this dissertation work titled "**COMPARATIVE STUDY OF FUNCTIONAL OUTCOME OF INTERLOCKING NAILING AND DYNAMIC COMPRESSION PLATING FOR DIAPHYSEAL FRACTURE HUMERUS IN ADULTS**" of the candidate **Dr.PULISERI SRINIVAS** with Registration Number **221812201** for the award of Master of Surgery in the branch of Orthopaedics and Traumatology, I personally verified the urkund.com website for the purpose of plagiarism check. I found that the uploaded thesis file contains from introduction to conclusion pages and result shows **12%** percentage of plagiarism in the dissertation.

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## DECLARATION

I, **Dr. Ravindran.S**, do solemnly declare, that this dissertation **"ANALYSIS OF FUNCTIONAL OUTCOME OF EXTRA ARTICULAR PROXIMAL THIRD TIBIAL FRACTURES TREATED BYINTRAMEDULLARY NAILING"**, is a bonafide record of work done by me, in the Department of Orthopaedics and Traumatology, Thanjavur Medical College, Thanjavur, under the supervision of my Professor and Head of Department **Dr.S.KUMARAVEL, M.S.ORTHO, D.ORTHO, DNB.ORTHO, Ph.D,** between May 2018 to October 2020. This dissertation is submitted to the Dr. M.G.R. Medical University, Chennai, in partial fulfilment of the University's regulations, for the award of M.S. Degree (Branch – II) in Orthopaedics, to be held in May 2021.

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## TABLE OF CONTENTS

# INTRODUCTION

Fractures of the Tibia are the most common long bone fractures of the human skeleton in the present century. They constitute about 17% of all lower limb fractures. Extraarticular proximal-third fractures of Tibia account for 5% to 11% [1] of all tibial shaft fractures and occur as a outcome of a variety of mechanisms including road traffic accidents, industrial accidents, sports injuries etc.,

Diaphyseal tibial fractures of the middle third have been effectively managed with Interlocking nailing for many years. But proximal third tibia fractures present diverse problems with respect to all aspects of management and must be distinguished from mid diaphyseal fractures. Treatment is more challenging than for more distal fractures and the rates of compartment syndrome and arterial injury are higher, especially for displaced fractures. The problem of fixation of any long bone fracture with a short proximal or distal fragment [2] is a long-recognized entity. Goals of management of any skeletal injury with regards to perfect fracture alignment, retaining the limb length and earliest functional recovery holds good for Proximal Tibia fractures too.

Every skeletal injury also includes the adjacent musculo-ligamentous structures [3] and the incidence of which being high with Proximal Tibia Fractures due to the higher amount of injury involved, proper care needs to be taken to prevent devastating complications.

Closed management often leads to varus malunion [4] especially when the fibula is intact. Closed treatment should therefore be reserved for nondisplaced or minimally displaced fractures with little soft-tissue injury.

The treatment of fractures of the proximal tibia is complex and makes complex demands on the implants used. Plating of the proximal tibia has become a less popular alternative [5] because of the high incidence of infection and fixation failure. External fixation although an attractive alternative devoid of soft tissue complications has got its own share of drawbacks to consider it a stable long-term construct.

Although intramedullary nailing can lead to valgus malunion in a sizable percentage of patients with this injury, it can be useful for stabilizing fractures with proximal fragments longer than 5 to 6 cm [5]. Placing the entry portal more proximal and lateral, locking in extension, and using specific techniques, such as blocking screws, can improve alignment after nailing. Use of an algorithm that takes into account the severity of soft-tissue injury, the length of the fracture fragment, and the degree of fracture stability allows effective decision making among current treatment techniques.

The advantages of Interlocking nailing for Proximal third tibia Fractures [6] include load sharing, preservation of Extraosseous blood supply, very minimal soft tissue dissection thereby reducing the risk of postoperative complications.

The typical deformity caused by intramedullary nailing of proximal tibial fractures is valgus and apex anterior angulation [5] with anterior translation of the proximal fragment. Various means of insertion of Interlocking nail and reduction of the fracture have been established to minimize these difficulties. Use of one or more of these techniques has resulted in lesser incidence of mal-reduction.

Recent advances in nail designs has increased the indications for nailing and extended the spectrum of proximal tibial metaphyseal and diaphyseal fractures suitable for fixation. Currently there is very little literature available to date to clearly put forth the improved functional and radiological outcome following interlocking nailing of Proximal third Extraarticular Tibial Fractures.

The above factors justify this separate study with regards to the prognosis of this spectrum of injuries.

## AIM OF THE STUDY

To analyze Functional Outcome of Extraarticular Proximal third Tibia Fractures treated with Intramedullary Nailing done in Department of Orthopaedics and Traumatology, Govt Thanjavur medical College and Hospital between the period of July 2018-October 2020.

# LITERATURE REVIEW

The following table serialize the events in the evolution of the intramedullary nailing technique

| | | |
|---|---|---|
| 1875-1886 | Heine, Bardeheuer, Socin, Burns, Bircher | Ivory Pegs were started being used experimentally and clinically |
| 1902 | Lejahrs | Referred ivory pegs as NAILS |
| 1907-1916 | Lambotte,Heygroves | Use of Metallic Intramedullary implants begun |
| 1940 | Gerhardt Kuntscher | Announced intramedullary nailing at Berlin in German Surgical Congress |
| 1942 | Habler | First book on technique of intramedullary nailing published |
| 1942 | Lorenz Bohler (Representative of conservative fracture treatment) | At Viennese Medical Society he stated "Intramedullary nailing is the most important contribution to treatment of fractures of long bones. Kuntscher's intramedullary nailing is the method of future" |
| 1945 | Kuntscher, Maatz | Published their book "The technique of intramedullary nailing" |
| 1951 | Herzog | Introduced rigid cloverleaf nail |
| 1951 | Livingstonbar | short I-bean pattern nail pointed at both ends, had short slots for cross pinning with screws |
| 1968 | Kuntscher | At annual meet of German Surgical Society introduced the name "interlocking nail" since it describes the principle of new nail better. |

| | | |
|---|---|---|
| 1960-<br>1970 | Klemm, Schellmann, Gross-Kemp | Front runners of current generation of interlocking nails. |
| 1966 | Kaessuman | Introduced the concept of compression nailing. |
| 1995 | Lang, Bernishke, Freedman, | Extensive evaluation with regards to complications following proximal tibial fracture fixation particularly IL nailing studied |
| 1999 | Krettek | Used “Poller screws” in stabilizing tibia fractures with short proximal or distal fragments after insertion of small diameter intramedullary nails |
| 1999 | Tornetta P III | Semi extended position for nail entry and risks of articular damage in nail insertion studied |
| 2000-<br>tilldate | Various workers | Oblique locking screws, Less Herzog bend,<br>Intraoperative two pin external fixator,<br>Anterior Unicortical plating etc., evolved |
| 2010 | Eastman, Gelbke | Retro patellar approach for proximal tibial nailing |

## APPLIED ANATOMY

Extraarticular Proximal third Tibia fractures are complex injuries that involve both bone, soft tissue and neurovascular structures. Relevant musculoskeletal anatomy must be understood, consequently, from both a skeletal and a soft tissue standpoint. Very clear understanding of the intra articular structures is usually necessary for identifying the proper entry point for nail insertion.

### SKELETAL ANATOMY

Of the two leg bones, the **Tibia** accepts the majority of the body's weight, while the fibula serves as a site for muscular attachment. The tibia is a triangular-shaped bone in cross section in its diaphysis. The **Extraarticular proximal tibia** refers to the proximal end of the tibia including the epiphyseal, metaphyseal and the diaphyseal regions with the wide medullary canal which work contrary to the principle of interlocking nailing.

According to the described AO-OTA classification, the **Tibial plateau** includes the metaphysis to a distal distance equal to the width of the proximal tibia at the joint line [7]. But even fractures little further down into the diaphysis have been posing problems of malreduction due to the strong musculotendinous forces acting distally apart from the wide skeletal architecture. The Proximal tibial **articular surface** is divided into medial and lateral plateaus [7] as well as the tibial eminence which are lined with hyaline cartilage. This tibial eminence is further divided into prominent medial and lateral tibial spines. The **Tibial spines** are between the plateaus. The medial and lateral tibial spines serve as attachment points for the anterior and posterior cruciate ligaments in addition to the menisci.

Proximally, the **Tibial tubercle** is found anterolaterally about 3 cm below the articular surface. This site serves as a point of attachment for the patellar tendon. Directly posterior to the patellar tendon is a richly vascularized fat pad. Further lateral on the proximal tibia is Gerdy's tubercle where the iliotibial band inserts.

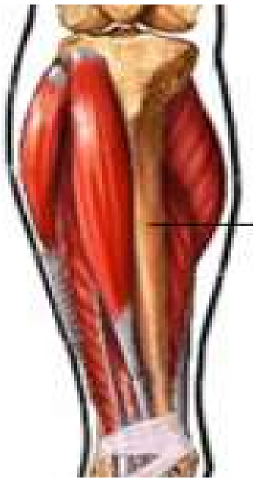
One of the most important anatomic distinctions related to the proximal end of the tibia is the size and shape of the medial and lateral condyle. The medial condyle with its articular surface [5] has a slightly concave shape and is larger in both length and width than the lateral condyle, which has an articular surface slightly convex in shape. Understanding the size and shape differences between the two condyles aids interpretation of radiographic landmarks and knee pathology

Another important anatomic difference is the difference in height of the lateral and medial **Condyles**. The lateral tibial plateau lays around 2 to 3 mm superior (proximal) to the medial plateau. There is a slight **Varus alignment** of the proximal tibia (medial proximal tibial angle = 87° (85–90°)[8] . It is also important to recognize that the proximal end of the tibia has a **Posterior slope** of approximately 9° (posterior proximal tibial angle = 81° (range = 77–84°).

The fibular head lies along the posterolateral border of the lateral tibial plateau and adjoins the tibia at the proximal tibiofibular joint, which begins just distal to the knee joint line. The fibula head serves as the attachment for several important knee posterolateral corner stabilizers. The tibial tubercle is the main attachment site for the patellar tendon, which has a broad flat insertion of about 3 cm in width.

**Muscle attachments**

It is vital to recognize some of the critical muscle attachments to the proximal end of the tibia as these muscles are important secondary stabilizers for the knee and their attachments may contribute to the deforming forces acting at the fracture site.

On the anterolateral portion of the tibia, the iliotibial band attaches to Gerdy's tubercle. The patellar tendon attaches to the anterior tibial tubercle. The pes anserine tendons (made up of the sartorius, gracilis, and semitendinosus) attach to the anteromedial tibia approximately 5 to 7 cm below the joint line [9]. Posteriorly, the semimembranosus attaches over a broad area to the proximal medial end of the tibia, and the popliteus originates from the posteromedial border of the proximal tibia.

## NEUROVASCULAR ANATOMY'

Neurovascular structures are at danger with proximal tibia fractures. The common peroneal nerve courses around the neck of the fibula distal to the proximal tibia-fibula joint before it splits into its superficial and deep branches. It is at risk with severe displacement subsequent to high-energy fractures of the proximal tibia. The trifurcation of the popliteal artery into the anterior tibial, posterior tibial and peroneal arteries occurs posteromedially in the proximal tibia. Vascular injuries to these structures are common following knee dislocation, but can happen in high-energy fractures of the proximal tibia as well.

## CLASSIFICATION

The AO classification is currently the most comprehensive

System for describing tibial fracture patterns. This system considers non-articular proximal tibia fractures separately from tibial shaft and plateau fractures. Furthermore, it distinguishes between simple (type A2) and comminuted (type A3) fractures of the proximal extra-articular tibia. Comminuted fractures are usually more unstable. Other factors, including initial displacement, fracture pattern, and severity of soft-tissue damage, must also be considered to develop an accurate assessment of the fracture character; however, those characteristics are not included in the AO classification.

## AO CLASSIFICATION

Proximal third Extra-articular tibial Fractures were usually classified with AO classification as it allows better reproducibility in terms of measuring the functional and radiological outcome. All of those fractures fall within the classes of 41-A2 &A3 The description of the numbering follows:

4- Tibia

1- Proximal segment

A- Extraarticular

1. Avulsion
2. Simple

.1- Mediolateral oblique

.2- Anterior Oblique

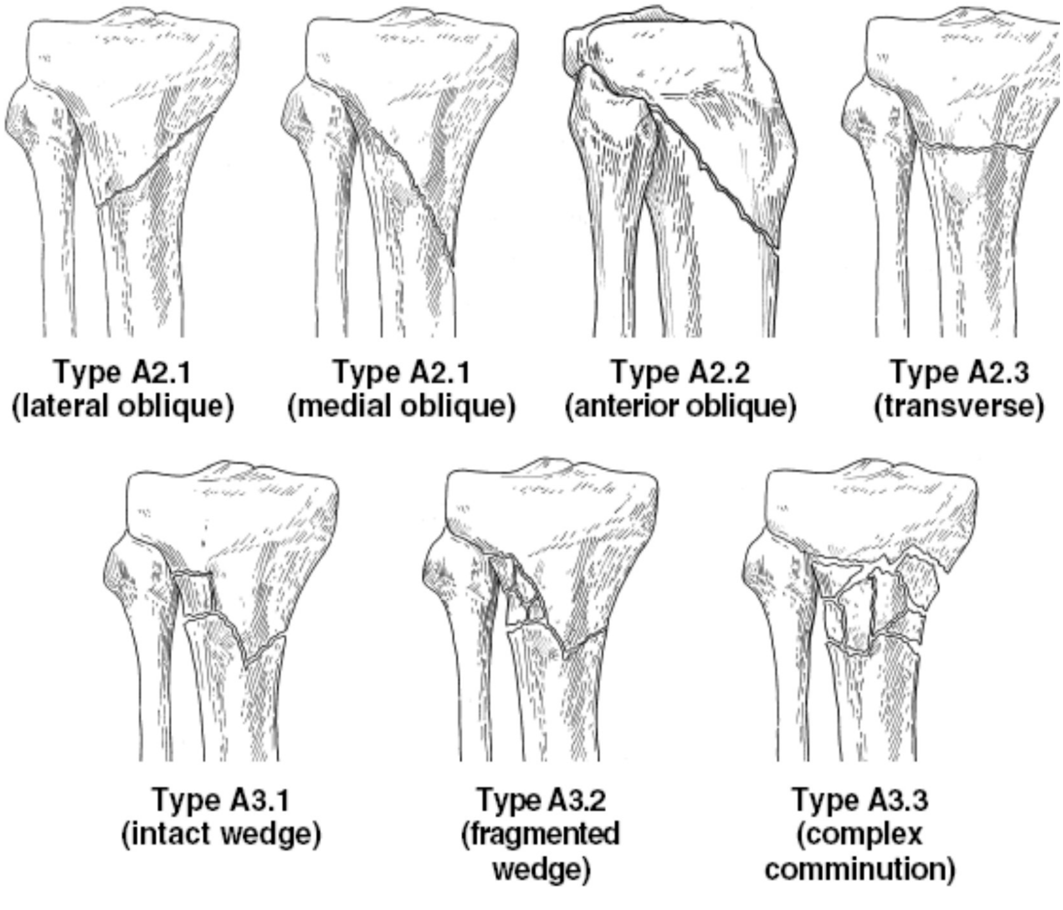
.3- Transverse

3. Comminuted

.1- Intact Wedge

.2- Fragmented wedge

.3- Complex Communition




**AO classification of proximal third extra-articular tibial fractures**

## WINQUIST AND HANSEN CLASSIFICATION

In 1980, Winquist proposed a classification based on fracture comminution which is most useful for determining the need for interlocking nails

Type I: Minimal or no comminution

If comminution is present, there is involvement of 25% or less of the bony circumference.

Type II: Comminuted fragments involve up to 50% of the width of the bone.

Type III: Comminuted fragment involves more than 50% of the width of the bone that leaves only a small area of contact between the proximal and distal fragments.

Type IV: Comminution involves the entire bony circumference and there is no cortical contact.

## TECHNICAL CONSIDERATION OF THE PROXIMAL TIBIA FRACTURES-SAFER ENTRY SITE - BIOMECHANICS OF THE NAIL INSERTION AND POLLER SCREWS

## BIOMECHANICS OF THE FRACTURE

Deforming forces acting on the proximal tibia fracture contribute to the typical apex anterior deformity. The patellar tendon inserts on the tibial tubercle and pulls the proximal fragment into extension [10] while the hamstring tendons and Gastrocnemius muscle pull the distal fragment into flexion. This deformity is further increased as the knee is flexed [9] for standard IM nailing. The pes anserinus inserts anteromedially on the proximal fragment, and the anterior compartment muscles originate on the anterolateral proximal tibia. The force exerted on the tibia by these attachments contributes to valgus deforming forces.

The triangular bony architecture of the proximal tibia consists of a wide metaphyseal region that narrows distally to form a well-defined cortical tube. In the patient with proximal tibia fracture, the nail fits loosely in the proximal fragment and cannot maintain alignment. In addition, the ventral axis of the tibial shaft is slightly lateral to the midline of the epiphysis, and the anteroposterior width of the shaft is narrower medially [11] If the initial point is located too far medially, the medial tibial metaphyseal cortex acts as a chute that deflects the nail laterally. A valgus deformity is produced as a result of the decreasing sagittal space and pronounced lateral slope of the medial wall. When the nail come into the diaphysis and becomes collinear with the tibial axis, the proximal portion of the fracture is tilted into valgus due to the erroneous starting point.

## BIOMECHANICS OF INTERLOCKING NAILING

Fractures of the proximal third of the tibial shaft are difficult to treat with intramedullary nails for several reasons. The nail is significantly smaller than the area within the proximal fragment [12] This makes alignment in both sagittal and coronal planes dependent on the operative reduction. A small angulation in the proximal fracture can be accentuated by the nail as it is passed. The obvious goal of treatment is to achieve anatomical reduction with stable fixation. However, even if this is achieved at surgery, it is difficult to maintain postoperatively.

When placed in a fractured long bone, IM nails act as internal splints with load-sharing characteristics. The volume of load borne by the nail depends on the stability of the fracture/implant construct.

This stability is determined by several factors, including nail size, number of locking screws or bolts, and distance of the locking screw or bolt from the fracture site.

IM nails are expected to bear most of the load initially, and then steadily transfer it to the bone as the fracture heals. With reaming of the canal and the use of locking screws, physiologic loads are transmitted to the proximal and distal ends of the nail through the screws. When interlocking screws [9] are absent, the implant acts to guide the motion of the bone along the longitudinal axis of the nail. The friction of the nail within the medullary cavity determines this resistance to motion. This friction between nail and bone is affected by the amount of bending of the nail (curvature), its cross-sectional shape (particularly the geometry of the surface of the implant), and its diameter, as well as the corresponding properties of the canal (e.g., size, shape, bone quality) [1]

Three categories of load act on an IM nail: torsion, compression, and tension. Physiologic loading is a combination of all three. When cortical contact across the fracture site is achieved postoperatively, most of the compressive loads are borne by the bony cortex.

Several factors contribute to the overall biomechanical profile and resulting structural stiffness of an IM nail. Chief among them are material properties, cross-sectional shape, diameter, and degree of radius of curvature [1]

The two most regularly used materials in the construction of IM nails are titanium alloy and 316L stainless steel. Titanium alloy has a modulus of elasticity that is about half that of 316L stainless steel, but it more closely approximates the modulus of cortical bone. Although there are measurable differences between titanium alloy and 316L stainless steel in the laboratory, the clinical results with either material appear to be equivalent.

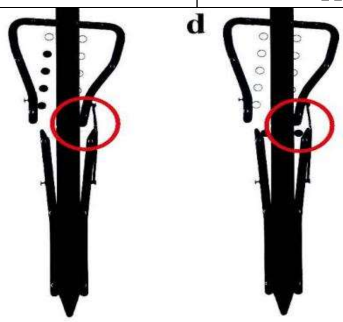
Interlocking screws or bolts are recommended for most cases of IM nailing. The number of interlocks used is based on fracture location, amount of fracture comminution, and the fit of the nail within the canal [13]. Oblique and comminuted fractures rely on interlocking screws for stability, as do very proximal and very distal metaphyseal fractures, where the medullary canal expands and is filled with weaker cancellous bone interlocking screws placed proximal and distal to the fracture site restrict translation and rotation at the fracture site; however, negligible movements occur between the nail and screws, permitting toggling of the bone. Placing screws in multiple planes [14] may lead to a decrease of this fragment toggle. Oblique proximal locking screws appear to increase the stability of proximal tibia fractures compared with transverse locking screws. Two screws can be introduced at angles to the cross-section of the nail to decrease motion between the screws and the nail, but anatomic structures must be taken into consideration when executing this technique.

Blocking screws are used to narrow the canal, to create a path, or as an artificial cortex for the nail to pass down [3]. For example, with a valgus deformity, the screw is placed from anterior to posterior, on the lateral side of the instrument path, and in the proximal segment. The screw functions as a so-called artificial cortex. Blocking screws can also be used for an anterior malalignment. The blocking screw is placed *slightly posterior to the midline*, from medial to lateral, in the proximal fragment. As a nail is introduced, it contacts the blocking screw, extending the proximal fragment and decreasing the apex anterior deformity. The screw should not be positioned in the midline since nail passage may be blocked by the screw.

# PRINCIPLE OF POLLER SCREWS

MEDIALISED NAIL ENTRY

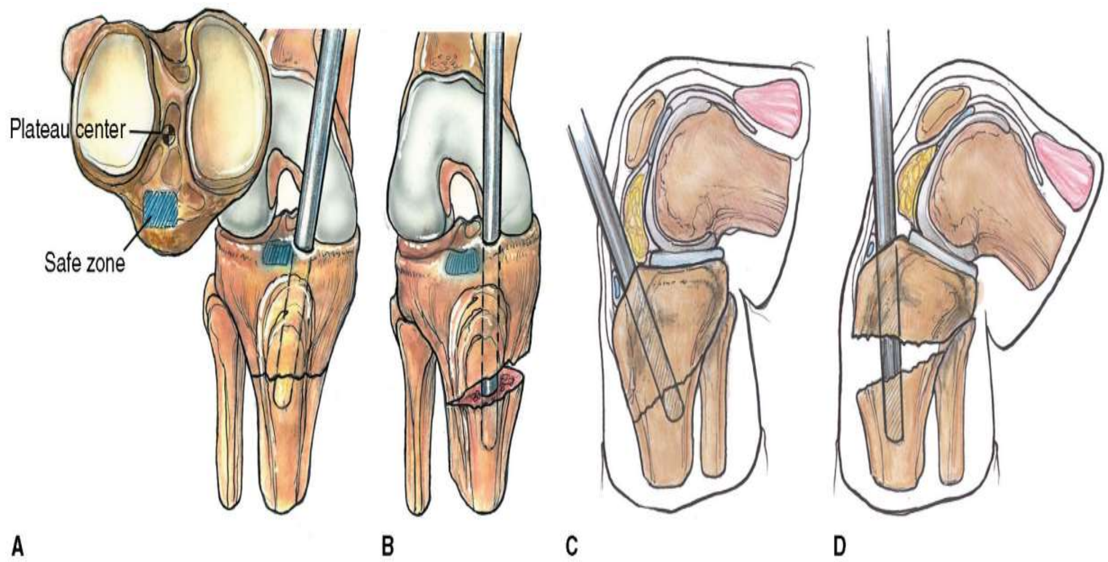
THREE POINT FIXATION




WRONG PLACEMENT OF BLOCKING SCREWS


CORRECT PLACEMENT


ANOTHER SCREW IN WIDE ENTRY




Illustrations of the knee joint demonstrating nail portal placement for intramedullary nailing of proximal tibia fracture. Inset, View of the superior surface of the tibia demonstrating the safe zone for nail insertion. A portal made too medial with a laterally directed entrance angle (A) can lead to **valgus deformity** (B). Lateral views of the knee demonstrating a nail portal begun too anterior and distal (C), resulting in a posterior entrance angle. This predisposes the patient to **apex anterior deformity** (D).

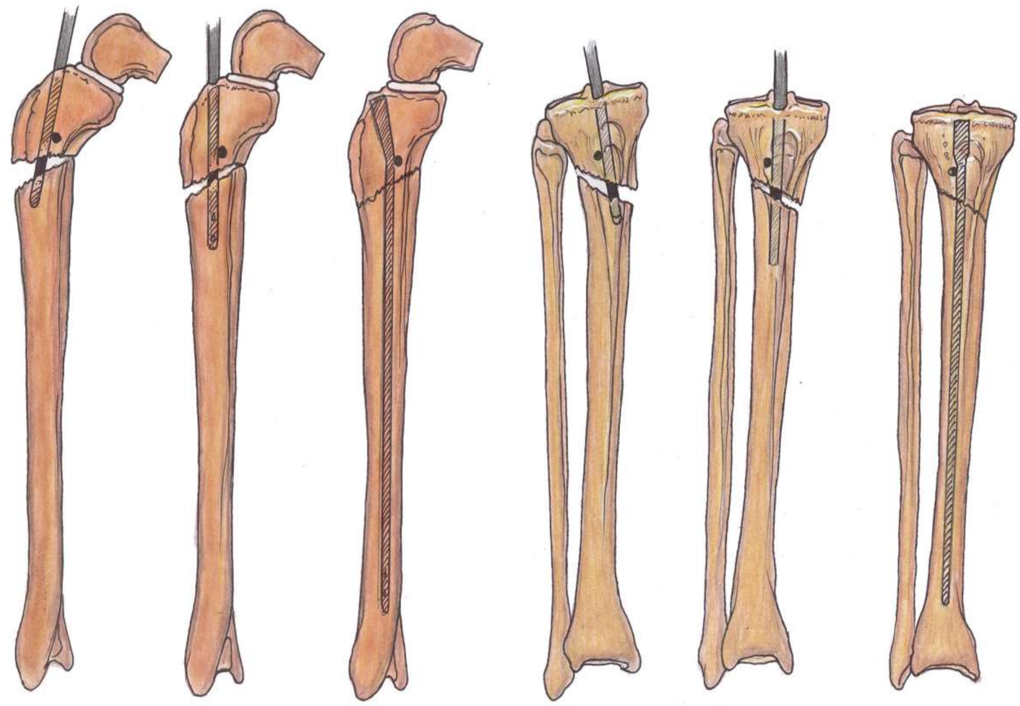



Illustration of lateral (A through C) and AP (D through F) views of a proximal tibia fracture. A through C, To prevent **apex anterior angulation**, a coronal blocking screw (black dot) can be placed in the posterior half of the proximal fragment to reduce the posterior intramedullary space. D through F, To prevent **valgus deformity**, a sagittal blocking screw can be inserted into the proximal fragment on the lateral concave side of the deformity.

IM reaming can act to increase the contact area between the nail and cortical Bone [6]. When the nail is the same size as the reamer, 1mm of reaming can increase the contact area by 38%. Increased reaming permits insertion of a larger-diameter nail, which provides more rigidity in bending and torsion. Biomechanically, reamed nails provide better fixation stability. Weight bearing through a locked IM nail could be allowed in fractures in which 50% cortical contact is present.

Biologic response to IM nailing hinge on the vascular anatomy of long bones and the nature of the vascular response to fracture. The vascular supply to bone is comprised of medullary arteries that supply the inner two thirds of the cortex and of periosteal arterioles that penetrate the cortex at fascial attachments and supply the outer one third. The haversian system acts as a conduit between the endosteal and periosteal circulation. There is a predictable local vascular response to fracture, composed of five separate phases. In the first phase, blood flow is temporarily interrupted, usually as a result of direct vessel injury. The second phase is marked by vasoconstriction. The third phase is marked by vascular recruitment. This leads to an increase in local vascular flow. This phase is initiated in the first 1 to 3 days after injury and can last for a total of 5 to 14 days. The fourth phase, neovascularization, is modulated by local growth factors. The fifth phase consists of remodeling of the newly regenerated vascular system. Revascularization of the bone can occur through four modes: endosteal, periosteal, intracortical, and extraosseous.

**Factors Contributing to Apex Anterior and Valgus Deformity**

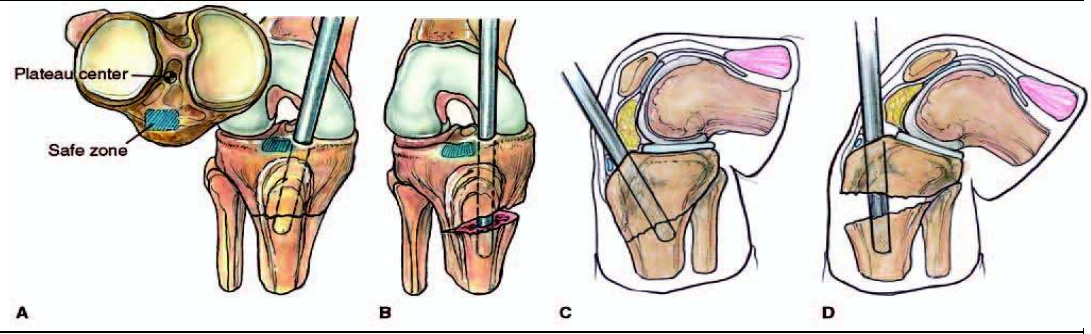
Apex Anterior Deformity [15]

1. Pull of the patellar tendon extends the proximal fragment
2. Gastrocnemius muscle and hamstring tendons act together to flex the fracture
3. Starting point located too anterior and distal
4. Posteriorly directed nail entrance angle
5. Lack of posterior cortex
6. Eccentric sagittal reaming of the anterior cortex
7. "Wedge effect" produced by distal Herzog curve of the intramedullary nail

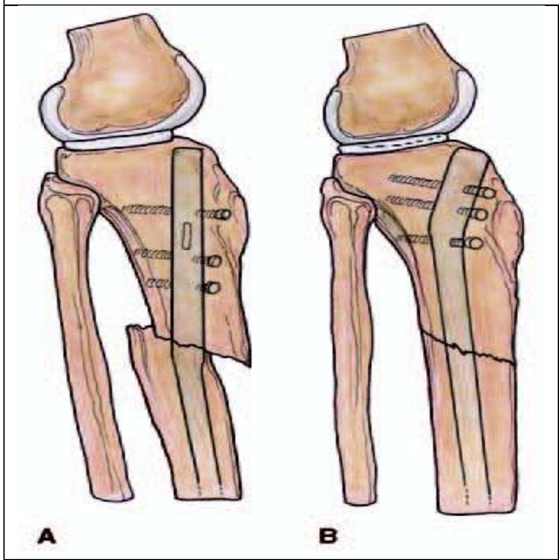
Valgus Deformity [15]

1. Deforming forces of pes anserinus acting on the proximal fragment
2. Pull of the anterior compartment muscles
3. Starting point located too medial
4. Laterally directed nail entrance angle
5. Eccentric coronal reaming of the proximal metaphyseal segment

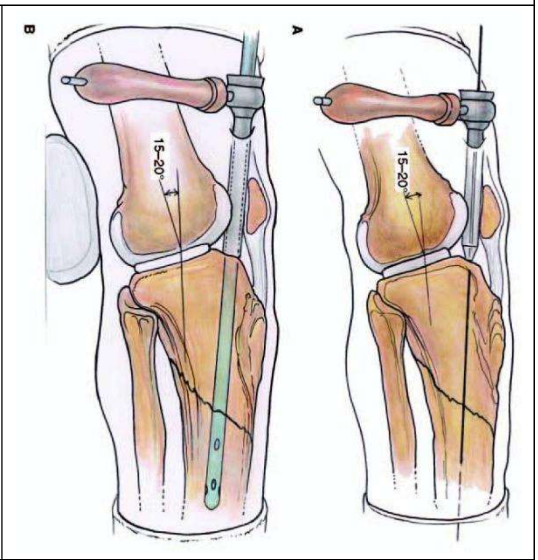
# BIOMECHANICS



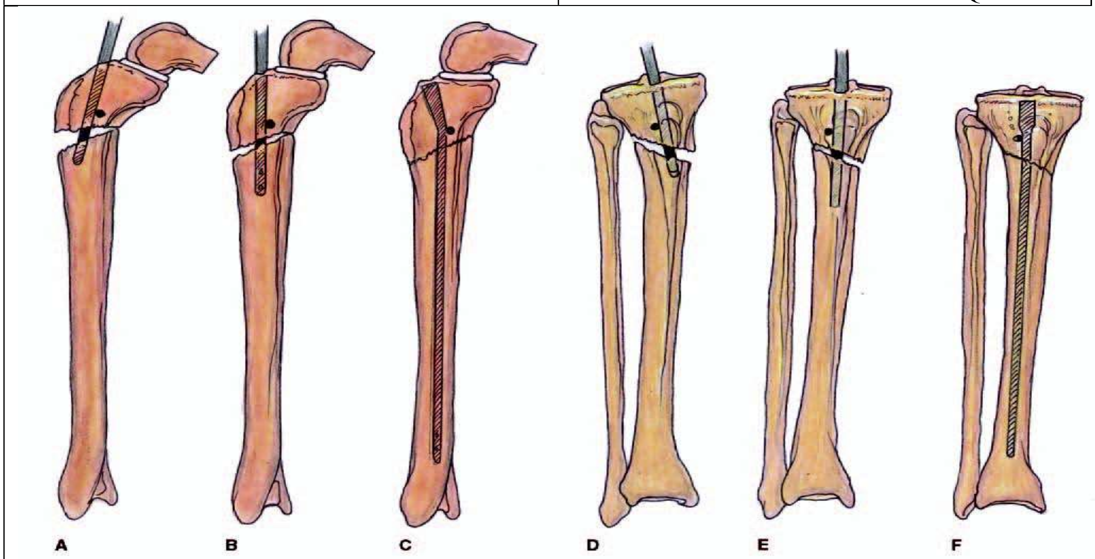

NAIL ENTRY DETERMINES THE FRACTURE ALIGNMENT




WEDGE EFFECT

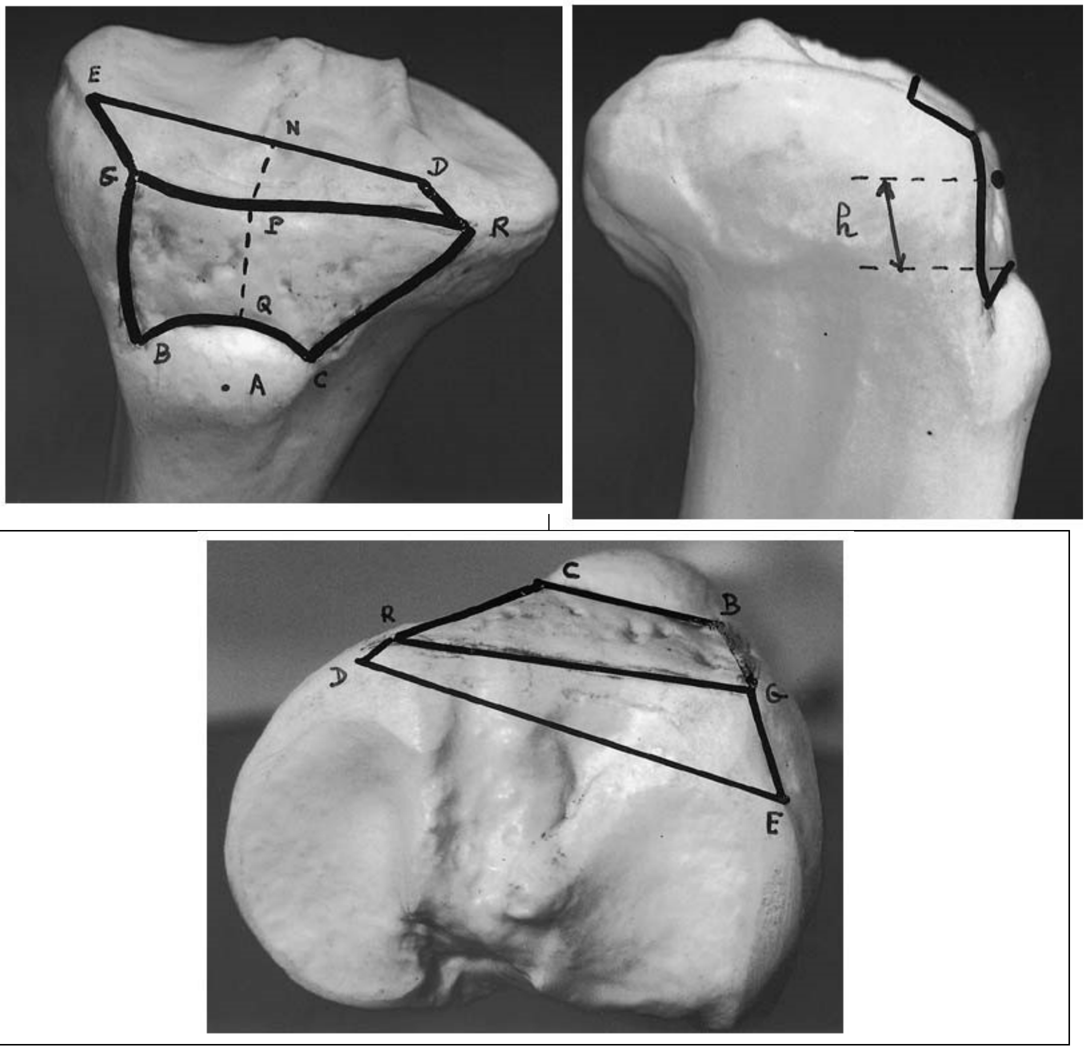



RETROPATELLAR TECHNIQUE




PRINCIPLE OF NAIL INSERTION

# SAFE ANATOMICAL LANDMARKS FOR NAIL INSERTION, DOTTED LINES SHOWS NAIL ENTRY POINT



# MATERIALS AND METHODS

This study was conducted to evaluate the Functional Outcome of Extraarticular Proximal third Tibia Fractures treated with Intramedullary Nailing done in Department of Orthopaedics and Traumatology, Government Thanjavur medical College and Hospital between the period of July 2018-October 2020 after getting Institutional ethical committee clearance.

**Inclusion criteria:**

1. Age more than 16 years.
2. Fractures of proximal tibia extending to the proximal diaphysis.
3. All closed fractures.
4. Segmental fractures involving the proximal third tibia with middle or distal third.
5. Fractures under AO classification 41.A2 and A3

**Exclusion criteria:**

1. Age less than 16 years.
2. Fractures presenting with early or delayed features of compartment syndrome
3. Proximal third tibial fractures with ipsilateral femur fractures (floating knee)
4. Fractures involving the articular surface of tibia. (Tibial plateau or Condylar fractures of tibia)
5. Open fractures
6. Pathological Fractures

Patients of both sexes were included in the study according to the devised inclusion and exclusion criteria.

**Patient evaluation:**

Patients presenting in the Emergency department and the Outpatient department were admitted for thorough evaluation. Detailed history taking is done to ascertain the duration of injury, mode of injury, co morbid illness, and history of previous surgeries and for ruling out any kind of head injury or other system involvement.

Detailed and thorough clinical evaluation was done for the patient as a whole and the limb in specific. General examination of the patient and complete skeletal survey evaluating the clavicle, chest, whole spine, pelvis and all long bones was done. Systemic examination of cardiac, respiratory, abdominal and neurological functions is done.

The involved limb is assessed for the injuries relating to skin in the form of abrasions, contusion, lacerations, punctured wounds etc. Diagnosis of fracture of tibia was done with the help of tenderness, swelling, deformity, abnormal mobility, crepitus and loss of transmitted movements or a palpable defect on the anterior part of tibia. Knee joint was examined for hemarthrosis, intraarticular fractures or instability. Vascular examination of the limb as a whole and palpation of popliteal, dorsalis pedis and posterior tibial pulses was done. Neurological examination of all peripheral nerves is completed with particular attention to Common peroneal nerve in view of its tendency to get injured because of its anatomical position.

Careful evaluation of the features of impending or established compartment syndrome was done for ruling out those fractures from the study. Specialist opinion to exclude other injuries was got. All suitable patients fulfilling our inclusion criteria were subjected to further radiological assessment.

**Radiological evaluation:**

All eligible patients undergone radiological examination in at least two views, Anteroposterior and Lateral including both the knee and ankle joints. In few numbers of cases with suspicion of fracture line extending into the articular surface CT of Knee was done and patient selection modified accordingly. Distance of the proximal most fracture line from the articular surface was calculated and recorded. Displacement and comminution of the fragments were noted. Whole length of the tibia was radiologically examined for the presence of segmental fractures. Fracture of the fibula, its location and relation to tibial fracture were noted. Radiographic classification was done.

**Pre-operative work-up:**

The limb was stabilized in an Above Knee slab temporarily and limb elevated to reduce the pain and swelling. Further investigations were done for anesthetist opinion and assessment obtained. All patients included in the study with full fitness obtained were subjected to the described surgical procedure.

**Surgical procedure:**

All nailing operations were done in Department of Orthopaedics and Traumatology, Govt Thanjavur medical College and Hospital. All the fractures were treated with an Intramedullary nailing system. The surgery was completed using a standard radiolucent table under C- arm guidance with manual traction alone. The decision for assistive reduction techniques such as Poller screws, Percutaneous plating, distractive external fixator as well as the number and location of the Proximal locking bolts was made at the surgeon’s choice. Reaming of the canal was done at the discretion of the surgeon considering the width of the medullary canal, location and character of the fracture. Open fractures were debrided and closed on admission before stabilization. Closed fractures were initially managed by reduction and application of splint followed by operative treatment to decrease the soft tissue swelling.

**Preoperative planning**

The nail length and diameter were estimated preoperatively with both the anteroposterior and lateral X-ray views and also on the normal limb with the distance between the tibial tuberosity and Tip of medial malleolus.

**Implants and instruments:**

Implant - tibial nail:

The Tibial Nail permits an intramedullary approach for the fixation of Proximal third Extraarticular fractures of the tibia. It provides stable fixation of fractures by using Poller screws and locking screws in the proximal and distal portions of the nail. The system consists of a series of cannulated nails, cancellous locking screws and standard locking screws. Cancellous bone locking screws are used proximally for better purchase in the cancellous bone. All of the implants are made of stainless steel 316L. Nails were of universal design for the left and right tibia. Diameter of the nail range from 8 mm to 13 mm (1 mm increments). Two medio-lateral (ML) locking options enable primary compression or secondary controlled dynamization.

**Locking Screws:**

Locking Screws 5.0 mm with a drill-bit diameter 4.0 mm

Used for medio lateral and distal locking

**INSTRUMENTATION:**

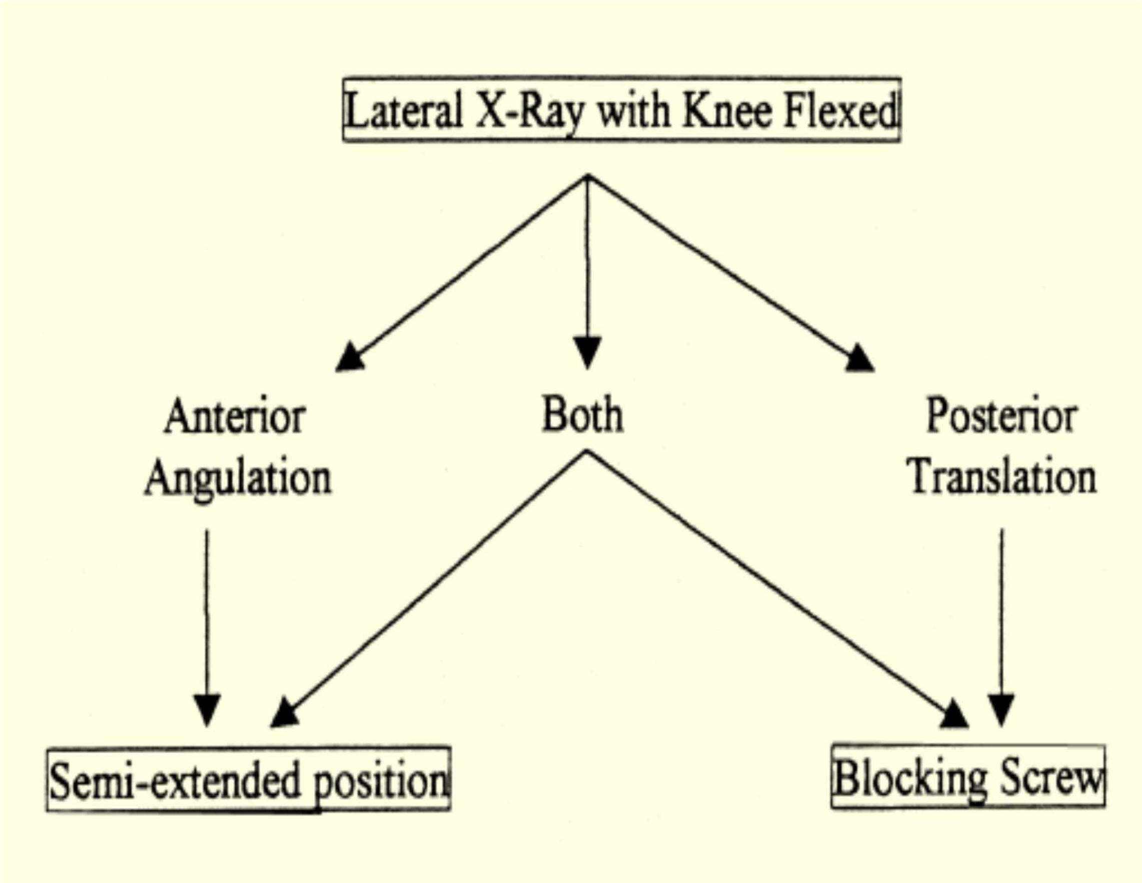
| | |
|---|---|
| Guide wire 3.2mm<br>Drill bit 3.2mm<br>Drill bit 4.0mm<br>Depth gauge<br>Flexible reamers | Insertion handle<br>Proximal jig<br>Hammer guide<br>Hammer<br>Battery operated power drill |
| Protection sleeve<br>Bone awl<br>Screw driver hexagonal<br>Wrench 11mm | Connecting bolt<br>Holding sleeve<br>Drill sleeve<br>Trocar |
| Intramedullary inter locking nails (In varying sizes 9,10,11) | Cortical screws of varying sizes, designated as “Poller screws” |

**Patient positioning:**

Position the patient supine on the radiolucent table. Ensure that the knee of the injured leg can be flexed at least 90°. Position the image intensifier such that visualization of the tibia including the articular surface proximally and distally is possible in anteroposterior and lateral views. Semi-extended position was used in few cases. This approach allowed the patella to be subluxed laterally availing the trochlear groove for use as a conduit for nail placement. Using only 15* knee flexion eliminated the extension force of the quadriceps on the proximal fragment, which otherwise would have tended to cause anterior angulation at the fracture site. Full flexion or Semi extended position was used at the discretion of the surgeon taking into account the nature of the fracture.

**Poller screw insertion/unicortical plating/pin fixator**

Poller screw insertion if planned is done before nail entry under fluoroscopic guidance. Unicortical plating or Temporary external fixation if planned is done as per routine techniques with the knee fully extended and the fracture reduced Perform closed reduction manually by axial traction under image intensifier before applying large distractor or external fixator.




**Approach**

Intra operative confirmation of the nail length and diameter is done under fluoroscopic guidance with the chosen nail and appropriate alterations made.

An incision is made in line with the central axis of the intramedullary canal. This incision can be trans patellar, medial or even lateral parapatellar. The incision starts proximally at the distal third of the patella along the patellar ligament down to the tibial tuberosity [6]. The infrapatellar corpus adiposum is mobilized laterally and dorsally without opening the synovia. A free access of the nail to the insertion point must be guaranteed. the entry site of the nail is prepared on the ventral edge of the tibial plateau.

**The entry point**

The entry point defines the optimal position of the Tibial Nail in the intramedullary canal. This is more important for proximal and distal third fractures to prevent fragment displacement. In anteroposterior view the entry point is in line with the axis of the intramedullary canal and with the lateral tubercle of the intercondylar eminence [7]. In lateral view the entry point is at the ventral edge of the tibial plateau. More proximal intraarticular entry is best achieved with the knee maximally flexed.

opening of medullary canal. Using a twisting motion, the awl is advanced to a depth of approximately 8–10 cm.

**Guide wire insertion**

Closed reduction of fracture done and guide wire passed

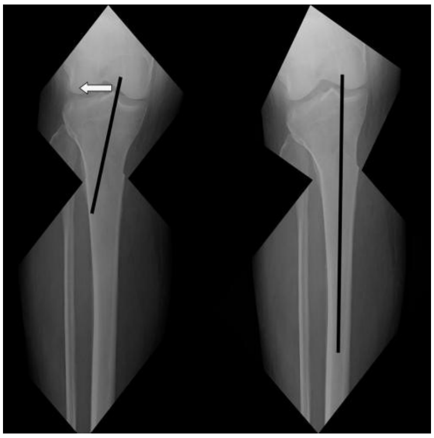
**Reaming the medullary canal**

Depending upon the availability of the medullary canal after Poller screw insertion, serial reaming with flexible reamers done.

**Nail insertion**

Insertion of the appropriate size nail after connecting securely to the proximal jig is done with the knee semi extended and holding the reduction under image guidance.

# RADIOGRAPHIC/FLUOROSCOPIC EVALUATION

| | | | |
|---|---|---|---|
|  |  |  |  |
| ENTRY POINT AP | ENTRY POINT LAT | POSTERIOR ANGULATION | ANTERIOR ANGULATION |
|  | |  |  |
| MEDIOLATERAL ANGULATION | | ENTRY POINT AP | POLLER SCREW |

Intra-operative C-arm images showing Poller screw placement and nail insertion

**Post-operative-protocol:**

All patients were given third generation cephalosporin intravenously during induction which was continued for 3-5 days post operatively. Post-operatively the leg was initially placed in a compressive dressing extending from foot to above knee and elevated for 48 to 72 hours to decrease swelling. Postoperative antero-posterior and lateral X-rays were taken and analyzed for alignment, locking and stability of the fixation. All patients were encouraged to begin an early active range of motion of the knee and ankle as tolerated. Sutures were removed on the $12^{th}$ post-operative day. Patients were not permitted to bear full weight for four weeks.

**Post-operative radiological evaluation:**

Entry point for the nail was assessed in all patients either as superior or inferior depending on the location and relation to the anterior edge of tibial plateau. Entry point was also evaluated in the coronal plane as either medial or lateral in relation to the lateral tibial spine, the tibial tuberosity and the medullary canal.

Number of cases with the nail dependent on Poller screw for passing anteriorly to prevent translational malalignment was recorded. Fracture alignment in the immediate postoperative period in the form of angulation or translation in any plane was calculated. Persistence of the alignment or changes if any was detected in the follow-up X-rays.

**Follow up evaluation:**

All patients were reviewed by a single observer. Clinical assessment included time to full weight bearing, return to work, presence of anterior knee pain, limb length discrepancy, and rotation, coronal and sagittal plane deformities. Radiographs were studied monthly for fracture union and to assess limb alignment. Bony union was defined in both clinical and radiological terms with radiological evidence of bridging callus across the fracture site in both anteroposterior and lateral views and clinical evidence of full weight-bearing without pain.

Malunion was defined as varus or valgus deformity, anterior/ or posterior angulations, or rotational deformity of more than 5º or shortening of more than 1 cm[1].The alignment was assessed by creating longitudinal line from the midpoint of the medial and lateral cortices (on anterior- posterior X ray) for varus – valgus measurement and midpoint of the anterior and posterior cortices (on lateral X rays) for Recurvatum –Procurvatum measurement[6].

**KLEMM AND BORNER SCORING SYSTEM** was used to assess the functional outcome.

| Grade | Description |
|---|---|
| Excellent | Full knee and Ankle motion,<br>No muscle atrophy,<br>Normal alignment |
| Good | Slight loss of knee and ankle motion <25%<br>Muscle atrophy <2cm<br>Angular deformity <5* |
| Fair | Moderate loss of knee and ankle motion >25%<br>Muscle atrophy >2cm<br>Angular deformity 5*-10* |
| Poor | Marked loss of knee and ankle motion<br>Marked muscle atrophy<br>Angular deformity >10* |

Delayed Union was defined as the failure to see evidence of union on radiographs at various time-points[5].

# RESULTS

A study on observation of 20 patients who had met with road traffic accidents  and accidental fall with extra articular proximal third tibial fractures treated with intramedullary nailing and were followed up for a period of 1.5 yrs.The following observations were made of the data collected from studies.

Results are divided into two sections:

1) Descriptive statistics using frequency distribution.

2) Inferential statistics using chi square test and Fisher Exact test.

## Descriptive statistics using frequency distribution

### AGE GROUP

**Table 1.frequency distribution of Age group**

| S.no | Age group(years) | Frequency (20) | Percent (%) |
|---|---|---|---|
| 1. | 18-30 years | 4 | 20 |
| 2 | 31-40 years | 6 | 30 |
| 3 | 41-50 years | 8 | 40 |
| 4 | >50 years | 2 | 10 |

Among the study populations, Age ranged from 18 to 55 years with mean age 39.2 years of age and SD-9.73 . Maximum cases were in 4$^{rd}$ decades of life .

## GENDER

Among the total study populations (20 ), more than 80% were males.

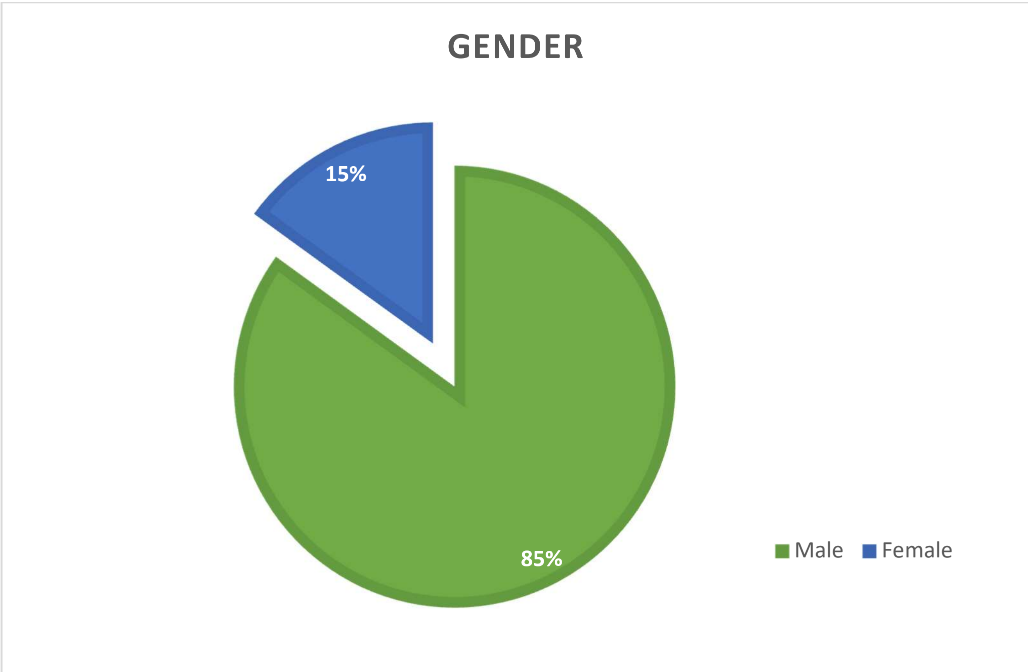



Chart 1. frequency distribution of gender

## MODE OF INJURY

**Table 2.frequency distribution of mode of injury**

| S.no | Mode of injury | Frequency (20) | Percent (%) |
|---|---|---|---|
| 1. | Accidental fall | 2 | 10 |
| 2 | Road traffic accidents | 18 | 90 |

Among the total study population (20 ), most of them had road traffic accidents (90%).

**SIDE OF INJURY**

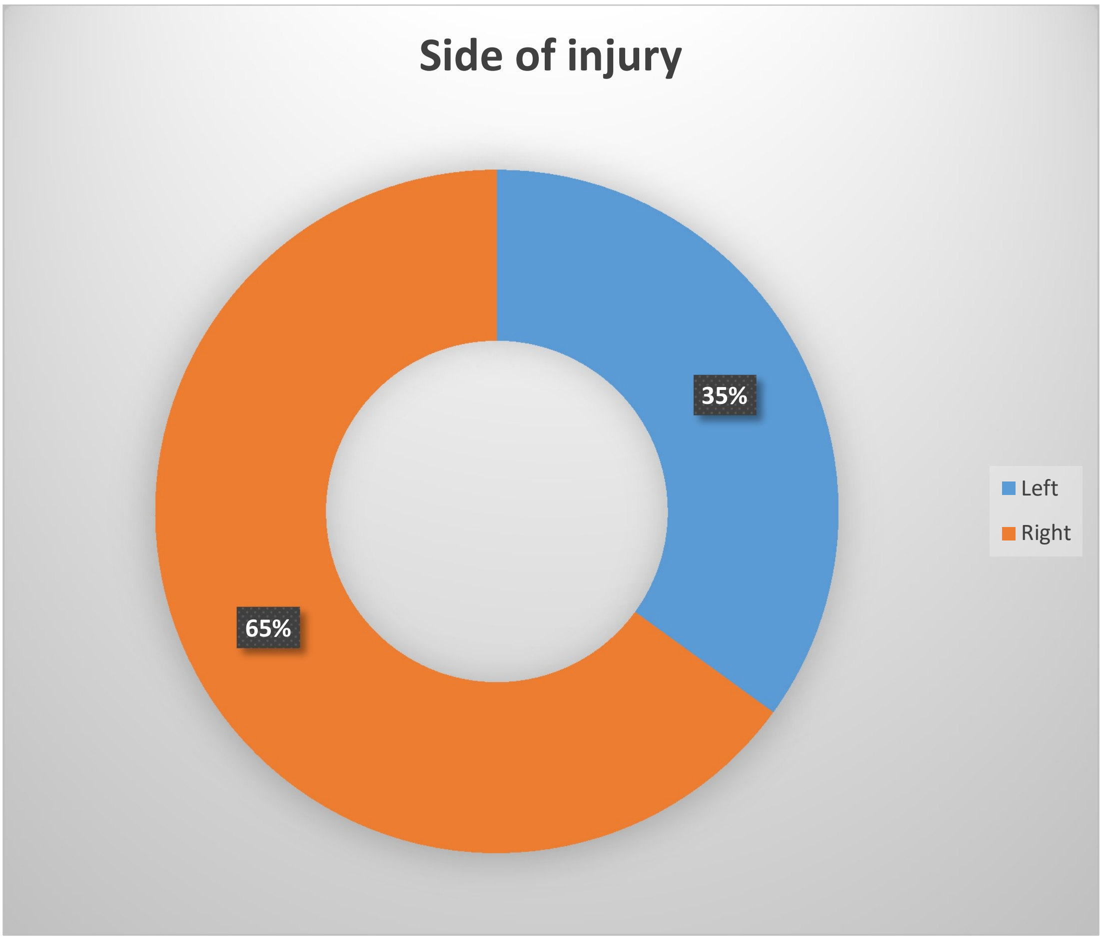



Chart 2. frequency distribution of side of injury

Among the total study populations 65% fractures were on the right side.

## FRACTURE LOCATION FROM KNEE JOINT

**Table 3. Frequency distribution of fracture location from knee joint**

| S.no | Fracture location from knee joint (cm) | Frequency (20) | Percent (%) |
|---|---|---|---|
| 1. | 3.5-4.5 | 5 | 25 |
| 2. | 4.6-6.5 | 11 | 55 |
| 3. | 6.6-8.0 | 4 | 20 |

Among the total study populations (20 ), mean fracture location from knee joint 5.5cm and standard deviations 1.28

**PRESENCE OF ANOTHER DISTAL FRACTURE**

Among the total study populations (20), another distal fracture present in 15% of the participants.

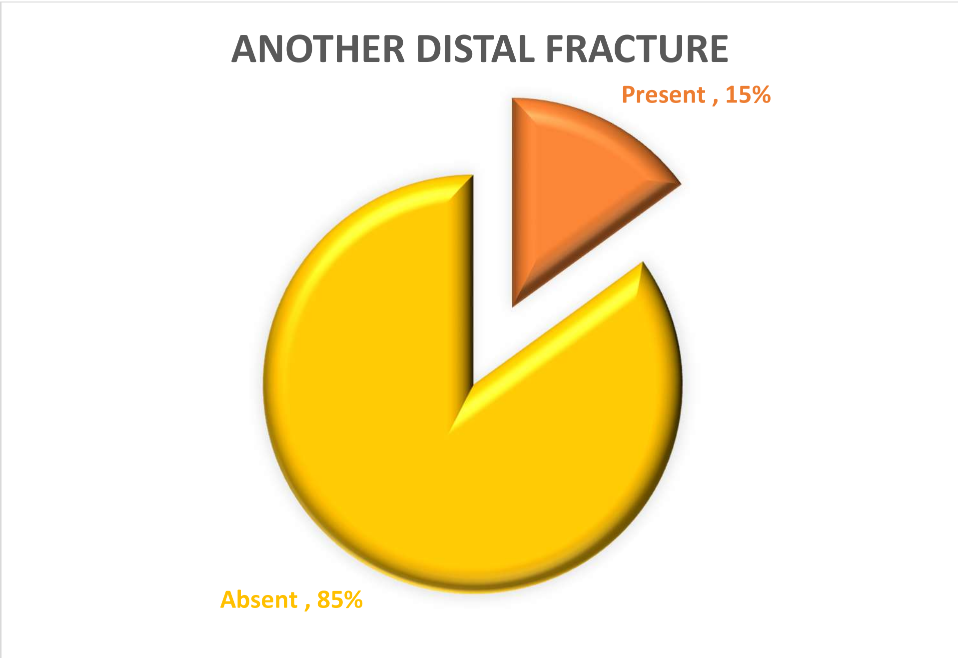



Chart 3. frequency distribution of another distal fracture

## AO CLASSIFICATIONS

Table 4. Frequency distribution of AO classifications

| S.no | AO classifications | Frequency (20) | Percent (%) |
|---|---|---|---|
| 1. | 2.1 | 3 | 15 |
| 2. | 2.3 | 3 | 15 |
| 3. | 3.1 | 3 | 15 |
| 4. | 3.2 | 10 | 50 |
| 5 | 3.3 | 1 | 5 |

Among the total study populations (20 ), AO classifications 3.2 seen in 50% of the participants .

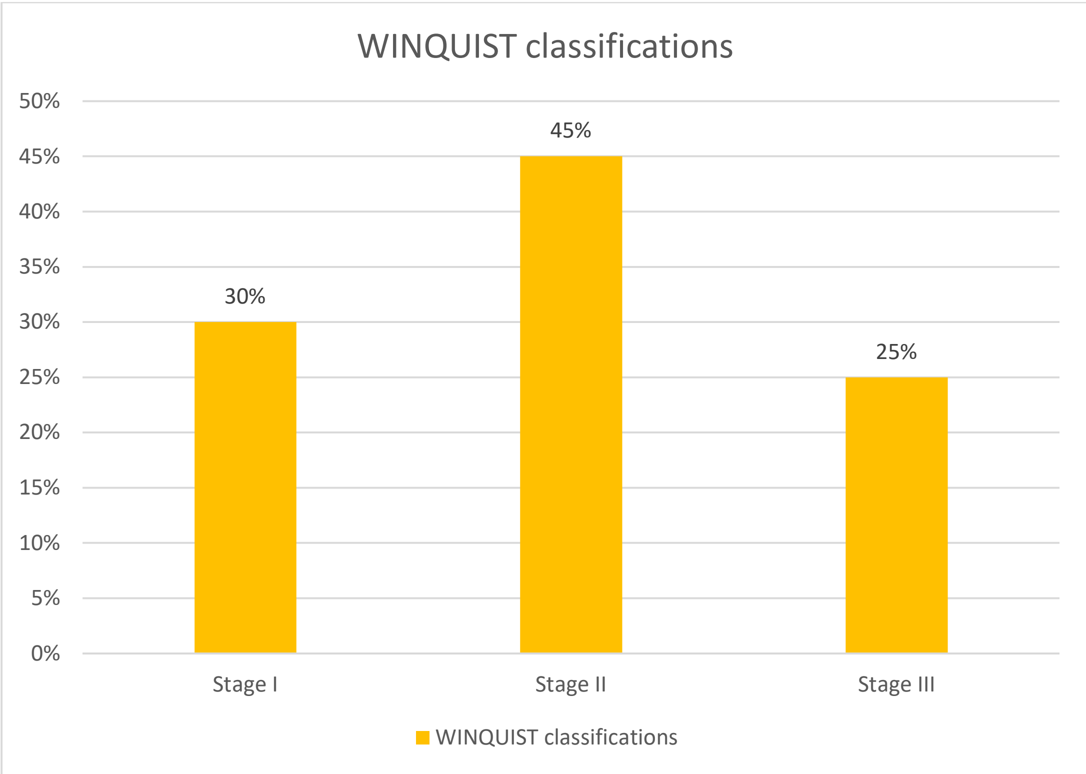



Chart 4. frequency distribution of Winquist classifications

Among the total study populations (20), present in 45% of the participants had type two Communition

**NUMBER OF POLLER SCREWS**

Table 5.Frequency distribution of number of Poller screws

| S.no | Number of poller screws | Frequency (20) | Percent (%) |
|---|---|---|---|
| 1. | No poller screw | 7 | 35 |
| 2. | 1 | 10 | 50 |
| 3 | 2 | 3 | 15 |

Among the study populations (20), fifty percent of the study populations had nailed with 1 Poller screw.

**ENTRY POINT FOR THE NAIL**

Among the study populations, three fourth of the patients were nailed superiorly (75%).

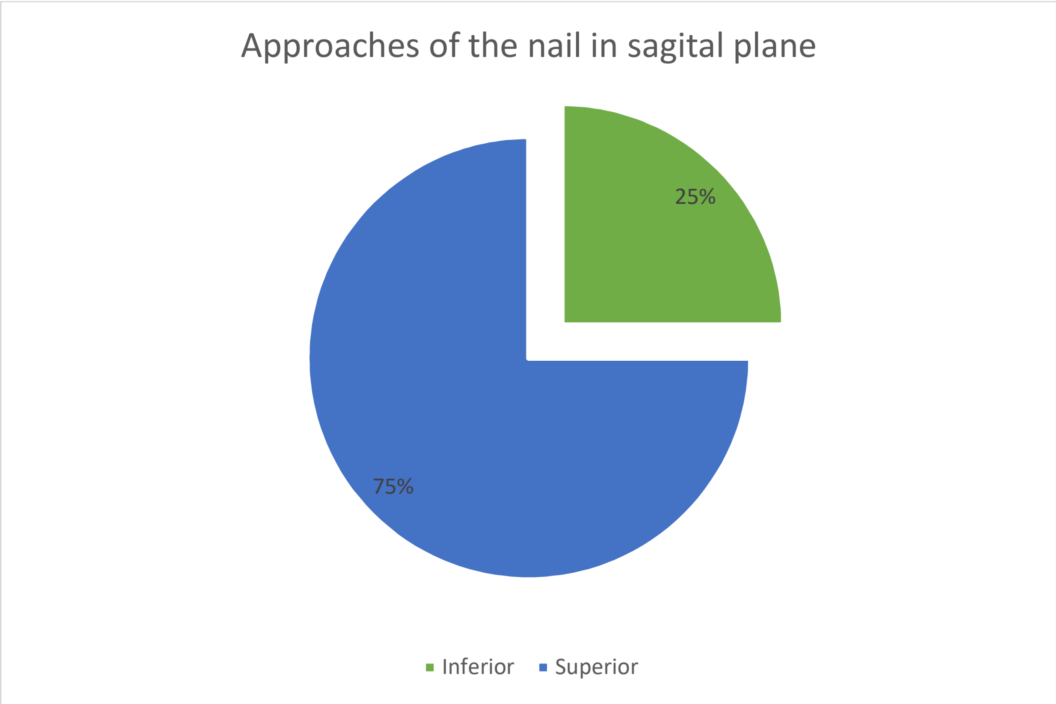



Chart 5 frequency distribution of approaches for the entry of the nail

## APPROACHES FOR THE ENTRY OF THE NAIL

Table 6. frequency distribution of entry point for the nail

| S.no | Entry point for the nail | Frequency (20) | Percent (%) |
|---|---|---|---|
| 1. | lateral | 8 | 40 |
| 2. | Medial | 2 | 10 |
| 3. | Middle | 10 | 50 |

Among the study populations midline entry point for the nail was commonly used.

**MALALIGNMENT OF THE FRACTURE**

Among the study population, more than 80% of the patients had acceptable level of malalignment in the fracture.

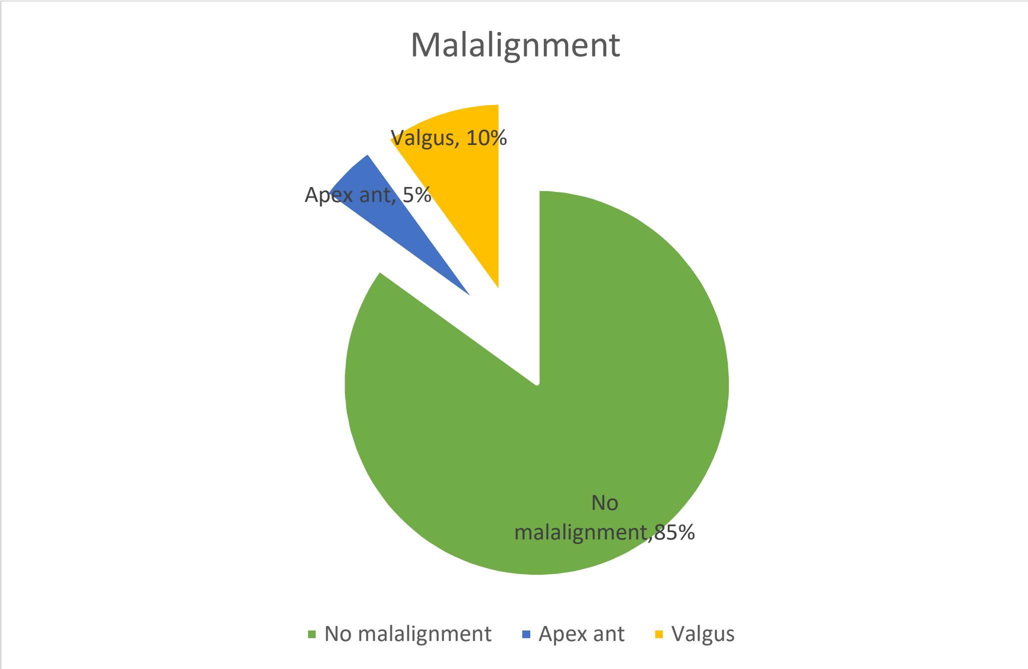



Chart 6. frequency distribution of mal alignment of the fracture

**SAGITTAL ALIGNMENT**

Table 7. Frequency distribution of sagittal alignment

| S.no | Sagittal alignment | Frequency (20) | Percent (%) |
|---|---|---|---|
| 1. | -3 | 1 | 5 |
| 2. | 0 | 12 | 60 |
| 3. | 2 | 2 | 10 |
| 4 | 3 | 2 | 10 |
| 5 | 4 | 2 | 10 |
| 6 | 10 | 1 | 5 |

Among the study population, 60 % had no malalignment in sagittal plane

## CORONAL ALIGNMENT

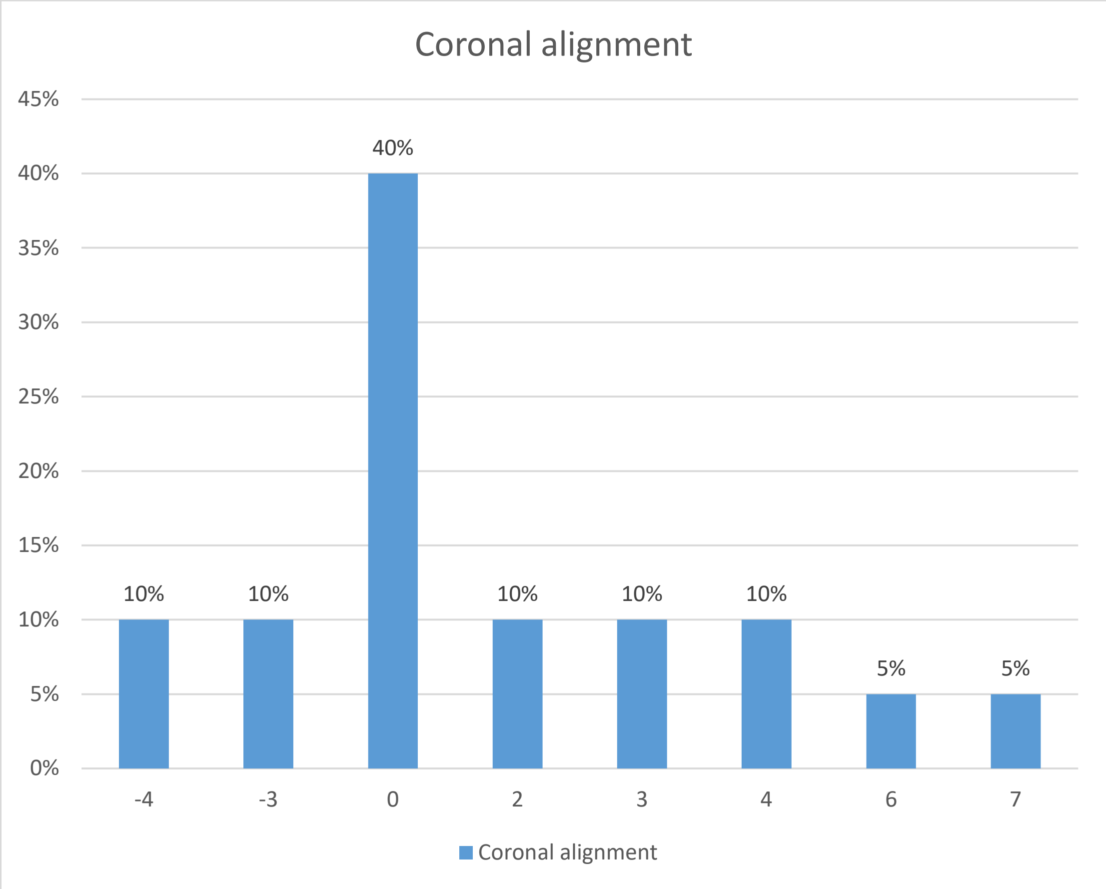



Chart 7. Frequency distribution of coronal alignment of the fracture

Among the study population, 40 % had no malalignment in coronal plane

**COMPLICATIONS**

Table 8.Frequency distribution of complications

| S.no | Complications | Frequency (20) | Percent (%) |
|---|---|---|---|
| 1. | Nil | 17 | 85 |
| 2. | Delayed union | 3 | 15 |

Among the study population(20),15% of the study participants had delayed union.

**WEIGHT BEARING TIME**

Among the study population(20), mean time for weight bearing was 8.45 weeks with standard deviations 1.79

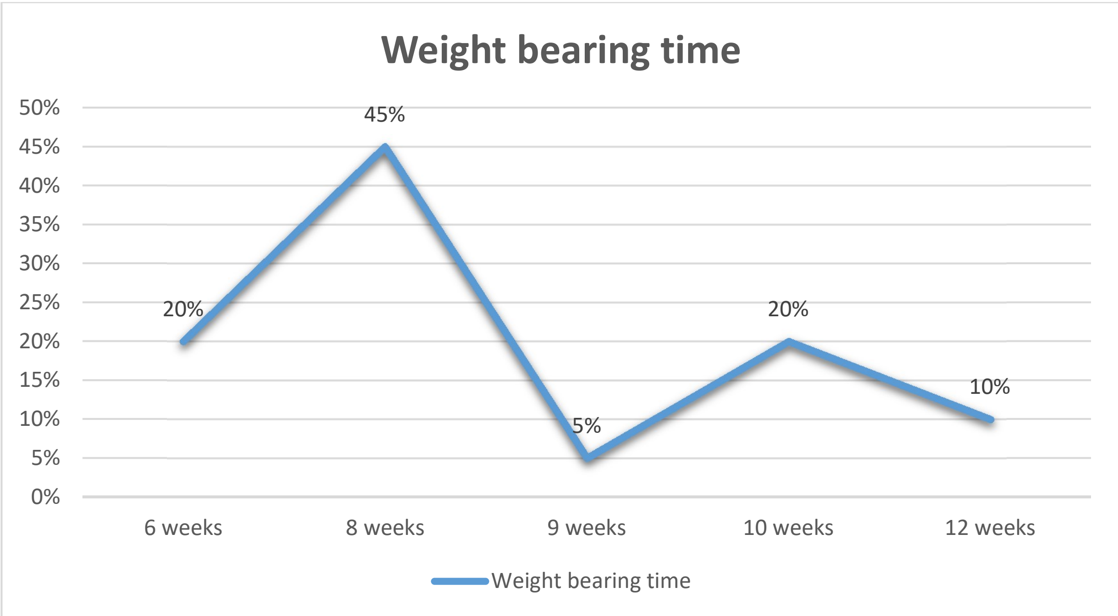



Chart 8. frequency distribution of weight bearing time

## TIME FOR UNION

Among   the study population(20), mean time for union 16.15 weeks with standard deviations 4.568

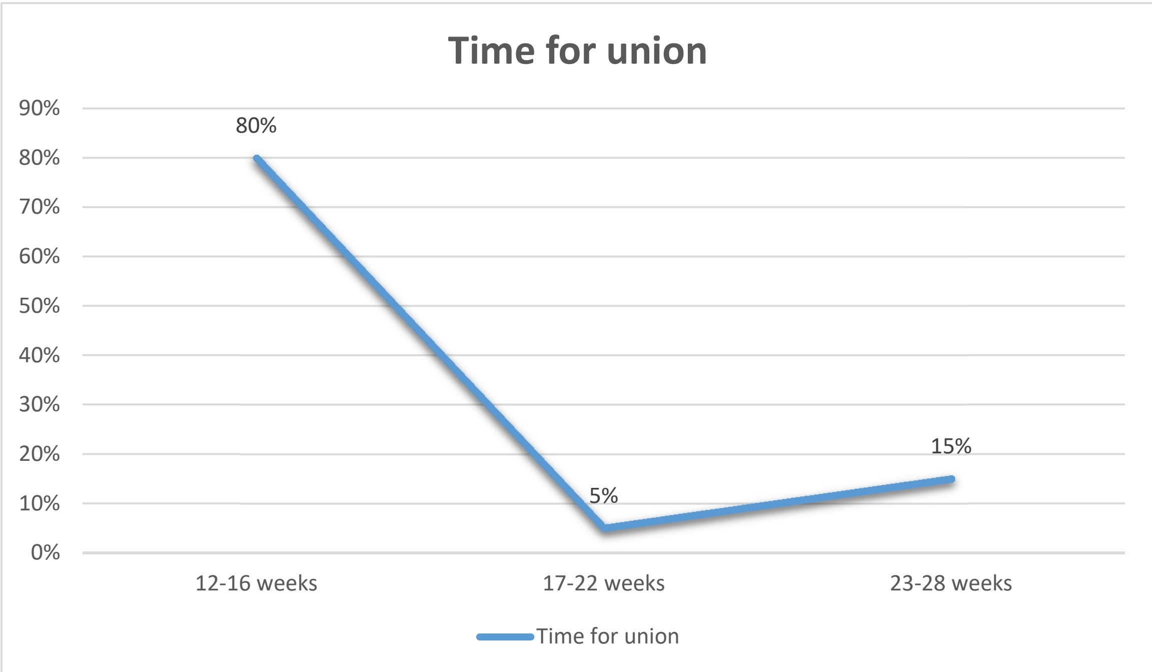



Chart 9.Frequency distribution of time for union

## SCORE

Table 9. Distribution of score

**score**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | EXC | 4 | 20.0 | 20.0 | 20.0 |
| | FAIR | 5 | 25.0 | 25.0 | 45.0 |
| | GOOD | 8 | 40.0 | 40.0 | 85.0 |
| | POOR | 3 | 15.0 | 15.0 | 100.0 |
| | Total | 20 | 100.0 | 100.0 | |

Among the study population(20), 40% of the participants had good scoring rate.

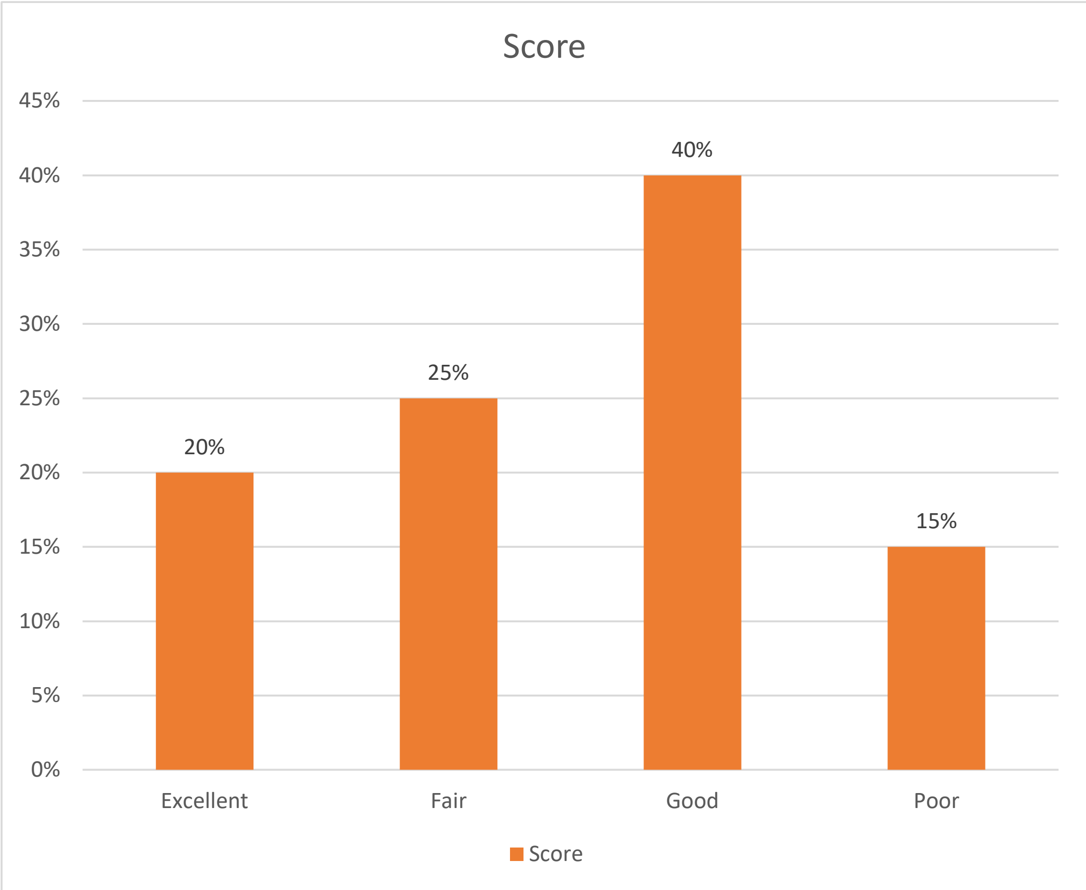
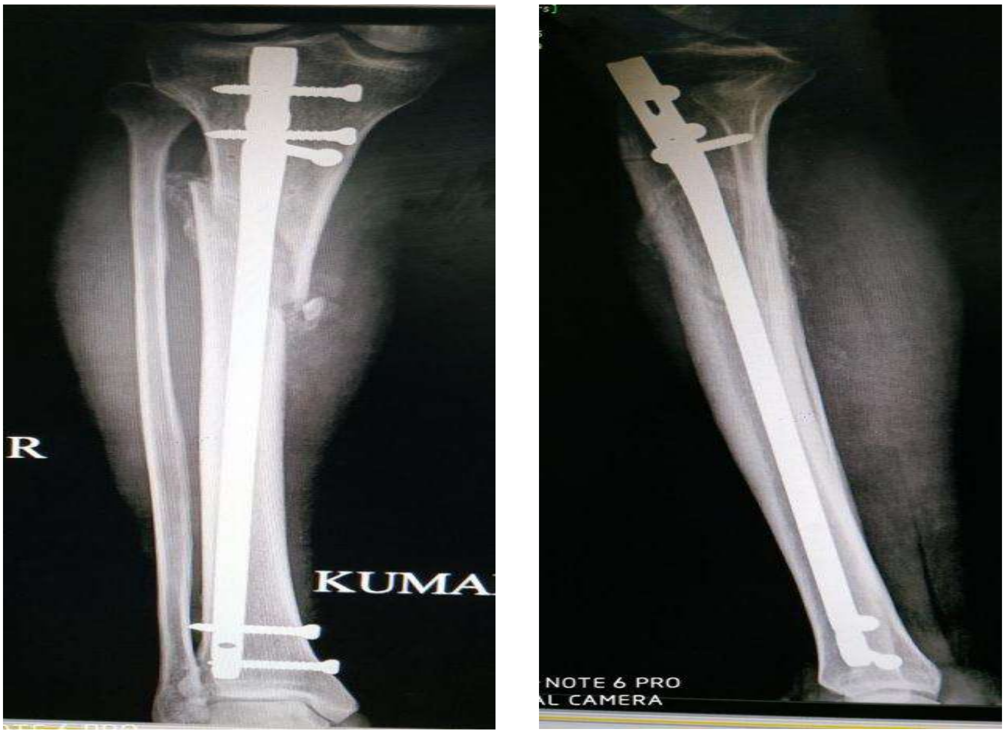



Chart 10. Frequency distribution of score

## CASE ILLUSTRATION 1

56 YEAR OLD MALE RIGHT SIDE FRACTURE

Pre operative radiograph showing Anterio posterior and lateral views




Post operative radiograph Anterio posterior and lateral views

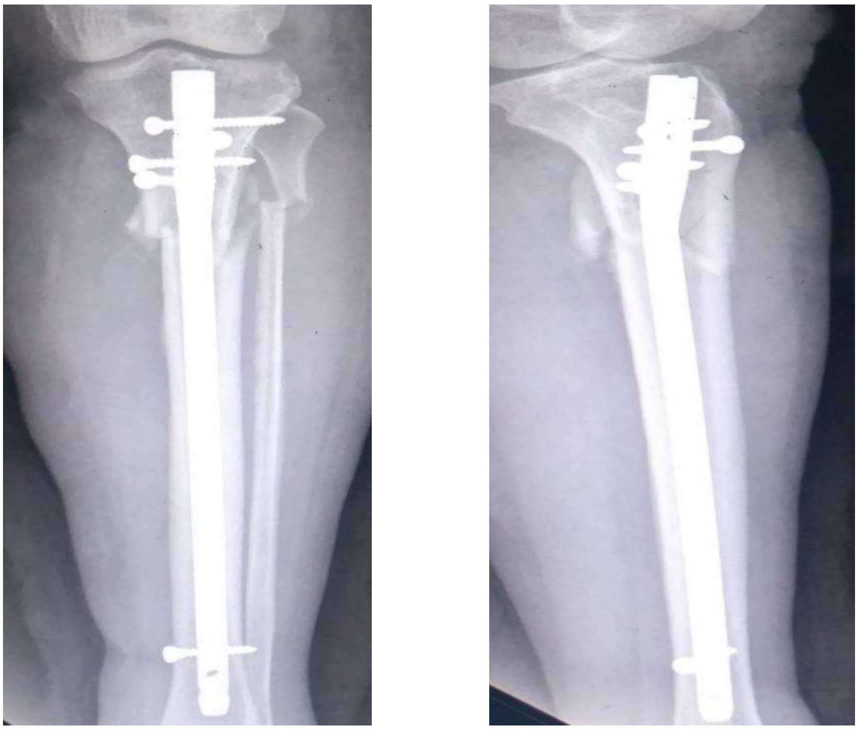
12 month follow up radiograph Anterio posterior and lateral views

Clinical picture showing flexion and extension of knee joint

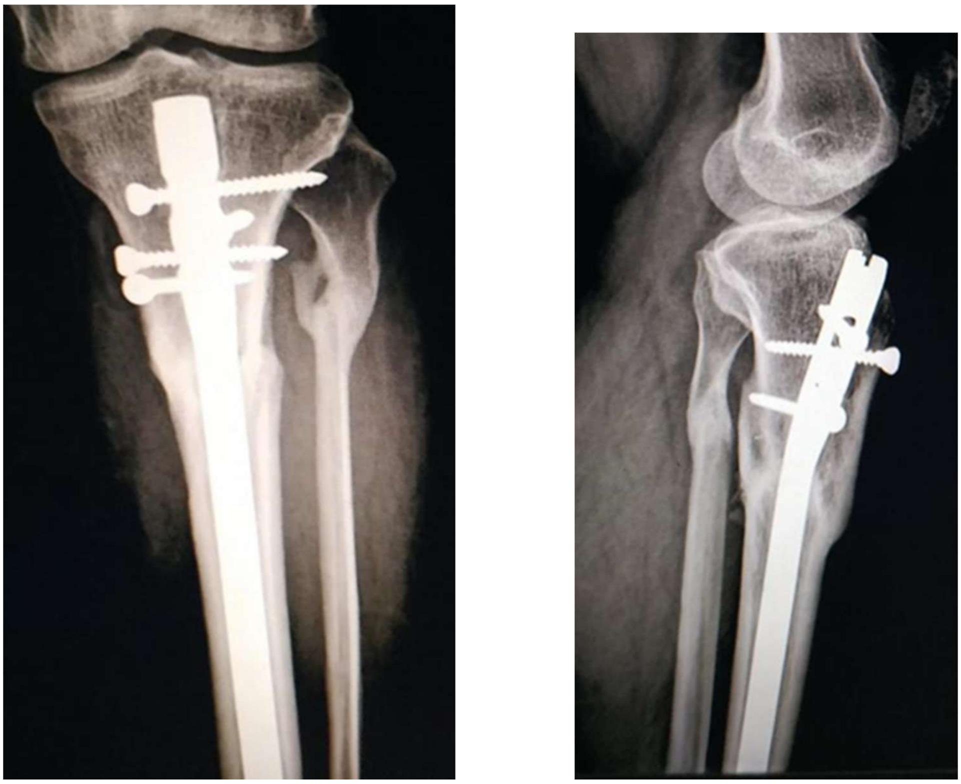
## CASE ILLUSTRATION -2

45 YEAR OLD FEMALE LEFT SIDE FRACTURE


Pre operative radiograph showing Anterio posterior and lateral views



Post operative radiograph Anterio posterior and lateral views



12 month follow up radiograph Anterio posterior and lateral views

Clinical picture showing flexion and extension of knee joint

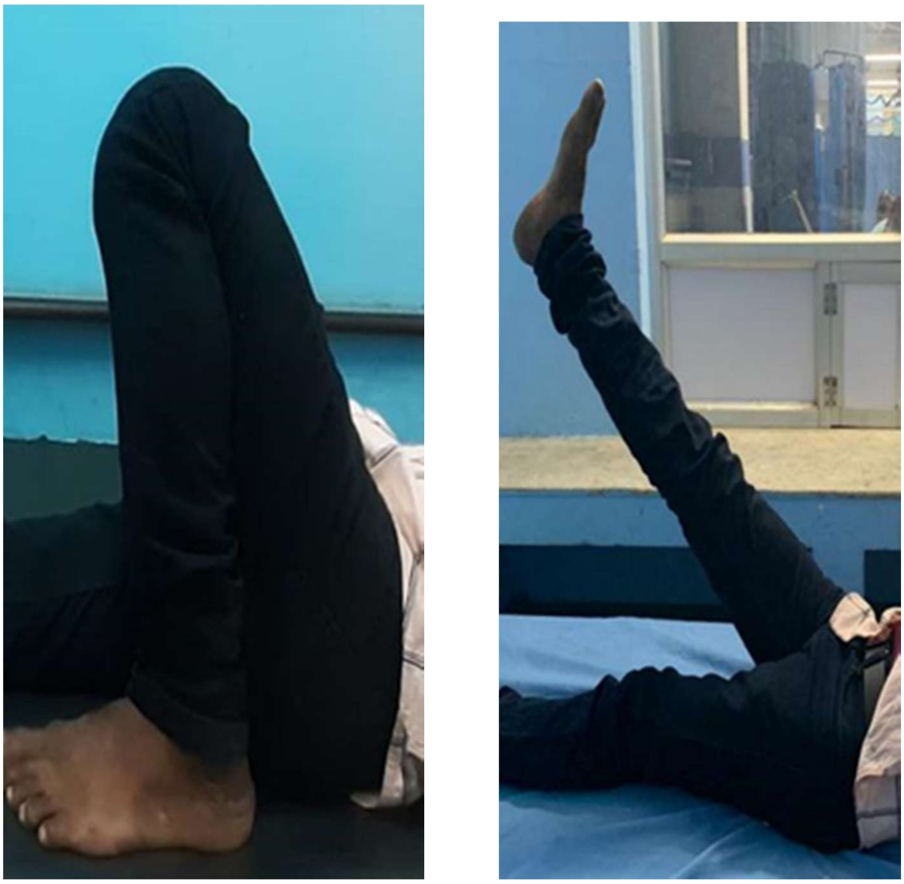
**CASE ILLUSTRATION 3**

48 YEAR OLD MALE RIGHT SIDE FRACTURE

Pre operative radiograph showing Anterio posterior and lateral views


Post operative radiograph Anterio posterior and lateral views


12 month follow up radiograph Anterio posterior and lateral views



Clinical picture showing flexion and extension of knee joint

# DISCUSSION

The incidence of Extra-articular Proximal tibial fractures has been put at 5-11% [1] in various literatures. But the exact numbers could not be arrived at considering the lack of proper definition for these fractures which tend to cause malalignment. Extra-articular proximal tibial fractures being high energy injuries present mostly after Road Traffic accidents as shown by Vidhyadhara et al[15]. It is evident in our study that 18 out of the 20 cases followed a road traffic accident.

In the previous studies, no sex or age predilection has been shown in these fractures. Males were involved in 17 of the 20 cases and the age range varies from 18 to 55 years in this study.

The fractures in our study fell in the category of almost all classes of AO classification and Winquist classification. Among the total study populations (20), AO classifications 3.2 seen in 50% of the participants and Winquist type II seen in 9 cases. The type of fractures had little effect on the final alignment and outcome, rather it was the surgical techniques and the implants used.

The average distance of the proximal most fracture line from the knee joint in the present study was 5.5cm and 11 of the cases fell in the category of 4.6 to 6.5 cm. Fractures located within 2.5cm were not amenable for nailing considering their complex nature and the failure to achieve atleast 2 locking screws with good purchase. With the present study the ideal location for proximal tibia nail could be argued as between 2.5 to 7. 5cm.Distance between joint line and fracture had little effect on the final alignment and outcome, rather it was the surgical techniques and the implants used.

In our study population of 20 proximal tibia fractures, average mean time for union 16.15 weeks. We had three cases of delayed union which take long duration to unite, average of 26 weeks. All these three cases fall under AO type A3.2 fragmented wedge fracture and Winquist type II fractures. Among three cases of delayed union two cases had valgus

Malalignment of +6º and +7 º and one had apex anterior malalignment Of + 10 º.3 cases of another distal tibia fracture treated with this method Which had excellent and fair results.10 cases had midline entry point,8

Cases had lateral entry and 2 cases had medial entry point. Common entry point is midline.15 cases had superior entry point and 5 cases had inferior entry point. Among 7 cases which did not had Poller screws ,3 cases went for malalignment and delayed union.

The average delay in surgery in our institution was 4 days and the range was 2 to 13 days. The delay was attributed to the long waiting list of patients, availability of the theatre days.

Primary malalignment of 58% was reported by Freedman et al[16] before the advent of newer implants and surgical techniques for treating these fractures. With surgical advancements the overall malalignment has got reduced in various studies by Rommens et al (17.6%), Josten et al (11.1%), Wysocki et al (6.6%), Bolhofner et al (2%), Nork et al (8.1%). In our study out of the 20 patients 1 had Apex anterior angulation more than 5*, 2 patients had Valgus malalignment. However, the average angular alignment in the sagittal plane was less than 4* and in the coronal plane was less than 2*. Hansen et al found that the average coronal plane angulation was 2*valgus (2*varus to 12* valgus) and the average anterior bow deformity in proximal third fractures was 7*(5*-12*).

In a study of 21 tibial fractures managed with IM nailing and blocking screws, Krettek et al[1] reported that all fractures went on to union, with a mean coronal alignment of −1.0°(range, −5° to 3°) and a mean sagittal alignment of 1.6° (range, −6° to11°). Ricci et al[1] also reported on the use of blocking screws with IM nailing of proximal tibia fractures in a series of 12 consecutive patients. One patient had an angular deformity >5° postoperatively; however, none of the patients had an angular deformity >4° in the plane in which the blocking screws were inserted. In addition to improving alignment, blocking screws have been shown to increase the biomechanical stability of the bone-implant construct by 25%.

The amount of coronal plane malalignment in this study in cases of perfect midline entry is lesser compared to medial or lateral entries. Also a superior intraarticular entry resulted in lesser degrees of Apex anterior angulation [15]. However, the exact technique to get a superior entry point via fully flexed knee, semi extended knee or a retro patellar approach needs further evaluation.

Buehler et al[10] documented an average anterior displacement of 3mm (0-17mm) with only modified surgical techniques. The range of anterior displacement varied from 3mm posterior to 8mm anterior in our study. The degree of angulation and the amount of displacement could not be correlated. But the utilization of Poller screws has reduced the translation in the anteroposterior direction. Also, a perfect entry in the midpoint presented with no translation in the mediolateral direction.

So-called blocking or Poller screws can be used during intra medullary nailing of proximal tibial fractures. They are placed preemptively in an effort to prevent a deformity. In studies by Cole et al and Ricci et al utilizing poller screws for proximal tibia fractures helped achieving only 1% of malalignment which is even bettered in our study. blocking screws are used in our study which ended with good union and good to fair alignment.

In another study by Tornetta et al [7] comparing the effectiveness of semi extended position nailing these fractures the average anterior angulation was 8* in those 5 fractures treated in the flexed position but of the 25 patients who were treated while in the semi extended position, none had more than 5* anterior angulation and 19 had no anterior angulation. We used semi extended position in only 3 patients and hence the clinical correlation with regards to malalignment cannot be commented upon. But the identification and placement of the correct entry point was found easier in the Fully Flexed position than the semi extended position.

| **Study** | **Number of fractures** | **Management** | **Number of Malreductions (%)** |
|---|---|---|---|
| Cole et al | 13 | Blocking screws | 1(7.7%) |
| Tornetta and Collins et al | 25 | Semi extended position | 0 |
| Ricci et al | 12 | Blocking screws | 1(8.3%) |
| Vidyadhara and Sharath et al | 45 | Semi extended position/Blocking screws | 7(15.6%) |
| This study | 20 | All the techniques described above were used | 3(15%) |

The relationship between the fracture malalignment and Klemm and Borner scoring [19] is consistent in the present study. A detailed scoring system pertaining to the long-term functional outcomes of knee joint and the leg following Extraarticular Proximal Tibia fractures need to be devised.

Valgus mal-alignment, the most common deformity after nailing these fractures, is due to the medial nail entry point and the laterally directed nail insertion angle in the proximal fragment. Valgus Mal-alignment may also be due to inadequate reduction before nailing. Varus angulation at the fracture site occurs if the nail entry is lateral, with the use of the lateral approach for tibial nailing.

Apex anterior angulation is the second most common deformity after nailing these fractures, caused when the nail is inserted with a certain degree of flexion of the knee, and by the patellar tendon pulling the proximal fragment anteriorly.

Posterior translation mainly depends on the Herzog's bend of the nails [4]. If this crosses the fracture into the distal fragment, it is likely to pull the distal fragment posteriorly. Loss of fixation with late deformities is caused by the wide metaphyseal fragment producing no endosteal contact with the nail, and also by the inability to pass at least two locking screws in the short proximal fragment when using most standard nails.

The following solutions [15] have been advocated in this study to address each of the Problems associated with nailing these fractures.

(1) Hyperflexion of the knee presents the proximal tibial surface better for nail insertion. However, such flexion makes the quadriceps pulls the proximal fragment into extension, producing apex anterior angulation. The semi extended position with 15—20* of flexion of the knee is recommended.

(2) Before reaming and nailing, temporary anatomical reduction is achieved in closed fractures by manipulation under image intensifier guidance.

(3) A long incision is made from the superior pole of the patella to the tibial tuberosity exposes the trochlea which allows lateral subluxation of the patella, and thus a more proximal and more lateral entry hole, which can further avoid hyperflexion of the knee.

(4) In proximal tibial fractures, it is important to insert the nail slightly lateral to the usual starting point, to avoid valgus angulation. In the anteroposterior view, the nail should be inserted in line with the medial edge of the lateral tibial spine. The entry hole should be placed on

the tibial plateau more posteriorly than usual, so that it encroaches on the joint surface.

(5) The reamer is directed anteriorly parallel to the anterior cortex of the tibia, never laterally. A neutral reaming angle, in both coronal and sagittal planes, has to be maintained. In this study this was not found at the last follow up to cause any problems with knee function.

. (6) To reduce the apex angulation and anterior translation of the proximal fragment, a posterior Poller screw is inserted in the mediolateral direction and placed in the distal portion of the proximal fragment slightly posterior to the longitudinal axis. To prevent valgus angulation, a lateral Poller screw is inserted in the anteroposterior direction and placed in the distal portion of the proximal fragment slightly lateral to the longitudinal axis. Blocking screws are inserted perpendicular to the plane of the deformity, on the concave side of the deformity, within the more mobile fracture segment.

# CONCLUSION

In our study of 20 patient, It was found that proximal tibial shaft fractures which had intra medullary nailing after correct placement of Poller screws, went for uncomplicated union and shown good results. Distance between knee joint line and fracture did not affect the result.

We conclude that Poller screws, when supplemented the intramedullary nailing of extra articular proximal third fractures of tibia,

1. were effective in achieving the fracture alignment, acting as a reduction tool
2. improved the stability of the bone – implant construct, by functionally reducing the medullary width
3. maintained the fracture alignment till union, preventing loss of initial reduction.

Covid19 and its implication on trauma has reduced the number of cases to 19, larger number of cases treated with above method can give more statistically significant results.

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# PROTCOL FOR EVALUATION

| PRE OPERATIVE EVALUATION | | |
|---|---|---|
| **NAME** | | |
| AGE/SEX | | |
| MODE OF INJURY | | |
| TIME FROM RTA TO ADMISSION | | |
| COMORBID ILLNESS | | |
| CLASS- WINQUIST WITH DETAILS | | |
| CLASS- AO | | |
| DISTANCE FROM JOINT LINE | | |
| INTIAL DEFORMITY | | |
| | APEX ANTERIOR | |
| | APEX POSTERIOR | |
| | ANT TRANSLATION | |
| | POST TRANSLATION | |
| | VALGUS | |
| | VARUS | |
| | MEDIAL TRANSLATION | |
| | LATERAL TRANSLATION | |
| SEGMENTAL FRACTURE | | |
| FIBULA # | | |
| OTHER INJURIES | | |
| **SURGICAL EVALUATION** | | |
| TIME FROM RTA TO SURGERY | | |
| TIME FROM ADMISSION TO SURGERY | | |
| DURATION OF SURGERY | | |
| KNEE POSITION | | |
| APPROACH | | |
| ENTRY- AP | | |
| ENTRY- ML | | |
| NAIL | | |
| MEASURED LENGTH | | |
| NAIL SIZE | | |
| NAIL POSITION | | |

| | | |
|---|---|---|
| PROX LOCKS | | |
| DETAILS | | |
| POLLER SCREW | | |
| DETAILS | | |
| PLATE | | |
| EX FIX | | |
| REAMING | | |
| BONE GRAFTING | | |
| **POSTOPERATIVE EVALUATION** | | |
| FOLLOW UP PERIOD | | |
| INFECTION | | |
| ANTERIOR KNEE PAIN | | |
| LEG LENGTH DISCREPANCY | | |
| KNEE ROM | | |
| NONUNION | | |
| DELAYED UNION | | |
| UNION | | |
| TIME TO UNION | | |
| ALIGNMENT | APEX ANT | |
| | APEX POST | |
| | ANT TRANS | |
| | POST TRANS | |
| | VALGUS | |
| | VARUS | |
| | MED TRANS | |
| | LAT TRANS | |
| SECONDARY DISPLACEMENT | | |
| | DEFORMITY | |
| | ANGULATION/DISPLACEMENT | |
| KLEMM AND BORNER SCORE | | |

# KLEMM AND BORNER SCORING SYSTEM

| Final score | R.O.M | Muscle atrophy | Alignment | Pain | Union |
|---|---|---|---|---|---|
| Excellent | 4 | 3 | 4 | 4 | 4 |
| Good | 3 | 2 | 3 | 3 | 3 |
| Fair | 2 | 1 | 2 | 2 | 2 |
| Poor | 1 | 0 | 1 | 1 | 1 |

| | Rating |
|---|---|
| R.O.M ankle **knee** | |
| No restriction | 4 |
| <25% | 3 |
| 25-50% | 2 |
| 50-75% | 1 |
| Muscle atrophy (calf) | |
| No atrophy | 3 |
| <2 cm | 2 |
| 2-3 cm | 1 |
| >3 cm | 0 |
| Alignment | |
| Normal | 4 |
| Angular deformity | 3 |
| 5-10° | 2 |
| >10° | 1 |
| Pain (at the fracture site) | |
| Absent | 4 |
| On prolonged | 3 |
| On weight bearing | 2 |
| At rest | 1 |
| Union (weeks) | |
| <12 | 4 |
| 13-24 | 3 |
| 25-36 | 2 |
| >36 | 1 |

R.O.M: Range of motion

## KEY TO MASTER CHART

Sex : M - Male

F - Female

MOI - Mode of Injury

RTA - Road traffic accident

AF - Accidental Fall

Side of Injury : R - Right

L - Left

Another Distal #- Fracture

Y - Yes

N - No

ENTRY

S - Superior

I - Inferior

LAT - Lateral

MID - Midline

MED - Medial

# MASTER CHART

| SNO | AGE | SEX | MOI | SOI | DISTANCE from KNEE JT | ANOTHER DISTAL # | AO | | WINQUIST | NO OF POLLER SCREWS | ENTRY | ENTRY | ENTRY | UNION | MALALIGNMENT | SAGIT ALIGN IN DEG | CORON ALIGN IN DEG | COMPLICATION | WEIGHT BEARING in weeks | TIME FOR UNION in weeks | SCORE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 54 | M | RTA | R | 5 | N | 2.1 | | I | 2 | S | S | LAT | U | ACCEPTABLE | 0 | -3 | NIL | 8 | 14 | GOOD |
| 2 | 18 | M | RTA | R | 7.5 | N | 3.2 | | II | 1 | I | S | MID | U | ACCEPTABLE | 0 | 0 | NIL | 6 | 12 | EXC |
| 3 | 45 | F | RTA | L | 5 | N | 2.3 | | I | 2 | S | S | LAT | U | ACCEPTABLE | 0 | -4 | NIL | 10 | 16 | GOOD |
| 4 | 50 | M | RTA | L | 4 | N | 2.1 | | I | 2 | S | S | MID | U | ACCEPTABLE | 0 | 0 | NIL | 8 | 14 | EXC |
| 5 | 48 | M | RTA | R | 8 | Y | 2.3 | | I | 1 | S | S | MID | U | ACCEPTABLE | 0 | 0 | NIL | 10 | 16 | FAIR |
| 6 | 24 | M | RTA | R | 4.5 | N | 3.1 | | II | 1 | S | I | LAT | U | ACCEPTABLE | +2 | 0 | NIL | 6 | 12 | GOOD |
| 7 | 55 | M | RTA | R | 5 | N | 3.2 | | II | 0 | | S | MID | U | VALGUS | 0 | +6 | DELAYED UNION | 12 | 28 | POOR |
| 8 | 44 | M | AF | R | 4 | N | 3.2 | | III | 1 | S | S | LAT | U | ACCEPTABLE | +2 | 0 | NIL | 8 | 14 | GOOD |
| 9 | 36 | M | RTA | R | 6.5 | N | 3.2 | | II | 1 | I | S | MID | U | ACCEPTABLE | 0 | 0 | NIL | 10 | 16 | EXC |
| 10 | 32 | M | RTA | L | 4 | N | 3.3 | | III | 0 | I | I | LAT | U | ACCEPTABLE | +3 | +2 | NIL | 8 | 14 | FAIR |
| 11 | 42 | M | RTA | L | 5 | Y | 2.1 | | I | 1 | I | S | LAT | U | ACCEPTABLE | 0 | +3 | NIL | 8 | 14 | EXC |
| 12 | 35 | M | RTA | R | 5.5 | N | 3.2 | | II | 0 | I | I | MED | U | VALGUS | 0 | +7 | DELAYED UNION | 10 | 24 | POOR |
| 13 | 45 | F | RTA | R | 5 | N | 3.1 | | II | 0 | S | S | MID | U | ACCEPTABLE | +4 | -3 | NIL | 8 | 14 | FAIR |
| 14 | 40 | M | RTA | R | 3.5 | N | 3.2 | | II | 1 | S | S | MID | U | ACCEPTABLE | 0 | +3 | NIL | 8 | 16 | GOOD |
| 15 | 28 | M | RTA | R | 5 | N | 3.1 | | III | 1 | S | S | LAT | U | ACCEPTABLE | -3 | +4 | NIL | 6 | 13 | GOOD |
| 16 | 40 | M | RTA | L | 7 | N | 3.2 | | II | 0 | I | I | MID | U | APEX ANT | +10 | +4 | DELAYED UNION | 12 | 26 | POOR |
| 17 | 36 | M | RTA | R | 6 | Y | 3.2 | | III | 0 | S | S | MID | U | ACCEPTABLE | +4 | 0 | NIL | 9 | 18 | FAIR |
| 18 | 42 | F | AF | L | 6.5 | N | 3.2 | | II | 1 | S | S | LAT | U | ACCEPTABLE | 0 | +2 | NIL | 8 | 16 | GOOD |
| 19 | 28 | M | RTA | L | 6 | N | 2.3 | | I | 1 | S | S | MID | U | ACCEPTABLE | 0 | -4 | NIL | 6 | 12 | GOOD |
| 20 | 42 | M | RTA | R | 7 | N | 3.2 | | III | 0 | S | I | MED | U | ACCEPTABLE | +3 | 0 | NIL | 8 | 14 | FAIR |