MANAGEMENT OF EXTRA ARTICULAR DISTAL TIBIAL METAPHYSEAL FRACTURES BY INTRAMEDULLARY INTERLOCKING NAILING

A SHORT TERM ANALYSIS

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CERTIFICATE

This is to certify that the dissertation titled ***"MANAGEMENT OF EXTRA ARTICULAR DISTAL TIBIAL METAPHYSEAL FRACTURES BY INTRAMEDULLARY INTERLOCKING NAILING A SHORT TERM ANALYSIS"*** is the original work done by ***Dr.MOHAMED SAMEER.M,*** post graduate in M.S., Orthopaedic Surgery at the Department of Orthopedic Surgery, Madras Medical College, Chennai-600 003 to be submitted to the Tamil Nadu Dr. M.G.R. Medical University, Chennai- 600 032, towards the partial fulfillment of the requirement for the award of M.S., Degree in Orthopaedic Surgery, March 2008.

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INTRODUCTION

Fractures of tibia remain a controversial subject despite advances in both non-operative and operative care. The goal in expert care is to realign the fracture, realign limb length and early functional recovery.

Treatment of distal tibial metaphyseal fractures can be challenging. Fractures in this region have not been clearly distinguished from pilon fractures, and the literature contains relatively little information on their treatment [28.31.32]. The mechanism of injury, treatment principles and prognosis for these fractures is different from and must be distinguished from those for both proximal diaphyseal fractures and distal intra-articular pilon fractures [5]. Treatment selection is influenced by the proximity of the fracture to the plafond, fracture displacement, comminution, and injury to the soft-tissue envelope.

Traditional methods of surgical fixation, such as open reduction and internal fixation have been associated with poor results, including soft tissue devitalization, skin slough and infection [19]. Conservative treatment in an attempt to avoid these complications has resulted in unacceptable deformity and loss of ankle range of motion [34,35]. Minimally invasive surgical techniques have been developed to avoid soft tissue complications while providing the stability and alignment offered with internal fixation [27]. Several techniques have emerged: hybrid external fixation, external fixation with limited internal fixation, percutaneous plate osteosynthesis and intramedullary nailing [23].

Intramedullary nailing of open and closed tibial shaft fractures has been associated with high rates of radiographic and clinical success, but the use of this procedure has not become widely accepted for distal metaphyseal fractures [29]. Because fractures distal to the tibial diaphysis and within 5 -6 cm of the ankle joint may represent a different injury, they have been excluded from reports on intramedullary nailing of tibial shaft fractures [15]. The distal segment of these fractures is more difficult to control with intramedullary implants because of the metaphyseal flare above the plafond which amplifies the bending moment.

Recent changes in intramedullary nail design have extended the spectrum of fractures amenable to this type of fixation [11]. But there are concerns about using intramedullary nailing as a treatment for distal metaphyseal fractures because of difficulties with reduction, risk of distal propagation of the fracture, hardware failure, and inadequate distal fixation leading to loss of reduction and malalignment. Only a few studies have assessed the use of intramedullary nailing in dealing with fractures below the tibial isthmus.

This justifies a separate review of the epidemiology and prognosis of these injuries.

AIM OF THE STUDY

To analyse the short term results of intramedullary interlocking nailing in the management of extra articular distal tibial metaphyseal fractures done in our institution during the period February 2005 to August 2007.

REVIEW OF LITERATURE

HISTORICAL REVIEW:

EVOLUTION OF INTRAMEDULLARY NAILING		
1875	HEINE	Used ivory pegs in experiments
1875	BARDEHEUER	Ivory pegs clinically
1875	SOCIN	Ivory pegs
1886	BURNS	Ivory pegs
1886	BIRCHER	Reported ivory peg use at German Surgical meet
1902	LEJAHRS	Referred ivory pegs as "nails"
1907	LAMBOTTE	First to use intramedullary metal splints
1916	HEYGROVES	Used solid intramedullary metal rods
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 (Known internationally as the 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 & MEATZ	Published their book
1951	HERZOG	Introduced rigid cloverleaf nail
1961	KUNTSCHER	documented the number of nails sold for treating tibial fractures Availability of reamers, muscle relaxants obviated the need of reduction apparatus and thicker and new nails improved the operative results
1968	KUNTSCHER	At annual meet of German Surgical Society introduced the ‘detensor” He introduced the principle of detention to remove harmful forces from frature site and to prevent shortening of bone just before his death. He agreed to change the name to “interlocking nail” since it describes the principle of new nail better.
1960-70	KLEMM,SCHELLMANN AND GROSS-KEMP	Front runners of current generation of interlocking nails

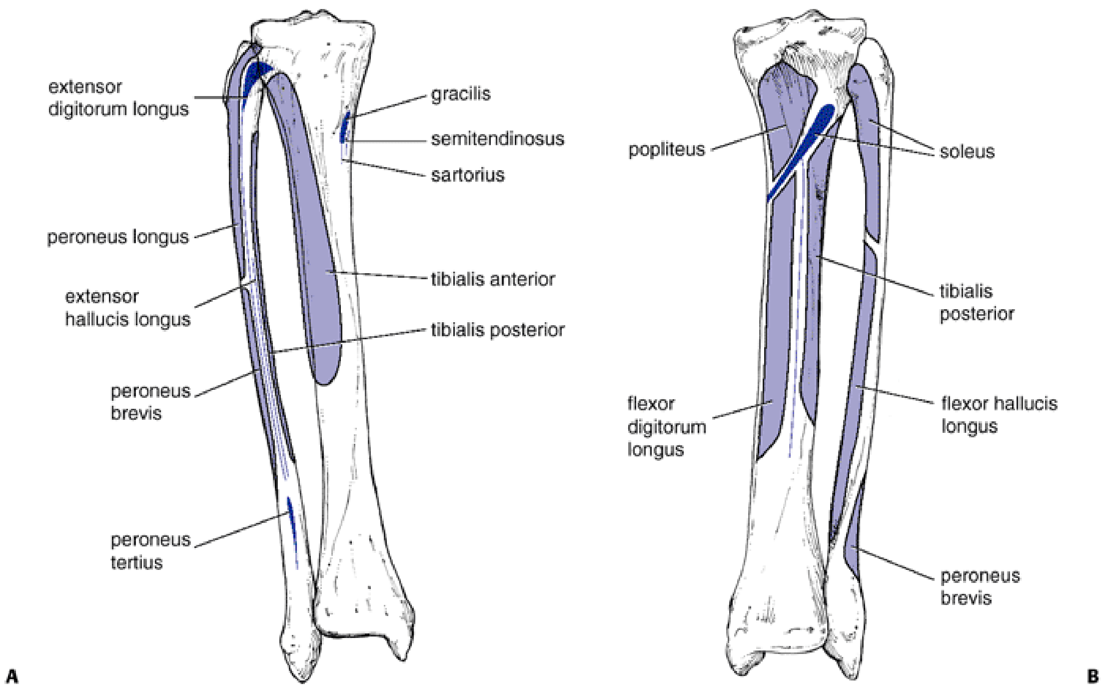
ANATOMY:

Tibia serves as a weight bearing support to body and also a conduit for neurovascular supply of foot. It with its asymmetric surrounding soft tissues, determines the shape of the leg. The location of the tibia and the fact that its anteromedial border is subcutaneous renders the bone susceptible to injury. The length of tibia varies from 30 cm to 47 cm, its intramedullary diameter from 8 mm-15 mm.

The diaphysis becomes thinner distally, which means that it is particularly at risk from twisting injuries. The shaft flares and becomes more rounded as it meets the distal metaphysis. The surrounding cortex thins and is centrally replaced by metaphyseal secondary spongiosa and cancellous bone. In active patients, this cancellous bone can be dense, thereby providing secure purchase for screws. The medullary canal is significantly more round in cross section than the external appearance of the bone. It is hourglass-shaped with a variably pronounced isthmus, such that a tight endosteal fit with intramedullary fixation is achieved only in the middle few centimeters of the diaphysis.

ANTEROMEDIAL SURFACE – TIBIA

It is a subcutaneous surface-has no muscular or ligamentous attachments. The palpable anteromedial surface increases in concavity distally as it approaches the medial malleolus.Restoration of the anteromedial concave surface are critical to avoid angular or rotational malunion.



ANTEROLATERAL SURFACE - TIBIA

Forms the medial wall of anterior muscular compartment of leg, with tibialis anterior proximally and more distally the neurovascular bundle and extensor hallucis longus muscles adjacent to it.

POSTERIOR SURFACE – TIBIA

It is buried and has muscular attachments from proximal to distal of semi membranous, popliteus, soleus, tibialis posterior and flexor digitorum longus. The posterior tibial vessels and flexor hallucis longus muscle approach it distally, curving around medial malleous behind tibialis posterior and flexor digitorum longus.

LOWER END - TIBIA

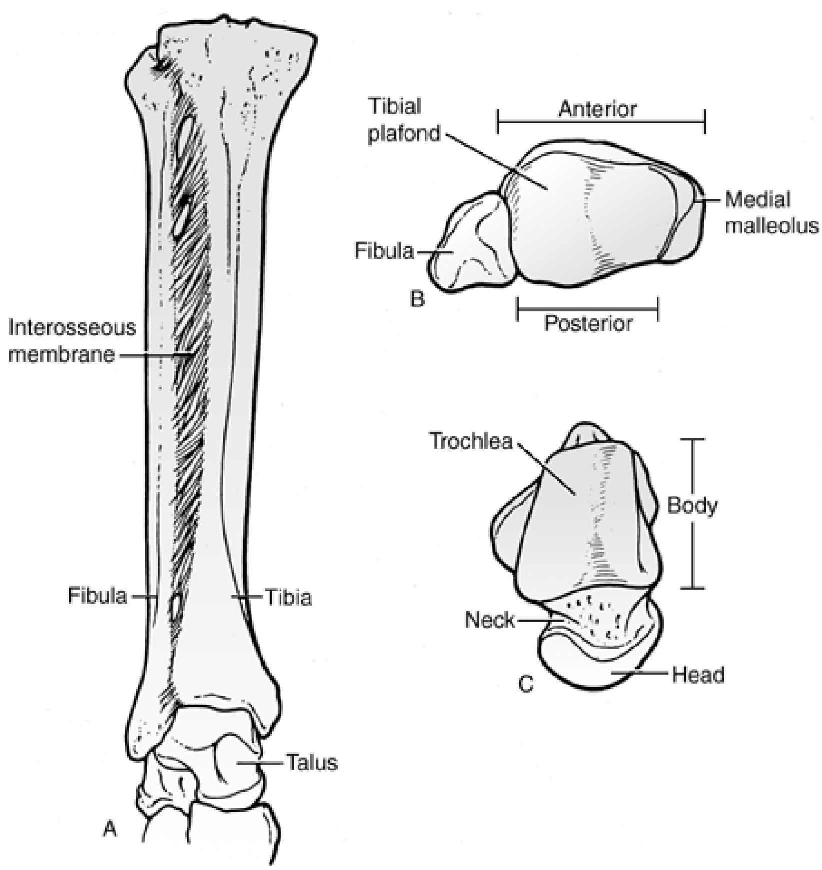
The lower end of the tibia is formed by five surfaces: inferior, anterior, posterior, lateral, and medial. The inferior surface is articular, concave anteroposteriorly, and slightly convex transversely, dividing the surface into a wider lateral and narrower medial segment.The medial surface is prolonged distally by the medial malleolus.

LOWER END –FIBULA

The fibula is situated posterolateral to the tibia; distally, it articulates with a shallow facet on the lateral surface of the distal tibial metaphysis. It is attached to the distal tibia through the syndesmotic ligaments as well as the distal interosseous membrane. It has two major surfaces, lateral and medial, which widen into the three-surfaced lateral malleolus at the level of the tibial plafond.

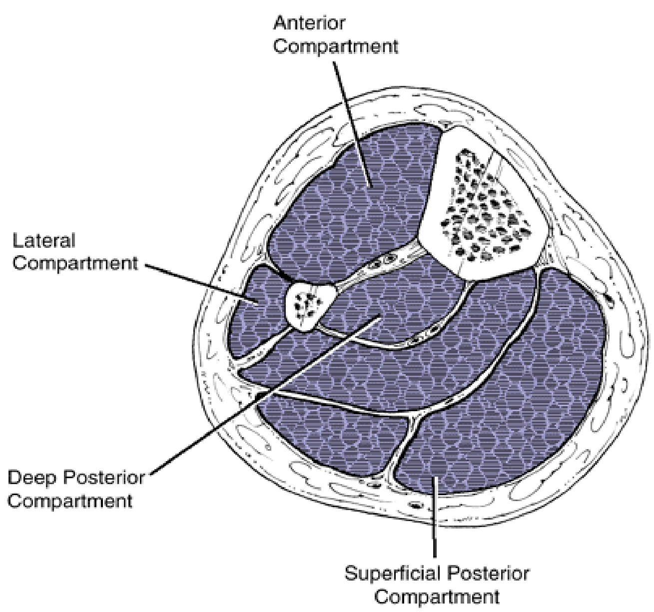
ANKLE JOINT

The ankle joint is a complex, three-bone joint. It consists of the tibial plafond,the medial malleolus,and the lateral malleolus. The joint is considered saddle-shaped, with a larger circumference of the talar dome laterally than medially. The dome itself is wider anteriorly than posteriorly, and as the ankle dorsiflexes, the fibula rotates externally through the tibiofibular syndesmosis, to accommodate this widened anterior surface of the talar dome. The lateral malleolus and the lateral ligamentous complex are critical to maintaining stability of the ankle joint



COMPARTMENTS

The muscle, tendon, ligament and neurovascular structures in leg are divided into anterior, lateral and posterior compartments. An anterolateral septum divides the lateral compartment from the anterior. A posterolateral septum lies between lateral and superficial posterior compartments. A posterior septum intervenes between the deep and superficial posterior compartments.



ANTERIOR

Includes tibialis anterior,extensor hallucis longus, extensor digitorum communis with peroneus tertius. It is a relatively unyielding compartment bounded by tibia medially, fibula laterally, interosseous membranes posteriorly and tough crural fascia anteriorly. Its neurovascular bundle consists of anterior tibial artery and veins joined in the proximal part of compartment by deep peroneal nerve.

LATERAL

It has peroneus longus and peroneus brevis.They protect fibula from direct injury.The superficial peroneal nerve runs in the intermuscular septum between peroneal muscles and extensor digitorum longus. The nerve is injured with fractures of fibular neck and fractures of shaft at junction of mid- third and distal-third fibula. No major vascular structures are present.

SUPERFICIAL POSTERIOR

It contains gastrocnemius, soleus, plantaris and popliteus muscles. Sural nerve, short and long saphenous veins are present. No artery of significance is present. Compartment syndrome can occur here. It also serves as a source for local muscle flaps for covering soft tissue defects in proximal- mid third of tibia.

DEEP POSTERIOR

It contains tibias is posterior, flexor, digitorum longus and flexor hallucis longus It lies distal to popliteal line. Popliteal artery, tibial nerve and Peroneal artery are the major neurovascular contents.

BLOOD SUPPLY

It is derived from three sources:

1. NUTRIENT ARTERY

It is a branch of posterior tibial artery. It pursues a very tortuous source, enters the posterolateral cortex of tibia at the origin of soleus just below the oblique line of tibia posteriorly. On entry it divides into tree ascending branches and one main descending branch. Each soon divides into a leash of vessels running towards metaphysis. While the lower nutrient artery reaches the junction of middle third and lower third, it is almost exhausted of its supply rendering lower third relatively avascular.

2. PERIOSTEAL VESSELS

The periosteal arteries of the tibia arise from the anterior and posterior tibial arteries and nourish the outer one fifth to one third of cortical bone. The metaphyseal and nutrient arteries supply the remaining inner cortex and endosteum. This route of blood supply is enhanced by attachment of muscles, tendons and ligaments on it to. In upper two third where fleshy muscles are attached the blood supply is good, whereas in lower third where only tendons surround the supply is very poor and is dependent on nutrient vessel branch.

3. EPIPHYSEAL VESSELS

Source is from vessels forming anastomoses around joint piercing the bone along the line of attachment of joint capsule.

APPLIED ANATOMY

- The cancellous bone in proximal and distal end varies in density according to both location and individual's metabolic bone status.
- Proximal tibia has apex anterior angulation averaging 15*, which requires a bend in the upper portion of medullary nails.
- Proximal tibial posterior wall is thin and flat which makes it possible to err and perforate the poster wall with drill or intramedullary nail.
- The distal cancellous bone provides secure purchase for screws and is often compact enough to restrict penetration by intrameduallary nail.
- Variably pronounced isthmus may limit the endosteal contact of intramedullary nail even with significant reaming.

- In cadaveric specimens, latex injection studies with microdissection demonstrated a well-defined network of vessels arising from the anterior and posterior tibial arteries, which arborize along the medial surface of the distal tibia and nourish this region. Injury to this delicate blood supply to the distal tibia may contribute to an increased risk of nonunion and infection after surgical fixation [4].

CLASSIFICATION

Distal tibia fractures are characterized descriptively, taking care to include all parameters that may affect surgical treatment and postoperative outcome.Fracture patterns are characterized as transverse, spiral, oblique, or segmental.

Soft-tissue status can be graded by the Tscherne-Gotzen and Gustilo-Anderson classifications for closed and open fractures, respectively.

Open fractures were classified by **Gustilo and Anderson**[12] in 1976, modified in 1987 which is mostly accepted and quoted throughout the world.

Type I: have less than one centimetre wound and are due to low energy injury. It is usually due to inside out injury due to bone piercing the wound.

Type II: wounds are greater than 1 centimetre as they are due to high energy injury. The injury is mostly outside in. The amount of soft tissue injury is mild to moderate. Wound closure is mostly possible without SSG or flap cover.

Type III: wounds are due to high energy outside in injuries with wound greater than 10 centimetres and extensive muscle devitalisation.

Type IIIA- minimal soft tissue and periosteal stripping; soft tissue cover and wound closure will not be a problem.

Type IIIB- extensive soft tissue and periosteal stripping; closure of wound requires a local flap or free tissue transfer.

Type IIIC- open fractures associated with vascular injury where a repair is required for limb salvage.

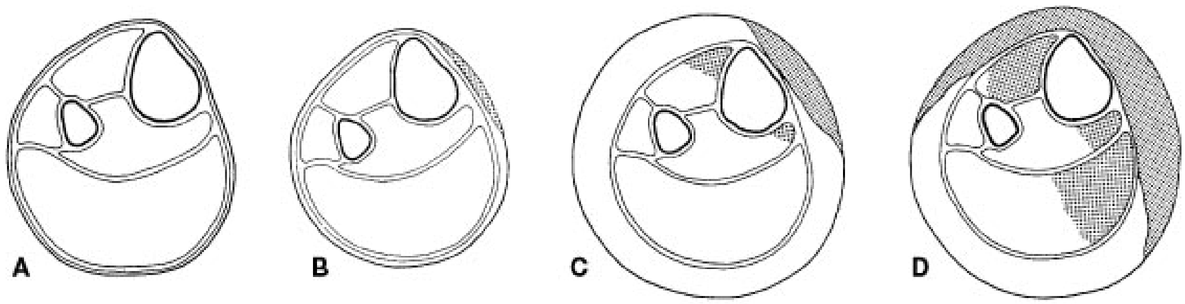
Soft tissue injuries in closed fractures are usually graded by **Tscherne and Gotzen** [26] grading.

Grade 0: little or no soft tissue injury(A).

Grade 1: superficial abrasion with local contusional damage to skin (B)

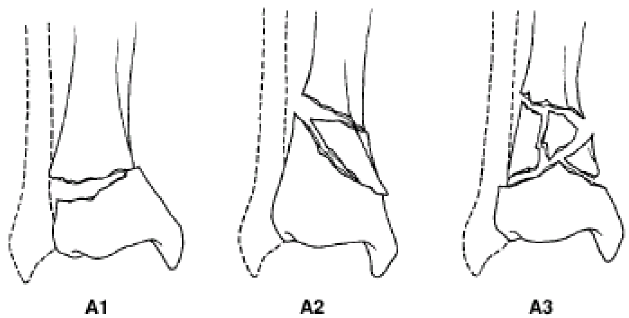
Grade 2:deep contaminated abrasion with local contusional damage to skin and muscle. (C)

Grade 3:extensive contusion / crushing of skin or destruction of muscle. (D)



There is no specific classification for Extra articular distal tibial metaphyseal fractures, although studies on this type of fracture commonly use the AO/OTA classification for the fractures of the tibial plafond (segment 43) and the classification by Robinson et al.

The AO/ASIF classification of long bone fractures provides a standardized way to classify fractures which has gained wide clinical acceptance [18]. The AO classification system for the fractures of the tibial plafond segment 43 divides articular fractures into three types (A, B, C), each with three main subtypes [24].

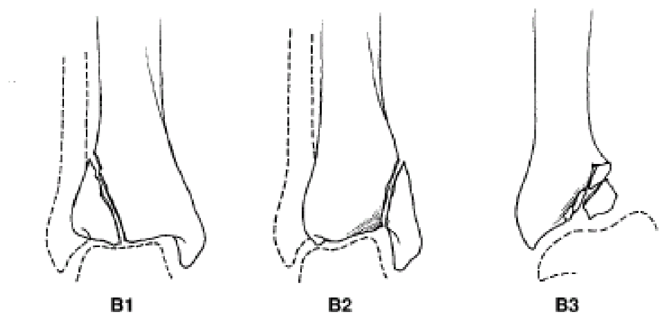


Type A Extra-articular

A1 Metaphyseal simple

A2 Metaphyseal wedge

A3 Metaphyseal complex

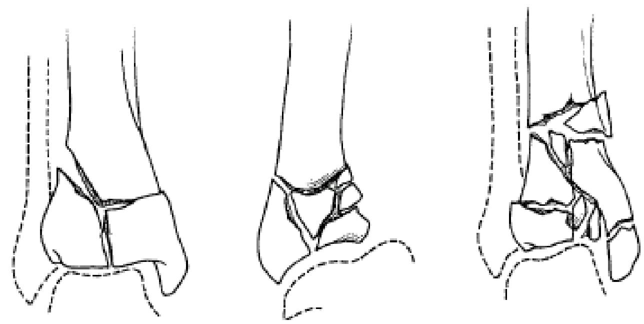


Type B Partial articular

B1 Pure split

B2 Split depression

B3 Multifragmentary depression



Type C Complete articular

C1 Simple articular with simple metaphyseal fracture

C2 Simple articular with multifragmentary metaphyseal fracture

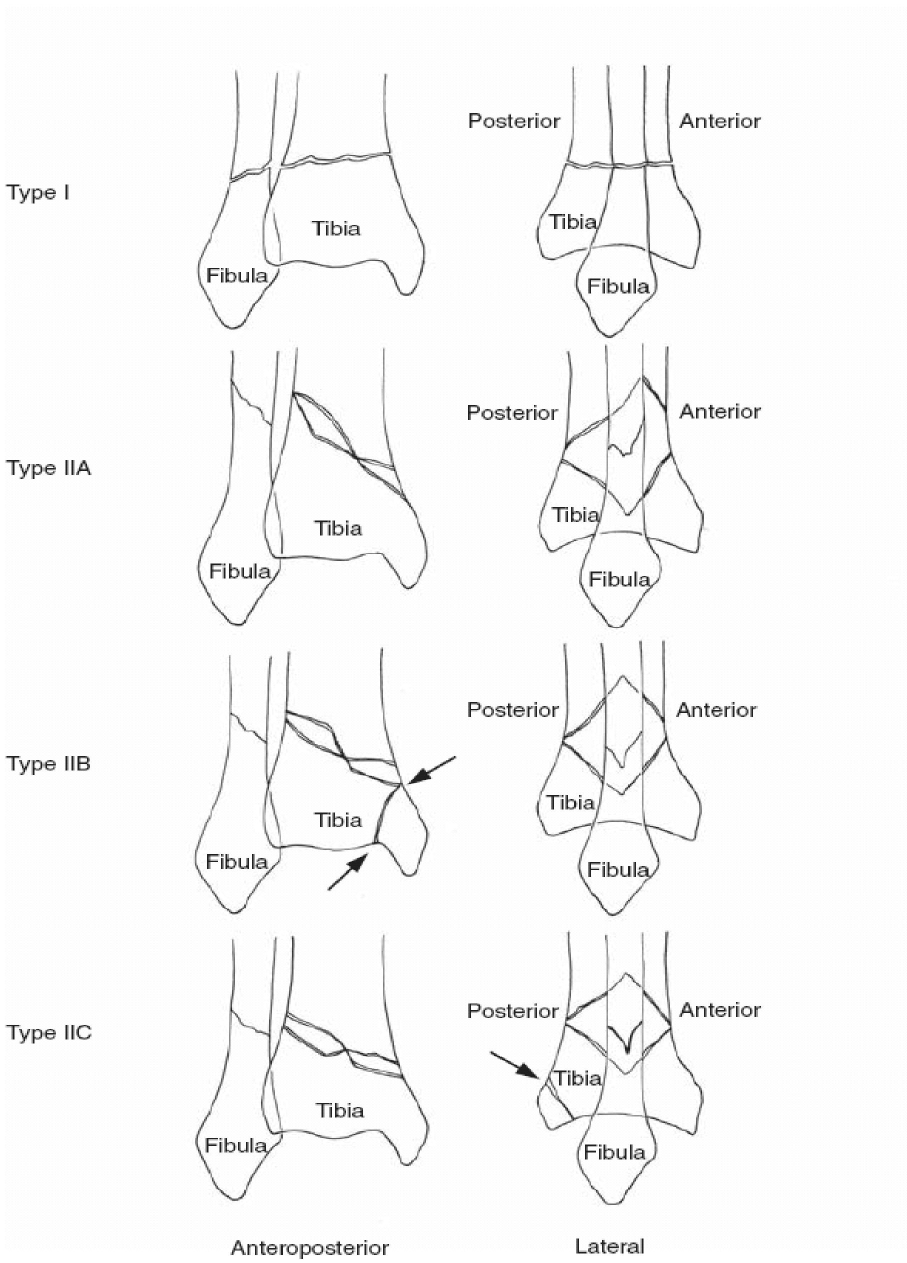
C3 Articular multifragmentary

Robinson et al [30] developed a classification system based on two discrete patterns of injury observed in their series of more than 60 distal tibia metaphyseal fractures with no or minimal involvement of the plafond.

Type I: Simple transverse or oblique fracture line with an associated fibular fracture at the same level. No intra-articular extension was observed.

Type II: Spiral fracture line with an associated oblique fibular fracture at the same or different level. Intra-articular extension in this group was sub classified based on simple extension of the fracture line to involve either the medial (IIB) or the posterior malleolus (IIC).

Both type I and II fracture patterns are distinct from those that occur with a vertical compression load, which results in articular surface comminution typical of pilon injuries.



BIOMECHANICS

BIOMECHANICS OF IM NAIL

IM nails act as internal splints with load-sharing characteristics. The amount of load borne by the nail depends on the stability of the fracture/implant construct. This stability is determined by nail size, number of locking screws or bolts, and distance of the locking screw or bolt from the fracture site [2]. In current practice, 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.

Friction of the nail within the medullary canal determines the resistance to motion. This friction between nail and bone is affected by curvature, its cross-sectional shape and its diameter, as well as canal. Fluting of the nail can increase its torsional friction within the medullary cavity. Three types 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; however, in the absence of cortical contact, compressive loads are transferred to the interlocking screws, which results in four-point bending of the screws [2].

As with all metallic implants, there is a relative race between bone healing and implant failure. Occasionally, an implant will break when fracture healing is delayed or when nonunion occurs. Unlocked nails typically fail either at the fracture site or through a screw hole or slot. Locked nails fail by screw breakage or fracturing of the nail at locking hole sites, most commonly at the proximal hole of the distal interlocks

BIOMECHANICS OF INTERLOCKING SCREW/BOLT

The number of bolts used is based on fracture location, amount of fracture comminution, and the fit of the nail within the canal. Oblique and comminuted fractures rely on interlocking screws for stability, as do very proximal and very distal metaphyseal fractures, where the medullary canal widens 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, minor movements occur between the nail and screws, allowing toggling of the bone. The stability depends on the locking screw or bolt diameter for a given nail diameter. Nail hole size should not exceed 50% of the nail diameter. Interlocking screws undergo four point bending loads, with higher screw stresses seen at the most distal locking sites.

The closer the fracture is to the distal locking screws, the less cortical contact the nail has, which leads to increased stress on the locking screws. The location of the distal locking screws affects the biomechanics of the fracture, but the effect of the orientation of the locking screws is less clear. Oblique or transverse orientation of the distal screws in distal-third tibia fractures has minimal effect on stability

To maintain optimal alignment in nondiaphyseal fractures, care should be taken to direct the nail into the center position of both fragments.In addition, multiple locking screws should be used in the metaphyseal fragment. Tibial nail designs can have very distal and proximal locking sites as well as multiplanar locking options for the fixation of proximal and distal metaphyseal fractures.

FRACTURE HEALING WITH MEDULLARY NAILING

Tibia is subjected to compression, torsion and bending stress. An intact bone which is a stiff bone becomes unstable after a fracture. Stability is the mechanical basis and vascularity the biologic basis of uncomplicated fracture healing. The haversian system acts as a conduit between the endosteal and periosteal circulation; normally, the flow is centrifugal. In >90% of patients, only a single proximal diaphyseal nutrient artery is seen in the tibia.

There is a predictable local vascular response to fracture, composed of five separate phases. In the first phase, blood flow is temporarily interrupted.The second phase is marked by vasoconstriction. The third phase is marked by vascular recruitment. 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 extra osseous. Animal studies have confirmed that the principle sources of increased blood flow in healing diaphyseal fractures are the periosteal and extra osseous tissues [38]. Although IM reaming has a negative effect on endosteal blood supply [22], it allows for insertion of a larger, stiffer nail with increased cortical contact [13]. In addition, reaming stimulates local extraosseous and periosteal blood flow, which is the most important source of nutrient flow during fracture healing [1,36].

Although it is clear that reaming causes embolization of marrow contents and alters levels of immune mediators, it has not been shown in either animal models or clinical human studies to increase mortality or alter pulmonary function [3].

OPERATIVE PROCEURE

POSITION OF THE PATIENT

In standard technique for interlocking nailing fracture table is used. Patients positioned supine with hip flexed to 45 degrees and knee flexed to 90 degrees under calcaneal pin traction. Alternatively, patient may be positioned supine on the ordinary table with the knees hanging down the end of the table. Patient may also be positioned supine on the ordinary table and the knee kept in flexion with pillow under the knee.

FRACTURE REDUCTION

Fracture can be reduced by the traction through the calcaneal pin when fracture table is used or manual traction and manipulation can be given when standard table is used usually under C-arm control. A femoral distractor or a fibular plating can also be used to reduce and align the fracture.

ENTRY POINT

Patellar tendon splitting approach: A vertical insertion from tuberosity to the lower end of the Patella is made. Patellar tendon is exposed and split in the middle. Entry point is made with awl, proximal to tibial tubercle approximately 1.5 cm distal to joint line and in line with the center of the medullary canal on the AP view.

Medial Parapatellar approach;Here incision is made from middle of the medial border of patella to tibial tuberosity. Patellar tendon is exposed and retracted laterally. Entry point is made similar to the previous approach.

REAMING,NAIL INSERTION AND LOCKING

After entry point is made ball tipped guide wire is passed under C-arm. Guide wire should be in center of the distal fragment on both views and advanced to within .5 mm to 1 cm of ankle joint. Then serial is reaming done in .5 mm increments. Then flexible Teflon sleeve is passed over the wall tipped guide wire. Then wall tipped guide wire is exchanged for a smooth tip wire for nail insertion.

Length of the nail determined by (Fluoroscopic measurement):

1. With the help of graduated guide wire.
2. Subtraction of the exposed guide wire from the total length of the guide wire.

3. Using radiopaque ruler and measuring distance between anterior edge of the entry portal to a point 0.5 to 1 cm proximal to ankle join.

Nail diameter is selected 1 mm less than the last reamer used. Now the appropriate nail mounted in the Jig and it is inserted over the guide wire under C-arm control. The distal tip of the nail should lie approximately 0.5 to 2 cm from the subchondral bone of the ankle joint. Now the traction is released to allow impaction of the fracture. Proximally counter sinking of nail is done up to 0.5 to 1 cm.

Distal locking is done under C-arm control as free hand technique. The number and orientation of the distal locking bolts were made at the surgeon's discretion. In general 2 medial to lateral locking bolts were preferred. Proximal locking is done with Jig. Before insertion of proximal locking fracture site is checked and if it is distracted reverse jamming is done.

MATERIALS AND METHODS

This study was designed to review the outcomes of the treatment of extraarticular distal tibial metaphyseal fractures by intramedullary interlocking nailing.

From Feb 2005 to Aug 2007, 28 consecutive extraarticular distal tibial metaphyseal fractures in skeletally matured patients managed by primary locked intramedullary nailing. Inclusion criteria were, fracture sustained within the past 1 week, skeletal maturity, fracture centre in the distal metaphysis of tibia involving the distal 5 cm , associated fibular fracture and treatment with an intramedullary nail of the fracture pattern that allowed placement of atleast 2 distal interlocking screws through the nail.

Patients with neglected fractures (more than 3 weeks), non union, and patient with multiple injuries or a history of previous knee or ankle pathology were not included as were patients who sustained high energy axial load injury causing disruption or impaction of the ankle plafond.

There were 24 men and 4 women with a mean age of 33 years (19 to 55). All fractures were classified by the AO system (Muller et al 1990), and the classification by Robinson et al. The severity of the soft-tissue injury in the open fractures was recorded on the Gustilo system and closed fractures were recorded on the Tscherne system. Biplanar injury radiography was evaluated to determine the fracture location and involvement of the distal part of the tibia by applying AO system of rule of squares. In all cases the fracture extended to within 5.5 cm of the ankle joint and there was associated fibular fracture. Low energy motor vehicle accident and fall from height causing a torsional or bending force was the mechanism of injury in majority of the patients.

All the fractures were treated with a primary reamed intramedullary nailing system that increased the distal fixation with up to 3 biplanar distal interlocking screws passing through the distal 4 cm of the nail. The surgery was done using a standard radiolucent table under c- arm guidance with manual traction alone. The decision for adjunctive fibular stabilisation as well as the number and orientation of the distal locking bolts were made at the surgeon’s discretion. In general 2 medial to lateral locking bolts were preferred. Open reduction of the fracture was done in 8 patients.

Patients suffering from open fractures underwent debridement and primary closure followed by stabilisation. Closed fractures were initially managed by reduction and application of splint followed by operative treatment to decrease the soft tissue swelling.

All patients were given I.V third generation cephalosporin during induction wich was continued for 3-5 days post operatively. The average time from the moment of injury to the operative fixation of fracture was 12 days (range 6 hrs to 20 days)

POST OP PROTOCOL AND FOLLOW UP:

All patients followed the same postoperative protocol. The leg was initially placed in a splint for forty-eight to seventy-two hours. Post operative antero-posterior and lateral X-rays were taken and analysed for alignment, locking and stability of the fixation. All patients were encouraged to begin an early active range of motion of the ankle and knee as tolerated. Sutures were removed on the twelfth post operative day. A detachable brace was then applied, if the patient was thought to be able to comply with the postoperative protocol. Patients who were thought to be unable to follow postoperative instructions wore a short leg cast for the initial four weeks. Patients were not allowed to bear full weight for four weeks.

All patients were reviewed by a single observer. Clinical assessment included time to full weight bearing, return to work, presence of anterior knee pain and limb length and rotation. Ankle motion was recorded and all patients were scored using the IOWA ankle evaluation system [20]. Radiographs were reviewed monthly for fracture union and to assess limb alignment. The alignment was assessed by constructing longitudinal line from the mid point of the medial and lateral cortices (on anterior- posterior X ray) for varus – valgus measurement and mid point of the anterior and posterior cortices (on lateral X rays) for recurvatum – procurvatum measurement [9].

Bony union was defined as evidence of bridging callus across the fracture site or the obliteration of the fracture lines based on the X ray findings. Mal union was defined as varus / valgus deformity, anterior/posterior angulations, or rotational deformity of more than 10 degrees or shortening of more than 1 cm [25]. Delayed Union was defined as the failure to see evidence of union on radiographs at various time-points ranging from twenty to twenty-six weeks.

IOWA ANKLE EVALUATION SCORE

Function: (40)

- Does housework or job without difficulty (8)
- Climbs stairs (10)
- Carries heavy objects, such as a suitcase (4) ___/40
- Is able to run, or work at heavy labour(4)
- Walks enough to be independent(8)
- Does yard work, gardening, lawn mowing (4)
- Has no difficulty getting in or out of an automobile (6)

Freedom from pain: (40)

- No pain (40)
- Pain only with fatigue or prolonged use (30) ___/40
- Pain with weight-bearing (20)
- Pain with motion (10)
- Pain with rest or continuous pain (0)

Gait:(10)

- No limp (10)
- Antalgic limp (8) ___/10
- Uses cane or one crutch (2)
- Uses wheelchair or can't walk (0)

Range of motion(10)

- Dorsifiexion and plantar flexion ___/10
- (2 Points for every 20 degrees)

TOTAL SCORE : ___/100

- Excellent : 100 - 90
- Good :89 - 80
- Fair :79 - 70

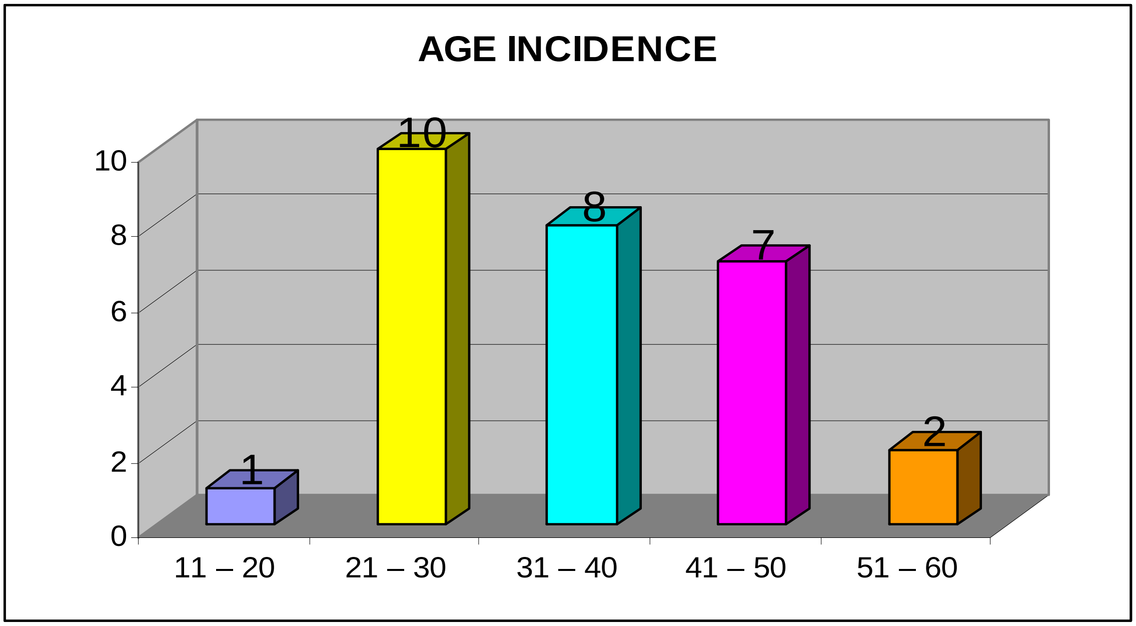
OBSERVATION

The following observations were made in the study.

AGE INCIDENCE:

Patients' age ranged from 19 to 55 years. Average: 32.

Age in yrs	No. of Patients
11 – 20	1
21 – 30	10
31 – 40	8
41 – 50	7
51 – 60	2
TOTAL	**28**



SEX INCIDENCE:

In our series, Male predominated with the ratio of 6:1.

Sex	**No. of Patients**
Male	24
Female	4

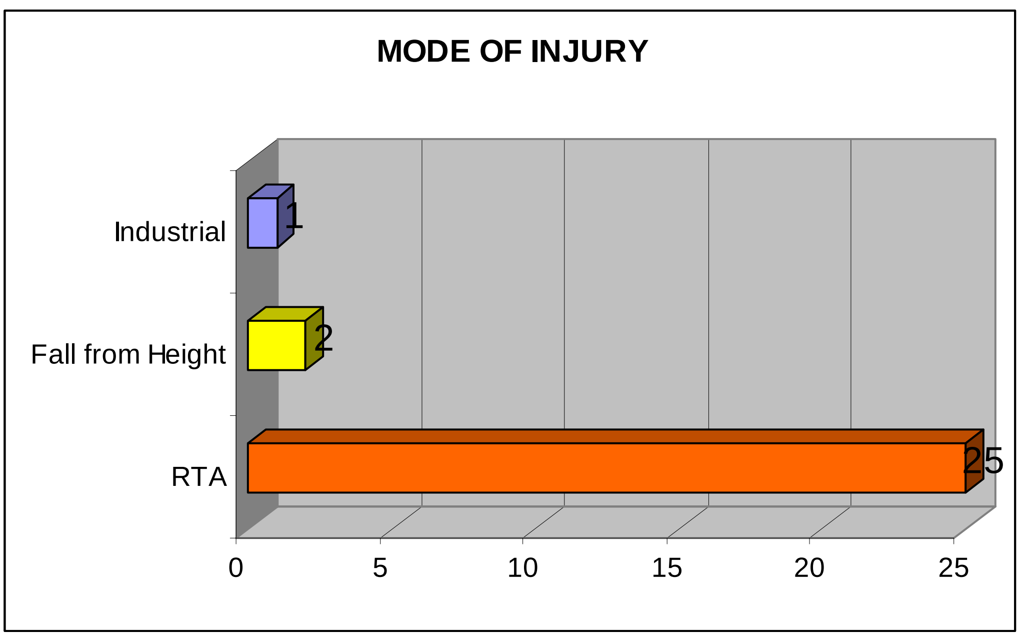
SIDE:

In our series, Right side was more common.

SIDE	**No. of Patients**
Right	18
Left	10

MODE OF INJURY:

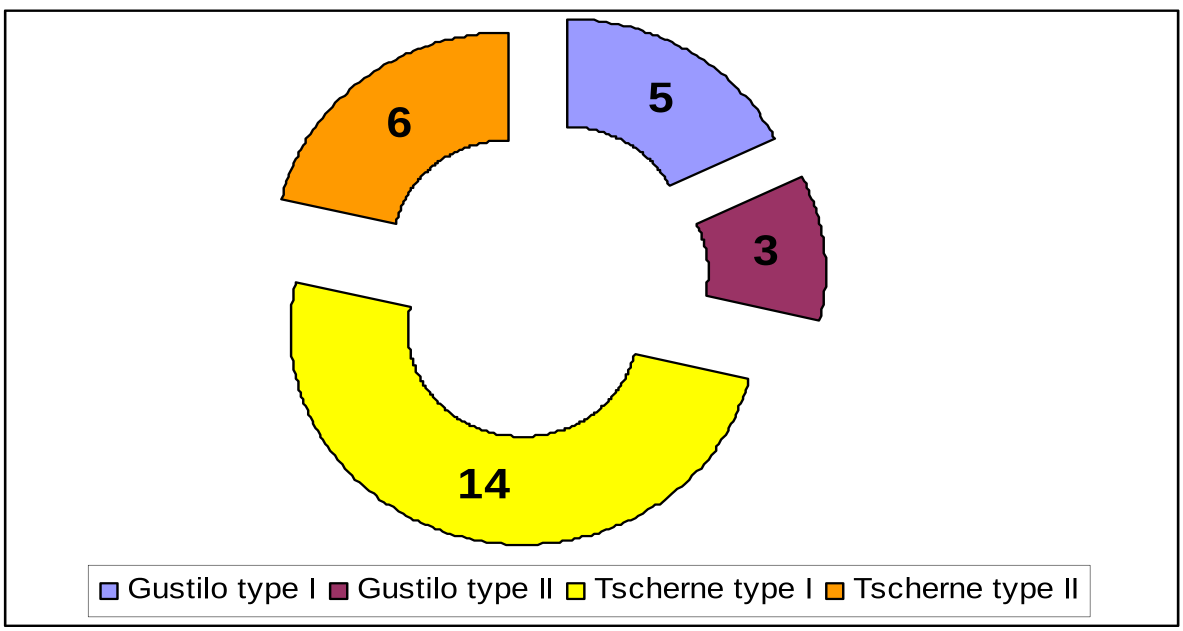
In our series, RTA is the predominant cause of injury. In RTA, pedestrian Vs 2 wheeler was the most common sub type.



FRACTURE CLASSIFICATION:

In our study,eight fractures were open: five were classified as Gustilo type I and three as type II. Of the remaining closed fractures fourteen were classified as Tscherne type I and six as type II.

FRACTURE TYPE		No. of Patients
Open	Gustilo type I	5
	Gustilo type II	3
Closed	Tscherne type I	14
	Tscherne type II	6



AO/OTA CLASSIFICATION:

According to AO/OTA guidelines, there were sixteen 43A1, nine 43A2 and three 43A3 fractures.

AO/OTA Type	**No. of Patients**
43 A 1	16
43 A 2	9
43 A 3	3

ROBINSON CLASSIFICATION:

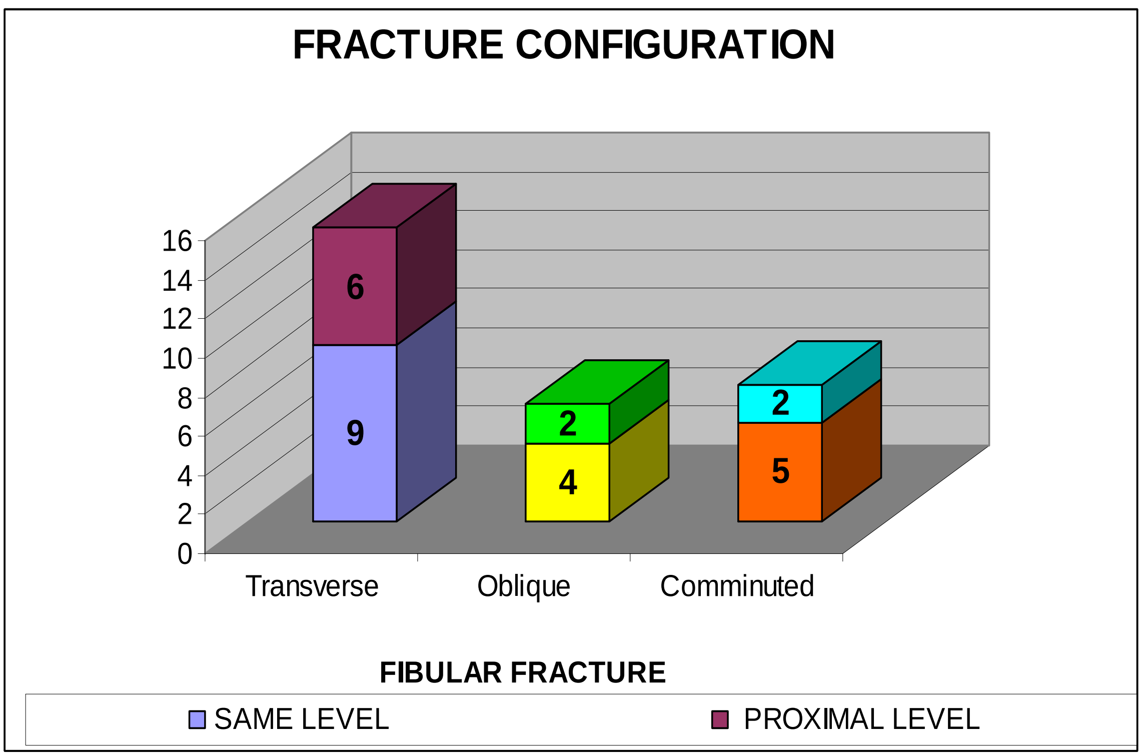
On using the classification of Robinson et al seventeen patients had type I and eleven patients had type IIA fractures

ROBINSON Type	**No. of Patients**
I	17
IIA	11

FRACTURE CONFIGURATION:

Type of Tibia Fracture	**Level Of Fibula Fracture**	**No. of Patients**
Transverse	Same level	9
	Proximal level	6
Oblique	Same level	4
	Proximal level	2
Comminuted	Same level	5
	Proximal/Segmental	2

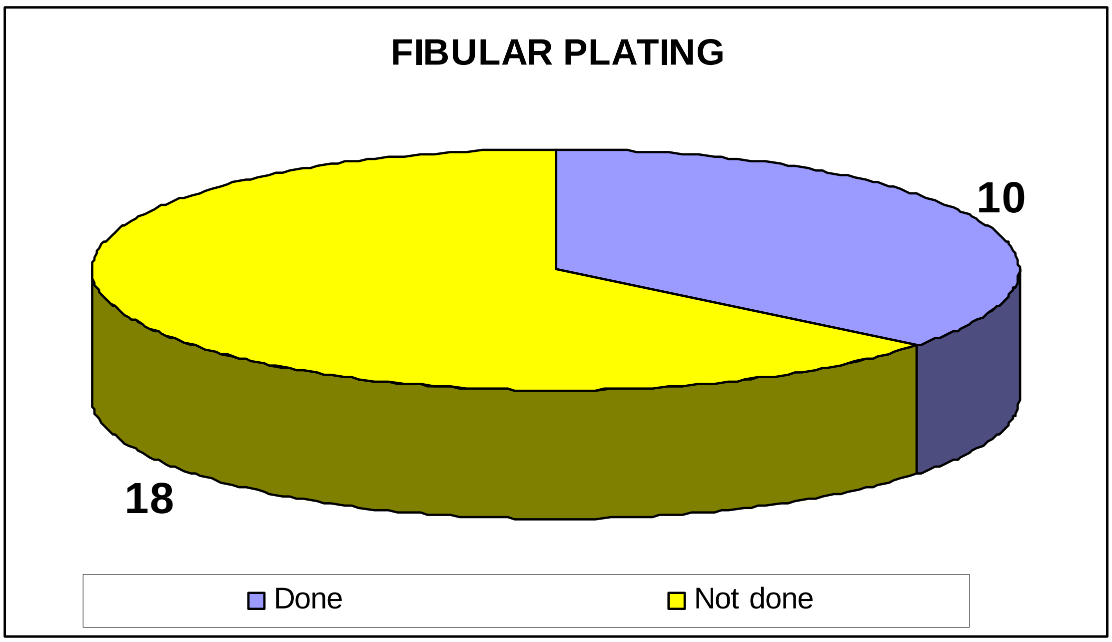
In our series, nearly 60% of fractures were transverse.

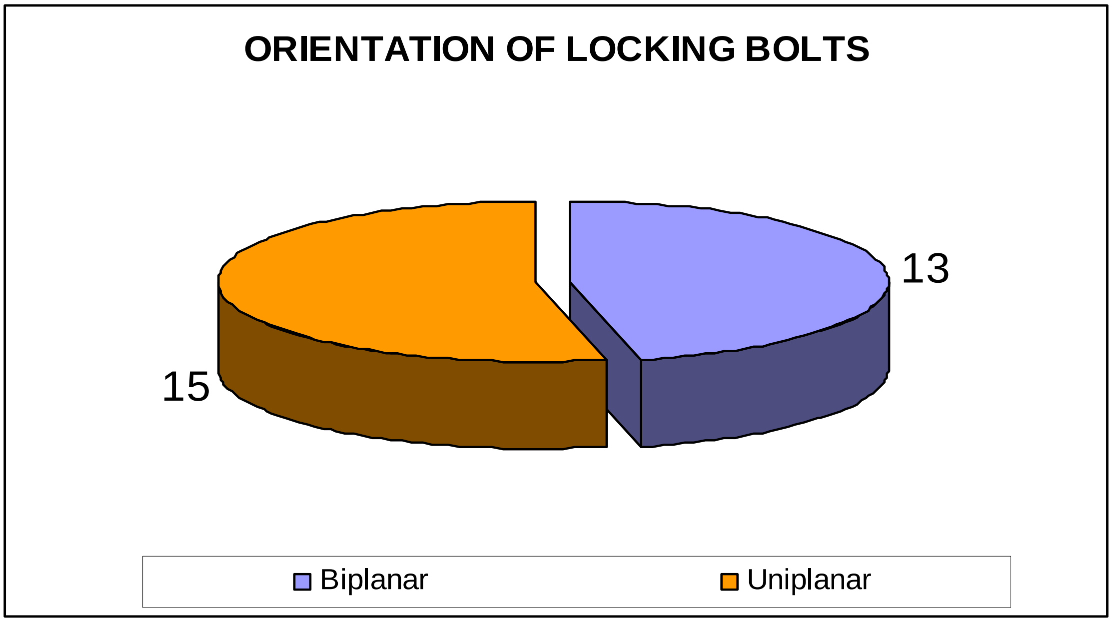


RESULTS

The mean follow up was 14 months (range 3m to 26 m).The average distance from the distal extent of the tibial fracture to the plafond was 4.8 cm (range, 4.2 cm to 5.8 cm). The average distance between the distal tip of the nail and the articular surface of the plafond was 12 mm (range, 4 to 15 mm).

The decision for adjunctive fibular stabilisation as well as the number and orientation of the distal locking bolts were made at the surgeon's discretion. Fibular plating was done in 10 patients. Two distal locking bolts were used in 26 patients; 2 patients had three distal locking bolts.





Acceptable alignment was obtained in 26 patients. The two patients who had immediate malalignment in the form of 10° valgus deformity had transverse fracture of tibia with same level fibular fracture (AO43A1 & Robinson type 1). In both the cases fibula was not stabilized. One patient underwent corrective surgery with fibular plating and the other patient denied surgery and was eventually lost for follow up.

In total out of the 28 patients in our study, two were lost to follow-up. Out of the remaining 26 patients, 25 had radiographic evidence of healing at the time of follow-up. The mean time for union was 19 weeks (range 12 – 26 weeks). The mean IOWA ankle functional assessment score was 82 (good) (range 68-94)

Of the two patients who were lost to follow-up, one had comminuted fracture with segmental fibular fracture and the other had transverse fracture with same level fibula fracture. The fracture patterns and immediate postoperative alignment in these patients were not significantly different from those in the remaining.

Eight patients had change in the final alignment in either the coronal or the sagittal plane compared with the alignment on the immediate postoperative radiographs. All the 8 patients had 2 distal locking bolts without fibular stabilization. The clinical and demographic details of these patients are given in the table.

Gender		
Male		7
Female		1
Fracture type		
Open (Gustilo)	Type 1	2
	Type 2	1
Closed(Tscherne)	Type 1	3
	Type2	2
Fracture classification		
AO/OTA	43 A 1	4
	43 A 2	2
	43 A 3	2
Robinson	Type I	6
	Type IIA	2
Fracture configuration		
Transverse		4
Oblique		2
Communited		2
Location of fibula fracture		
Same level		7
Different level		1
Locking bolts		
2 Medio-lateral		5
1 Anterio Posterior & 1 Medio Lateral		3
Distance of the fracture from ankle joint		4.6 cm (Avg)
Type of Malalignment		• Valgus angulation10° : 4 patients • Varus angulation 10° : 2 patients • Valus with recurvatum: 2 patients

Other complications included one superficial infection, one deep infection at the site of fracture,one delayed union and four patients of anterior knee pain. The superficial infection responded to local debridement and intravenous administration of antibiotics. In the patient with deep infection, the fibula was united and the patient underwent nail removal with postero-lateral bone grafting which went on to heal uneventfully. No bone-grafting procedures were required to obtain union in any patient. The patient with delayed union underwent dynamization procedure. Anterior knee pain was managed conservatively.

CASE ILLUSTRATIONS

CASE ILLUSTRATION: 1

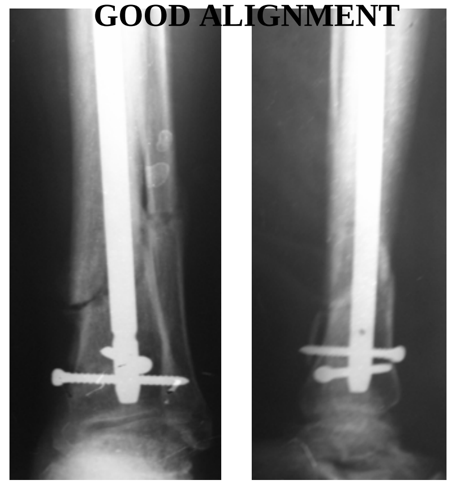
- NAME : Mr.N (Patient No:3)
- AGE/GENDER :26/M
- I.P.No : 732 201
- MODE OF INJURY :RTA
- NATURE OF INJURY :Closed Tscherne Type I
- DISTANCE FROM PLAFOND :5.2 cm
- CLASSIFICATION
    - AO : 43A1
    - ROBINSON :II A
    - TYPE :Oblique fracture of tibia with proximal fibular fracture
- DISTAL SCREW ORIENTATION:Biplanar
- FIBULAR PLATING :Not Done
- MALUNION ON FOLLOW UP :NIL
- TIME TO UNION :16 weeks
- IOWA SCORE : 92
- COMPLICATION :NIL

CASE ILLUSTRATION: 1: Mr. N (PATIENT: 3)

PRE-OP X RAY : AP & LAT

IMMEDIATE POST OP GOOD ALIGNMENT

6 WEEKS FOLLOW UP GOOD MALALIGNMENT



14 WEEKS FOLLOW UP UNION

RANGE OF MOVEMENTS AT 16 WEEKS

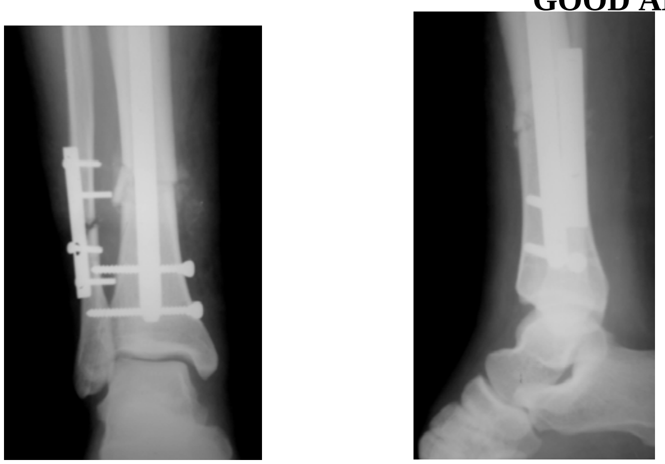
CASE ILLUSTRATION: 2

- NAME : Mrs.C (Patient No:7)
- AGE/GENDER :50/F
- I.P.No : 742 300
- MODE OF INJURY :RTA
- NATURE OF INJURY :Closed Tscherne Type I
- DISTANCE FROM PLAFOND :4.2 cm
- CLASSIFICATION
    - AO : 43A2
    - ROBINSON :II A
    - TYPE :Communited fracture of tibia with Same level fibular fracture
- DISTAL SCREW ORIENTATION:Uni planar
- FIBULAR PLATING : Done
- MALUNION ON FOLLOW UP :NIL
- TIME TO UNION :18 weeks
- IOWA SCORE :90
- COMPLICATION :NIL

CASE ILLUSTRATION: 2: Mrs. C (PATIENT: 7)

PRE-OP X RAY: AP & LAT

IMMEDIATE POST OP GOOD ALIGNMENT



12 WEEKS FOLLOW UP GOOD ALIGNMENT

RANGE OF MOVEMENTS AT 18 WEEKS

CASE ILLUSTRATION: 3

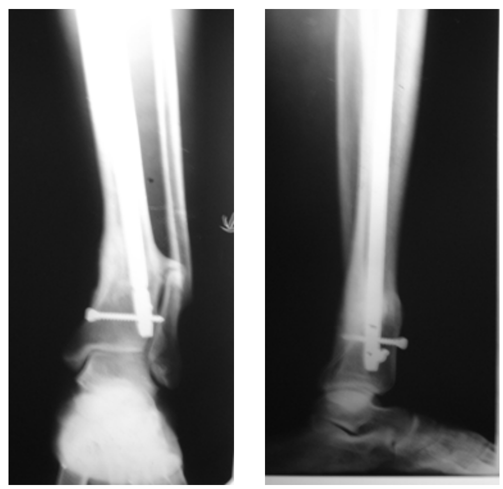
- NAME : Mr.S (Patient No:14)
- AGE/GENDER :23/M
- I.P.No : 784 401
- MODE OF INJURY :RTA
- NATURE OF INJURY :Closed Tscherne Type II
- DISTANCE FROM PLAFOND :4.0 cm
- CLASSIFICATION
    - AO : 43A2
    - ROBINSON :II A
    - TYPE :Communited fracture of tibia with Same level fibular fracture
- DISTAL SCREW ORIENTATION: Bi planar
- FIBULAR PLATING : Not Done
- MALUNION ON FOLLOW UP :VARUS MALUNION
- TIME TO UNION :15 weeks
- IOWA SCORE :72
- COMPLICATION :NIL

CASE ILLUSTRATION: 3: Mr. S (PATIENT: 14)

PRE-OP X RAY : AP & LAT

IMMEDIATE POST OP
GOOD ALIGNMENT

6 WEEKS FOLLOW UP
VARUS MALALIGNMENT



12 WEEKS FOLLOW UP
VARUS MALUNION

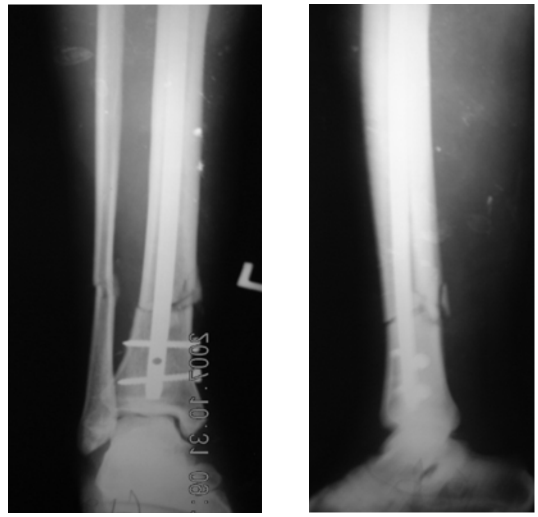
RANGE OF MOVEMENTS AT 15 WEEKS

CASE ILLUSTRATION: 4

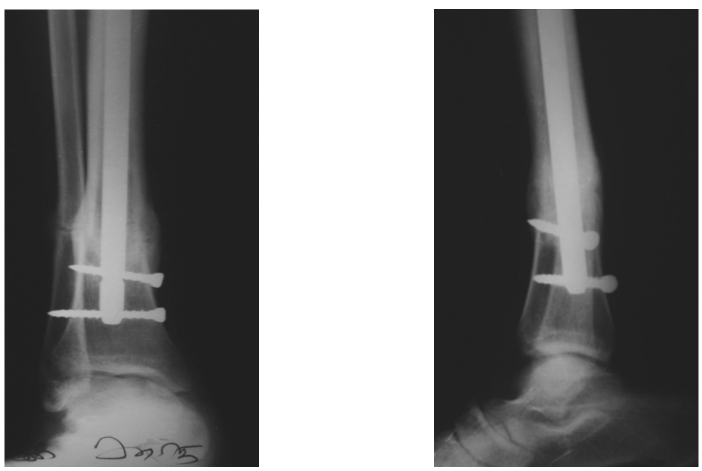
- NAME : Mr.A (Patient No:20)
- AGE/GENDER :32/M
- I.P.No : 800 245
- MODE OF INJURY :FALL
- NATURE OF INJURY :Closed Tscherne Type I
- DISTANCE FROM PLAFOND :4.5 cm
- CLASSIFICATION
  - AO : 43A1
  - ROBINSON :I
  - TYPE : Transverse fracture of tibia with Same level fibular fracture
- DISTAL SCREW ORIENTATION: Uni planar
- FIBULAR PLATING : Not Done
- MALUNION ON FOLLOW UP :Recurvatum
- TIME TO UNION :16 weeks
- IOWA SCORE :74
- COMPLICATION :NIL

CASE ILLUSTRATION: 4: Mr. A (PATIENT: 20)

PRE-OP X RAY : AP & LAT



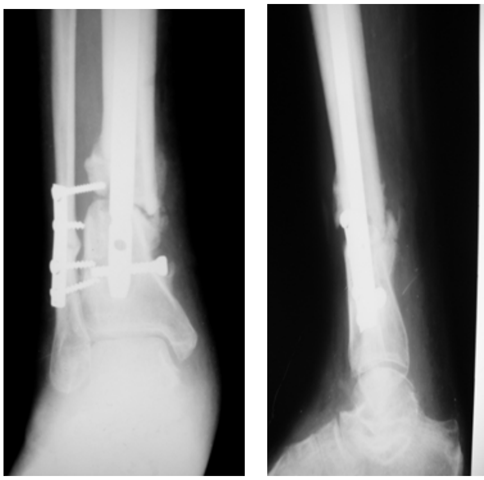
IMMEDIATE POST OP
GOOD ALIGNMENT



14 WEEKS FOLLOW UP - RECURVATUM MALUNION

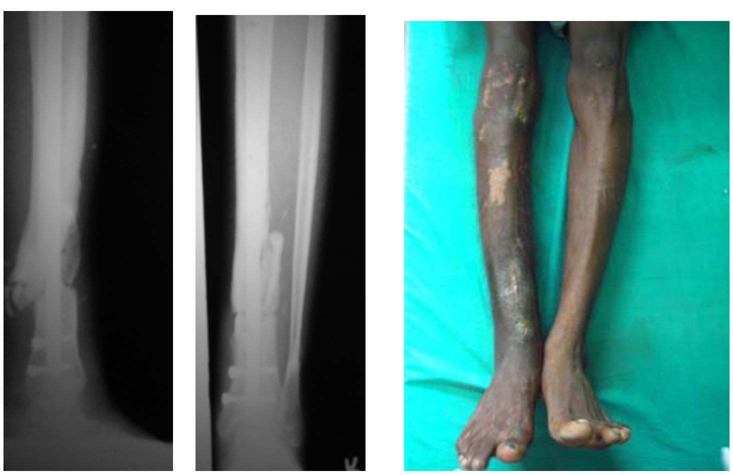
RANGE OF MOVEMENTS AT 18 WEEKS

COMPLICATIONS



1. DELAYED UNION REQUIRING DYNAMISATION

2. POST OP VALGUS ALIGNMENT



3. DEEP INFECTION REOUIRING IMPLANT EXIT

DISCUSSION

Treatment principles for extraarticular distal tibial metaphyseal fractures are different from and must be distinguished from those for both proximal diaphyseal fractures and distal intra-articular pilon fractures.

Muller defined the distal tibial metaphysis by constructing a square, with the sides of length defined by the widest portion of the tibial plafond. In our review, we considered fractures within 5.5 cm of the tibial plafond without extension to the plafond to be distal metaphyseal fractures.

The major difficulty in selecting candidates for intramedullary fixation of a distal tibial fracture is in differentiating low energy tibial fractures from axial high energy loading injuries with or without primary articular involvement [7,8]. Published studies often include fractures with intra articular extension and they utilize AO/OTA classification of tibial pilon fractures for classification which is inadequate, does not address the fibula and does not differentiate high energy axial load fractures with low energy extra articular fractures. Our study, all patients had the primary fracture centre being located in the metaphysis, without articular extension with associated fibular fracture.We utilized both AO/OTA classification for comparison and the new classification by Robinson et al.

The shortcomings we observed in this new classification were that the fracture patterns described were not common in our set up, it included an intraarticular and malleolar extension group which is difficult to recognize by X rays and does not address stabilization of fibula.

Nailing of extra articular distal tibia fractures is challenging, technically demanding and should be approached with caution [8]. Apart from malalignment which is recognized in the immediate postoperative period, primarily due to difficulty in controlling the short distal fragment and technical errors, loss of reduction can occur during the follow up due to unrecognized instability [9]. Though critical surgical tenets such as central placement of the guide wire and reamers, maintenance of the reduction at the time of nail passage and placement of nail in subchondral region, are described to avoid intraoperative malalignment [33], very few studies explore the causes and prevention of loss of reduction during follow up [7].

In our study we found that the loss of reduction and malunion was more – 8 patients (25%).Zelle et al [37] performed a meta-analysis of the English-language literature to assess the complications and healing rates associated with the different technique used to treat this injury. The results of this review revealed that the highest complication rates were in the intramedullary nailing group with malunion rate of 16.2%. In the study by Nork et al., on fractures located within 5 cm of the ankle joint treated by nailing an 8% rate of malunion was reported. No patient demonstrated loss of alignment during the follow-up period. The better results reflected in this series were related at least partly to the common use of multiple screws in the distal fragment and ipsilateral fibular plating.

Therefore excluding patient related causes for late malalignment, the two major factors which appear to affect the fracture construct stability are adjunct fibular stabilization and the number and orientation of the distal locking bolts [21].

Kumar et al [17] reported on the effect that fibular plating of the same level tibia-fibula fractures has on the rotational stability of distal tibial fractures treated with an IM nail. Fibular plate reduced axial rotation by approximately 1.5 deg when a torque of 1 to 5 N was applied to the proximal end of the tibia. Another study by Morrison et al [39] in cadavers found that plating the fibula improved resistance to deformation in axial loading by a factor of 2.2.

More recently, a clinical retrospective study, by Egol et al [40]., that was conducted at three level-I trauma centers, two groups of fractures were studied. In multivariate adjusted analysis, plating of the fibular fracture was significantly associated with the maintenance of reduction. The authors found that the use of at least two distal locking bolts also was protective against the loss of reduction.

In our experience, we found fibular plating a useful adjunct in the setting where the associated fibular fracture is in the same level with displaced transverse or oblique fracture of tibia and in the presence of significant metaphyseal comminution in which rotational and sagittal alignment may be difficult to maintain with nail fixation alone. Fibular plating also aids in obtaining and maintaining the reduction of a distal tibia fracture with significant valgus angulation before intramedullary nailing thereby potentially reducing the risk of a malalignment [10].

Two distal locking bolts certainly adds strength to fracture stability but there is some discrepancy in the literature regarding its orientation on fracture construct stability [14]. Chen et al [6] The authors found that there was no differences in angulation, rotation or translation of the distal fragment whether the locking bolts were placed in parallel or perpendicular to one another after cyclic loading of the fragments This is in contrast to the study by Smuker et al which found a significant difference in stability between constructs locked with bolts in parallel versus those placed perpendicular with 2 parallel locking bolts being a better construct. Our study had both types of constructs; both had failure to maintain alignment.

Some researchers have advocated the use of adjunctive blocking screws to obtain the reduction and alignment [16]. These screws were not used in our series because the patients were treated with alternative reduction methods, including plate fixation of the fibula prior to intramedullary nailing, reduction with a percutaneous clamp, and manual manipulation.

In our study, all the 26 patients had union of the fracture and the mean time for union was 19 weeks (range 12 – 26 weeks). No bone-grafting procedures were required to obtain union in any patient. One patient with delayed union underwent dynamization procedure following which the fracture united. This result is comparable to other studies on the management of such fractures by interlocking nailing. Anterior knee pain was noticed in four patients. The mean IOWA ankle functional assessment score was 82 (good) (range 68-94)

Study	Fracture Type	Surgical Technique	Outcome (Union)
Robinson et al	63 distal metaphyseal (10 open, 53 closed)	63 reamed, locked IM nail; 2 distal interlocking screws	59 primary union; 4 healed with secondary procedures Mean 16.2 weeks
Konrath et al	20 distal tibia (5 open, 15 closed)	Lag screw ± plate fixation;locked IM nail	19 primary union; 1 secondary procedure Mean 17 weeks
Fan et Al	20 distal tibia (5 open, 15 closed)	locked IM nail; 2 or 3 distal interlocking screws	All united at 17.2 weeks
Nork et al	36 distal tibia metaphyseal fractures, 6 with articular extension	Lag screw ± plate fixation locked IM nail	Primary union in 33 patients Mean 23.5 weeks
Our study	26 distal tibia metaphyseal fractures	locked IM nail; 2 or 3 distal interlocking Screws. plate fixation of fibula	All united Mean time : 19 weeks

Many studies stress the importance of obtaining and maintaining a reduction of distal tibial fractures with stable fixation allowing for early rehabilitation. But till now there have been no prospective, randomized trials on the types of treatment of this injury.

Limitations in this study include its retrospective design, the small number of patients, the fact that multiple surgeons participated in the treatment, and the nonstandardized radiographic assessments. Furthermore, the ability to differentiate which fractures are appropriate for intramedullary nailing with adjunctive fibular stabilisation was largely qualitative and based on experience and an understanding of the fracture pattern.

The role of fibular plating with nailing must be determined on an individual basis depending upon the fracture pattern. To our knowledge no distal tibial fracture classification in English literature specifically addresses concurrent fibular fracture fixation. Based on our experience we found that the two discrete groups of injuries with different mechanisms as described by Robinson et al produced three common fracture configurations. We propose a new classification for extra articular distal tibial metaphyseal fractures which takes into the associated fibular fracture and addresses its stabilization.

MMC CLASSIFICATION OF EXTRA ARTICULAR DISTAL TIBIAL METAPHYSEAL FRACTURES - A PROPOSAL

Type: I Low energy direct bending force- transverse metaphyseal fracture

I A: With fibular fracture at same level of tibial fracture

II B: With fibular fracture at proximal level (more than 3 cm) than tibial fracture

Type: II: Low energy torsional force- oblique/spiral metaphyseal fracture

II A: With fibular fracture at same level of tibial fracture

II B: With fibular fracture at proximal level (more than 3 cm) than tibial fracture

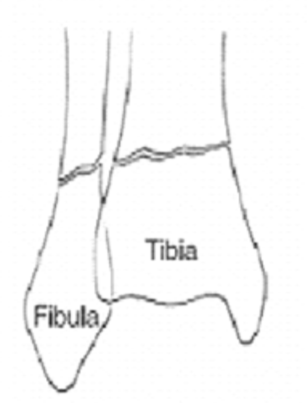
Type: III: High energy bending force- comminuted metaphyseal fracture

III A: With fibular fracture at same level of tibial fracture

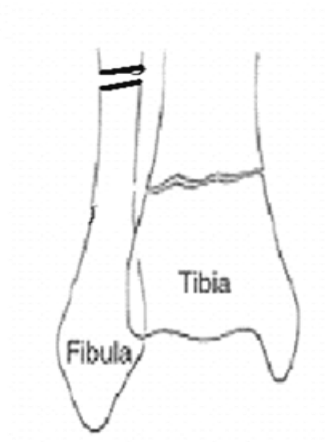
III B: Segmental fibular fracture

Type IA, IIA and Type III fractures must have the adjunctive fibular fractures stabilized.

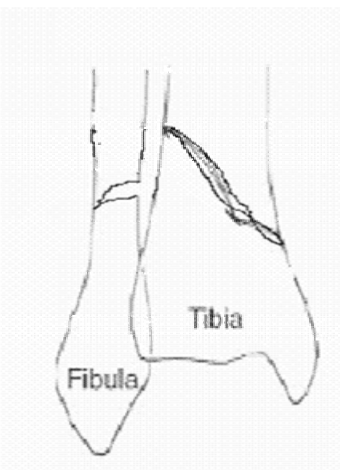
MMC CLASSIFICATION OF EXTRA ARTICULAR DISTAL TIBIAL METAPHYSEAL FRACTURES - A PROPOSAL



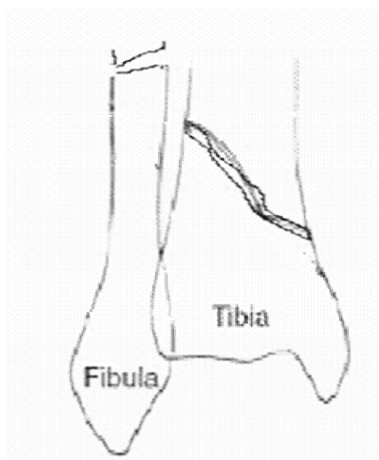
TYPE I A



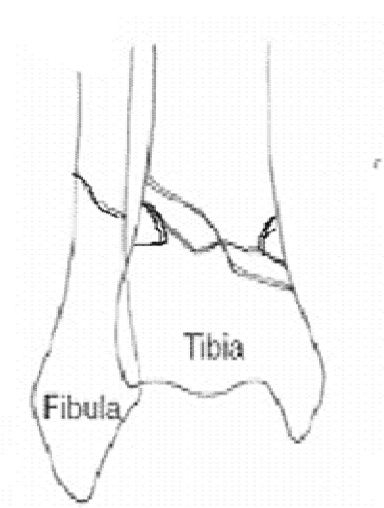
TYPE I B



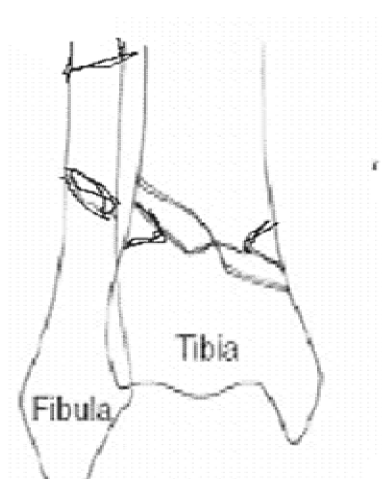
TYPE II A



TYPE II B



TYPE III A



TYPE III B

CONCLUSION

Intramedullary nailing is a safe and effective technique for the treatment of extra articular distal metaphyseal tibial fractures if careful preoperative planning is allied with meticulous surgical technique.

Acceptable alignment of the short distal fragment during surgery is necessary for good functional outcome. Knowledge and recognition of inherent instability of the short distal fragment is necessary to enable stable fixation and avoid loss of reduction on follow up. We propose a new classification to aid stable fixation of the distal fragment by fibular plating.

Prospective, randomized, clinical trials are needed to determine the outcomes of metohods of internal fixation in the management of extra articular distal metaphyseal tibial fractures.

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PROFORMA

Name: Age: Sex: Pt No:

IP No: Address:

Mode of Injury: Side :

Open / Closed: Type

Type of fracture:

1. AO
2. Robinson
3. Fracture Configuration

Surgery Details:

1. Method of reduction
2. Nail Size/ Fibular plating
3. Distal locking screws: Uniplanar or Biplanar
4. Complications

Secondary Procedures

Follow Up

I

II

III

IV

Time of Union

IOWA Ankle Score

S.No	NAME	AGE/SEX	MOI	DISTANCE	SIDE	OPEN/ CLOSED	TYPE	AO	ROB	SCREW ORIENT	FIBULA PLATING	UNION (WKS)	MALUNION	IOWA SCORE	COMPLICATION
1	MR.PRABHAKAR	30/M	RTA	4.5	R	O	2	A1	I	I	N	22	VALGUS	78	NIL
2	MR.RAMACHANDER	55/M	RTA	4.8	L	C	1	A2	IIA	I	Y	20	NIL	78	NIL
3	MR NARAYANAN	26/M	RTA	5.2	R	C	1	A1	IIA	II	N	16	NIL	92	NIL
4	MR RAVICHANDER	41/M	RTA	5.8	R	C	1	A2	I	II	N	18	NIL	84	SUP.INFECTION
5	MR SUDHAGAR	35/M	RTA	5.2	R	O	1	A2	I	II	Y	23	NIL	72	DELAYED UNION
6	MRS CENTHAMARAI	50/F	RTA	4.2	R	C	1	A2	IIA	I	Y	18	NIL	90	NIL
7	MR SOLOMONRAJ	19/M	RTA	5	R	C	2	A1	IIA	II	N	12	VALGUS	76	KNEE PAIN
8	MR BABU	23/M	RTA	5	R	C	2	A3	I	II	N	26	VALGUS	72	DEEP INFECTION
9	MR SAKTHI	23/M	RTA	4.4	R	O	2	A3	I	I	N		**LFU**		
10	MR SRIVASULU	41/M	RTA	4.6	R	C	1	A1	I	II	N	18	VALGUS	74	KNEE PAIN
11	MR RAMDOSS	45/M	RTA	4.8	L	C	2	A2	I	II	N	17	VARUS	78	NIL
12	MR RAGAVAN	50/M	RTA	5	R	O	1	A1	I	I	N	23	NIL	90	KNEE PAIN
13	MR SANTOSH	23/M	RTA	4	R	C	2	A2	IIA	II	N	14	VARUS	72	NIL
14	MRS BHUVANES	33/M	RTA	4.6	R	O	1	A1	IIA	II	N		**LFU**		
15	MR DILLIRAJ	49/M	RTA	4.8	R	C	2	A1	I	II	Y	22	NIL	82	NIL
16	MR NARESH	22/M	RTA	5.5	R	C	1	A1	I	I	N	14	VALGUS	80	NIL
17	MR YUSUF	35/M	RTA	5.5	L	C	1	A1	I	I	N	20	NIL	92	KNEE PAIN
18	MR AKBAR	26/M	RTA	4.5	L	C	1	A1	I	II	Y	16	NIL	80	NIL
19	MR ANBU	32/M	FALL	4.5	L	C	1	A1	I	I	N	16	RECURVATUM	76	NIL
20	MR ARUMUGAM	34/M	RTA	4.8	R	C	1	A1	IIA	II	Y	18	NIL	80	NIL
21	MR CHANDRAN	50/M	RTA	5	L	O	1	A2	IIA	I	Y	19	NIL	82	NIL
22	MR JOSEPH	32/M	RTA	5	L	O	1	A2	IIA	II	Y	20	0.5 CM SHORT	78	NIL
23	MR ARUN	25/M	RTA	4.6	L	C	1	A1	I	I	N	22	NIL	80	NIL
24	MR AZIZ	38/M	RTA	4.6	L	C	1	A2	IIA	II	N	20	0.5 CM SHORT	78	KNEE PAIN
25	MR RAGAVAN II	34/M	RTA	5	R	O	2	A1	I	II	N	24	NIL	82	NIL
26	MRS MARI	55/F	FALL	5.2	R	C	1	A1	I	I	Y	25	NIL	82	NIL
27	MRS UMA	30/F	RTA	4.8	L	O	1	A1	I	I	Y	22	NIL	80	NIL
28	MR PALANI	28/M	IND	5	R	C	2	A3	IIA	I	N	19	VARUS/RECUR	76	NIL