"RANDOMISED STUDY OF REAMED VERSUS UNREAMED INTRAMEDULLARY INTERLOCKING NAILING FOR OPEN TIBIAL DIAPHYSEAL FRACTURES "

By

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ABSTRACT

Objectives :- Open tibial diaphyseal fractures are one of the commonest long bone fractures encountered by most of the orthopaedic surgeons. Because most of the length of tibia is subcutaneous, open fractures are more common in tibia than any other long bone. As high prevelance of complications are associated with these fractures, management is often difficult and the optimum method of treatment remains a subject of controversy.

This study was conducted to evaluate results of intramedullary interlocking nailing by reaming and unreaming in the treatment of open tibial diaphyseal fractures by comparing the fracture union and clinical outcome.

Material and methods :- this study was performed with 60 open tibial diaphyseal fractures of tibia which are randomized as per the statistician, 30 open fractures were operated by reamed and remaining 30 by unreamed intramedullary interlocking nailing in R.L.Jalappa hospital, Sri Devaraj Urs Medical college, Tamaka, Kolar after Ethical clearance. All the fractures were fresh and traumatic in nature. Wound debridement and intramedullary interlocking nailing was done as early as possible and secondary procedure like repeated debridement, skin grafting, dynamisation, bone grafting were done when required. All the cases were followed for 6 to 8 months

Results : - Bony union was achieved in an average of 30.5 weeks in reamed group and average of 29.5 weeks in unreamed group, with excellent to good results of 25 patients (83.33%) in reamed group and 21 patients (70%) in undreamed group. Superficial complications were 6 patients (20%) in both reamed and unreamed group. Deep complications were 1 patient (3.3%) in reamed group and 3 patients (10%) in unreamed group. 1(3.33%) delayed union in reamed group and 2 patients in (6.67 %) in unreamed group. 1 non union (3.33%) in both the groups

Conclusion :- This study reinforces earlier studies that use of both reamed and unreamed intra medullary inter locking nails is feasible in open diaphyseal fractures of tibia. Rigid intra medullary stabilization helps in healing of the fracture. The presence of the wound upto type IIIB may not increase the chances of spreading the infection. Intra medullary stabilization helps in early mobilization of the patient, preventing joint stiffness, minimal hospital stay and early return to activity. Repeat wound debridement allows the wound to granulate well. Skin grating was all that was required in our series.

Reaming or unreaming for the intra medullary nailing of open tibial fractures marginally altered the union rate, but had no deleterious effect for the wound management.

Key words :- Open tibial diaphyseal fractures ; Intramedullary interlocking nailing ; Reaming ; Unreaming

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INTRODUCTION

"The primary objective in the management of an open fracture is union with prevention or eradication of wound sepsis."

- Gustillo et.al

With increase in population industrialization and traffic density there is high incidence of road traffic accidents. The incidence of high energy trauma are increasing in the same proportion.

Tibial diaphyseal fractures are the commonest long bone fractures encountered by most orthopaedic surgeons .The annual incidence of open fractures of long bones has been estimated to be 11.5 per 1,00,000 persons ,with 40% occurring in lower limbs,commonly at tibial diaphysis . There is a bimodal distribution of tibial fractures with a preponderance in young males.[1]

Because one third of the tibial surface is subcutaneous throughout most of its length, open fractures are more in tibia than in any other major long bone. The blood supply of tibia is more precarious than that of bones fully enclosed by muscles.[2] The are five common causes for tibial diaphyseal fractures are motor vehicle accidents, falls, sports,injuries, assaults. The important factors in prognosisfor open tibial fractures are (1) amount of initial displacement (2) degree of communition (3) severity of soft tissue injury and 4) whether infection has developed.

Tibial fractures may be associated with compartment syndrome, vascular or nerve injury. The presence of hinge joints at the knee and the ankle, allow no adjustment for rotatory deformity after fracture. Complications associated with open tibial fractures are more, management is often difficult. Hence The optimum method of treatment remains a subject of controversy.

"Every fracture is an individual problem, and the decision to treat it by internal fixation or indeed conservatively should be based on a realistic assessment of the advantages and the hazards of each method in the circumstances of that particular case .This calls for a high degree of clinical judgement which is harder to acquire or to impart than technical virtuosity in the operating theatre".[3]

Management of the fractured tibia requires the vast experience. The best of clinical judgement has to choose the most appropriate treatment for a particular pattern of injury[4].

There are various modalities for treatment of fractures of tibia. Conservative treatment including manipulation and use of either short leg or long leg cast,Surgical modalities include open reduction and internal fixation with plates and screws , intra medullary fixation and external fixation techniques. Surgeon should be capable of using all these techniques and must weigh advantages and disadvantages of each one and adapt the best possible treatment . The best treatment should be determined by a thoughtful analysis of morphology of the fracture, the amount of energy imparted to the extremity, the mechanical characteristics of the bone, the age and general conditions of the patient and most importantly the status of the soft tissues (the skin, muscle and associated neurologic and vascular structures of the leg).

Three goals must be met for the successful treatment of open fractures of tibia.

The prevention of infection, the achievement of bony union and the restoration of function . These goals are interdependent and usually are achieved in the chronologic order given. For example failure to prevent infection results in delayed union or non union and delays functional recovery of the limb.

Immobilization in a plaster cast for open tibia fractures has been used commonly in the past. It does not always maintain the length of the tibia and it leaves the wound relatively inaccessible[5].

Open reduction and internal fixation with plates and screws has yielded unacceptably high rates of infection in open tibial fractures[6,7,8]. This method may be selected for more severe injuries with associated displaced intra articular fractures of knee or ankle.

External fixation has been considered the treatment of choice by many truamatologists. But apart from the disadvantages of the bulky frames and frequent pin tract infections, non- unions, and malunions also may result[6,9]. Conversion of external fixation to definitive fixation is also time consuming with doubts about union till the end .

Spanish archives briefly mentioned that Incas and Aztecs used resinous wooden pegs in the medullary canal of long bones for the treatment of nonunion. later materials like ivory pegs were used for intramedullary nailing . Hoguld used bone instead of ivory pegs in 1917.Later metal was first used by Senn, Lambotte and Hey Grooves.

In1930 German orthopaedist Gerhard Kuntscher invented a metallic intramedullary nail for fixation of femoral fractures. Later Rush brothers introduced metal nails in 1937 and its known as “Rush nail”. The current nails in use have evolved mainly from the work of Kuntscher in Germany and Rush family in the USA.

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

Intramedullary nails such as Lottes and Ender nails used without reaming have been employed successfully in the treatment of open tibial fractures and have been associated with low rates of post operative infection . Whereas in communited fractures there tends to be shortening or displacement of fractures around these small nails.[9,11]

The locking of intramedullary nails decreases the incidence of malunion of communited fractures .Until recently, all interlocking intramedullary nailing involved Reaming.[12] The rate of infection after treatment of open tibial fractures with intramedullary nailing with reaming has been relatively high, causing most investigators to discourage the use of this technique for grade II and III open tibial fractures. Court-Brown, Pubished clinical data on the use of reamed intramedullary nails in the management of open tibial fractures. They suggested that reamed locking intramedullary nailing is a safe and effective technique for management of open tibial fractures.[13]

In Open fractures, there is no significant differences in the time of union or number of additional procedures performed to obtain union in patients with reamed nail insertion compared with those without reamed insertion.[14]

This lead us to design a, Randomized study of reamed versus unreamed intramedullary interlocking nailing for open tibial diaphyseal fractures.

AIMS AND OBJECTIVES

To study the fracture union and clinical outcome of open diaphyseal fractures of Tibia treated with reamed versus unreamed intramedullary interlocking nailing.

REVIEW OF LITERATURE

Gustillo's (1992) treatise Medicatrix Nature provided early advice on treatment of tibia fibula fracture.[13] Rest and immobilization of the injured extremity by splinting, with fracture healing to follow in time. He recommended preliminary skeletal traction for 1 to 3 weeks for difficult tibia fractures followed by long leg cast treatment, an approach that yielded satisfactory results.

The Watson Jones R[14] (1942), Advocated long leg cast treatment for several months, or untilthe fracture had healed. His rate of non-union was very low, but it was not reported in detail. For example he did not mention the effect of prolonged cast immobilization on joint motion and muscle atrophy.

Sarmiento A[15] (1967), Almost single handedly stemmed the tide of open reduction and internal fixation of tibia fractures. He advocated closed reduction and the use of patellar tendon bearing casts or functional bracing. His treatment of over 500 closed tibia fractures with closed reduction and functional bracing resulted in an almost unbelievable union rate of 99.3 %, with 0.7 % nonunion and no patients of infection .In 250 open tibia fractures union rate of 96% was seen.

Anderson LD[16] (1974), Reported a 95 % union rate in 250 open and closed fractures treated with pins and plaster method.

Charnley J[10] (1961), Wrote his classic text "Closed reduction of common fractures ". He meticulously described in detail how to reduce tibia fibula fractures (making use of the periosteal sleeve), and outlined the limitations of the technique described. He recognized a problem reported recently by others, namely, the problem of the intact fibula, which allows the tibia to drift into varus and increase the incidence of delayed healing.

The conservative school of treatment[14] flourished for almost three decades until early 1960's when the Swiss Arbeitsgemeinschaft Fur Osteosyntesfragen (AO) group advocated open reduction and internal fixation with plating as a primary treatment of both closed and open tibia fractures. Their rationale was that prolonged cast immobilization led to poor results. Numerous publications in the early 1970's supported the AO approach and documented early recovery and good functional result.

In this approach, however, the incidence of sepsis and nonunion increased considerably, particularly in primary plating of open fractures. In 1980[13] ,the AO approach to fracture treatment was further propagated by the development of creative educational workshops which greatly enhanced the surgeons ability to perform open reduction and internal fixation of tibia fractures .This aggressive surgical approach spread very quickly across North America and challenged the conservative approach to fracture management . Anatomic reduction and rigid internal fixation with early motion were the bywords in this period.

In 1971 Burwell HN[17] treated with plating in 181 patients of tibial fractures, and had 95 % union and of 4.4% nonunion.

In 1974 Nicoll EA[3] outlined the major factors affecting the results after observing 800 tibial fractures. They were:

(1) degree of initial displacement

(2) fracture communition

(3) soft tissue damage

In 1976 Ruedi T[18] reported 97% excellent and good results in 323 closed fractures treated with DCP .The infection rate was less than 1 %. In the same study 80% of the 95 open fractures had good or excellent results.12 % had infection. The patients were kept in bed for one week after surgery and they were allowed partial weight bearing until fracture healing.

Intramedullary nailing (unreamed nails) for tibial fractures was extensively reported in US by Lottes JO[19] 1974. In majority of both open and closed tibia fracture patients he achieved excellent results, with a 98% union rate in closed tibia fractures with less than 1% infection .He allowed early weight bearing, and in most patients, postoperative cast immobilization was not required .Infection rate in his study was 7.3% of 200 patients.

Chapman MW[20] 1979 achieved a fracture healing rate of over 90% with using the Lottes nail in tibia fractures. The primary drawback of Lottes nailing was its limited application in the isthmic part of the tibia (a necessity to achieve the fracture stability).Ender nail and other flexible nails have also been used with a high rate of success in closed and type I and II open fractures .

Pankovich AM[21] 1981 reported good results in 36 of 38 fractures with flexible nailing .Ender type curved pins with medial and lateral entry portals for rotational control of the fractures were used .Stacking of multiple pins exert spring force to resist angulation and rotation .They require a stable fracture configuration and fracture of middle one third were best controlled.

Velasco A[22] in 1983 used the Lottes nails and other authors (1986,1989) in a prospective study used Ender type unreamed nails successfully in the treatment of open tibial fractures and associated lower rates of postoperative infection. They are however, contraindicated for communited fractures, as they tends to shatter and displace such fractures around these small nails.

Subsequent reports by Chapman MW, Bone LB[23,24,25] on reamed intramedullary nailing have extended the application of intramedullary nailing to longer portion of the shaft with locked nailing. This even included the distal and proximal thirds of tibia fractures and achieved stability.

Bone LB[23] 1989 reported unacceptably high infection rates (13.6% to 33%) in small series of open tibial fractures treated with reamed nailing .These reports led to the belief that medullary reaming is contraindicated in open tibial fracture, particularly Gustillo II and III types. Studies of open tibial fractures treated with unreamed Ender pins and Lottes nails during the same time period reported infection rates of 6-7 %.

Throughout the 1980 s external fixation was the treatment method most often recommended for open tibial fractures.

DeBastiani G[26] in 1984 treated 91 closed tibial fractures with the orthofix frame with a 91 % union rate and an average time of 3.6 months to union.

Court Brown CM[25] in 1985 obtained worse results with static external fixators and believed it led to higher delayed and nonunion rate than other treatment.

Complications unique to external fixation are pin tract infection and pin loosening which occur in 50% of patients. Loss of frame stability also becoming a more recognized entity and may account for the higher malunion rate of up to 45% .

Over the years, intramedullary techniques for tibia have evolved from use of Ender pins to interlocking nails of the tibia.

Weller S[27] 1998 demonstrated that the insertion of the nail without reaming result in less damage to blood supply than with reaming .This is probably due to the avoidance of embolization in the intracortical blood vessels. This type of embolization might be induced by the pressure generated in front and at the side of the reamer. He obtained good results with interlocked unreamed nailing in open fractures of tibia. He used the solid AO unreamed interlocked tibial rod with good success in severely open fractures.

Whittle AP[28] 1992 studied , 50 open fractures of the tibial shaft that were treated with debridement and interlocking nailing without reaming were followed for an average of 12 months .Most of the fractures were the results of high energy trauma and 68 % of the fractures wounds were grade III. Forty-eight (96%) of the 50 fractures united at an average of 7 months and there were no malunions .

Four infections (8%) all at the sites of grade III fractures .Locking screws broke in five patients (10%) ,but the breakage did not result in a loss of reduction .Three nails broke ,two at the sites of ununited fractures and one at the site of a healed fracture .These results are comparable with or better than those obtained with other forms of fixation ,including immobilization with a cast ,unlocked intramedullary nailing and external fixation The authors reported retrospective review of nonreamed tibial nails compared with external fixation of open tibial fractures. They reported a 49 %

incidence of infection with external fixation including pin tract infections and a 2 % incidence of infection with nonreamed tibial nailing.

Muller CA[29] 1998, 69 open fractures of tibia were primarily treated with unreamed nailing .The distribution of fracture type according to the AO classification and soft tissue injury according to Gustilo were as follows ;fracture type ;A-28%,B-52%,C-20%,soft tissue injury ;I-30%,II-28%,IIIA-12%,IIIB-12% ,IIIC-6%..Of the 65fractures assessed 46 (71%) healed within 18 weeks without secondary intervention .There was delayed healing in 3 fractures requiring secondary conversion to reamed nailing .8 fractures (12%) developed pseudoarthrosis of which 5 (8%) healed uneventfully. Deep infections manifested in 4fractures (6%).Three of these infections developed after secondary intervention to treat pseudarthroses .Seven of eight pseudarthroses and three of the four infections healed eventfully .Revision procedures were necessary in 11 patients (17%) to deal with disturbed fracture healing or infection (10reamed nailing procedures ,three cancellous bone grafts ,and one of each of the following ;sequestrectomy, fibular osteotomy ,plate fixation ,external fixators ,monorail procedure).The results show that the same infection rates were achieved for the UTN as for the external fixators . The advantages of UTN are, however, a lesser need for secondary intervention and greater patient comfort.

Henley MB[30] 1994 in a prospective randomized study compared nonreamed locked intramedullary nails to external fixation (21% versus 11%). They reported a higher incidence of wound problems in the external fixation groups as well as increased incidence of malunion of 24% versus 5% in intramedullary nailing group.

Godina M 1986 [31] in his study proposed radical excison of necrotic tissue should be performed so that all non viable tissue including bone is removed .

Gopal S 2000[32] in his study, stated that open fractures should never be closed primarily because of the risk of gas gangrene.

Tornetta P[33] (1994),compared treatment of open tibial fractures with non reamed intramedullary nailing and external fixator and concluded intramedullary nailing can be widely accepted for stabilization of diaphyseal fractures of lower extremity.

Cole JD[34] (1998) , in his study concluded that for grades(1-111A) secondary wound closure yielded best results .In grade111b and 111c fractures delayed wound care with repeated debridement and extended exposure of deep structures results in additional tissue loss through desiccation and infection.

Bhandari M 2001[35] In a multicenter, randomized study of 1319 adults in whom tibial shaft fracture was treated with either reamed or unreamed intramedullary nailing, no difference was found between approaches with open fractures.

Anglen 1995[36] compared reamed and unreamed nailing of tibia in University of Missouri Hospitals and Clinics, Columbia,it was found that there is significant difference in healing times, with unreamed taking an average of 34.5 wks to heal while reamed nailings took 22.5 wks.

Singer WR[37] 1995 In a study conducted in Carolinas Medical center, Charlotte for open tibial fractures which were treated with unreamed locked intramedullary nailing it was found that 42 of 43 fractures united in an average of 6.1 months. They concluded that the use of locked intramedullary nailing for open tibial diaphyseal fractures has produced comparable results with those of historical controls of unilateral external fixation.

Kakar S[38] 2007 In a study conducted in Boston University Medical center, Boston for Open fractures of the tibia treated by immediate intramedullary tibial nail insertion without reaming it was concluded that the use of immediate tibial nailing without reaming is safe and effective in treatment of open tibia fractures.

Bhandari M [39] 2008 in their study concluded that there is no difference in outcomes in reamed and unreamed groups in open tibial fractures.

Jain V[40] 2005 conducted study in Moulana Azad Medical college and Lok Nayak Hospital, New Delhi for open tibial fractures it was concluded that primary unreamed intramedullary nailing offers advantage of rigid fixation, low incidence of infection, non-union, good functional results early return to work.

Relative merits of reamed versus unreamed nails in the treatment of open tibial fractures remain uncertain.

SURGICAL ANATOMY

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

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

MUSCLES OF LEG:

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

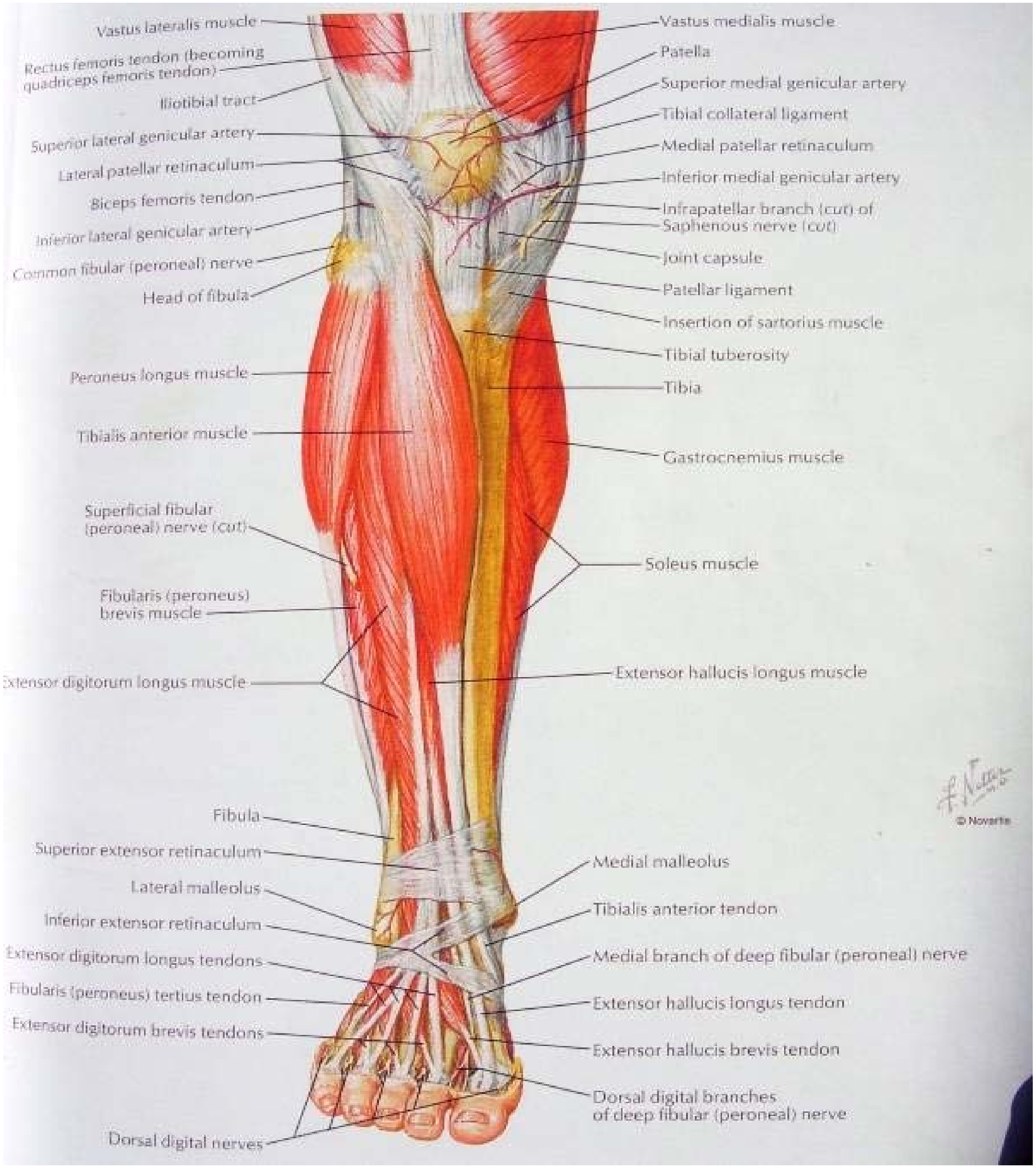
1. Anterior compartment

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

2. Lateral compartment:

Lateral compartment contains the muscles peroneous longus and peroneous brevis and they protect the fibular shaft expect near the ankle .So isolated fractures of Since the majority of its fibres run down wards and outwards, the interosseous membrane serves to distribute indirect violence acting on the tibia to the fibula.

MUSCLES OF LEG (SUPERFICIAL DISSECTION): ANTERIOR VIEW



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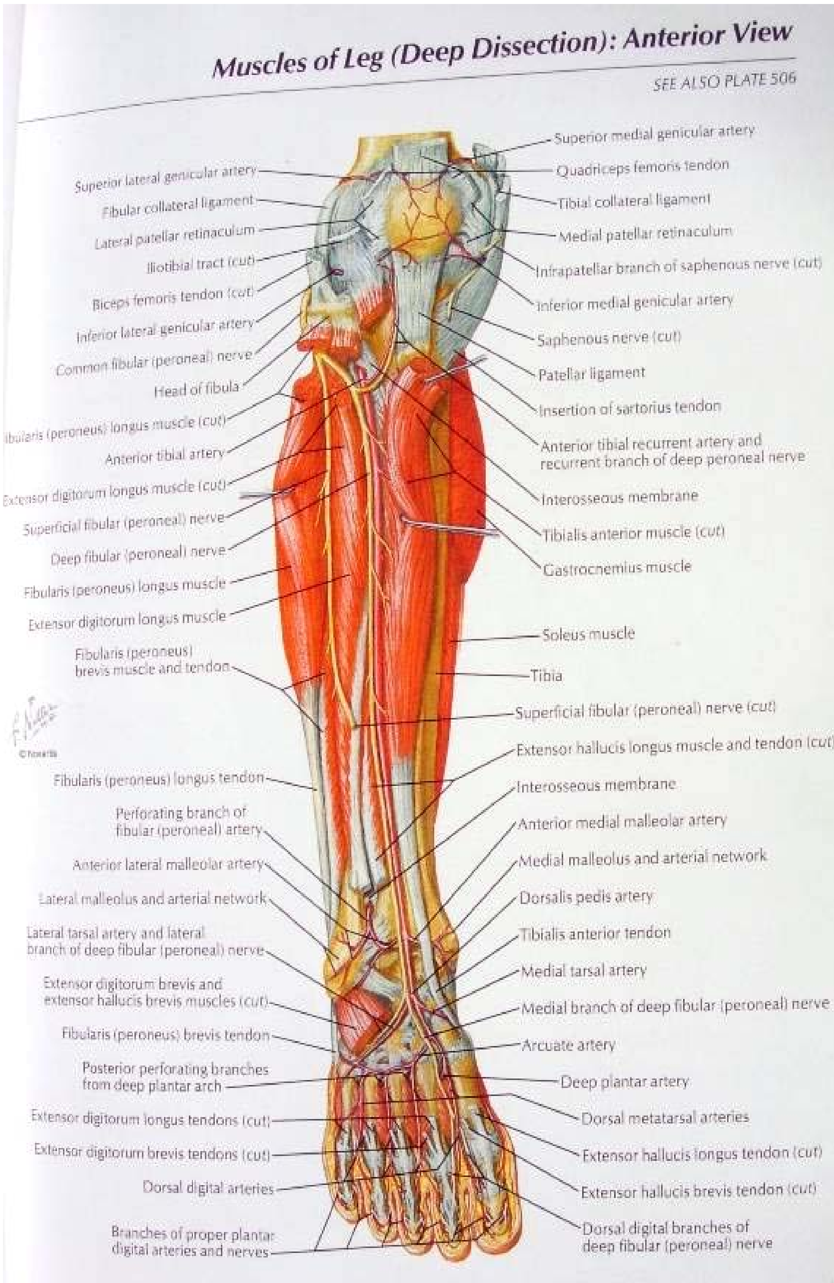
MUSCLES OF LEG (DEEP DISSECTION): ANTERIOR VIEW



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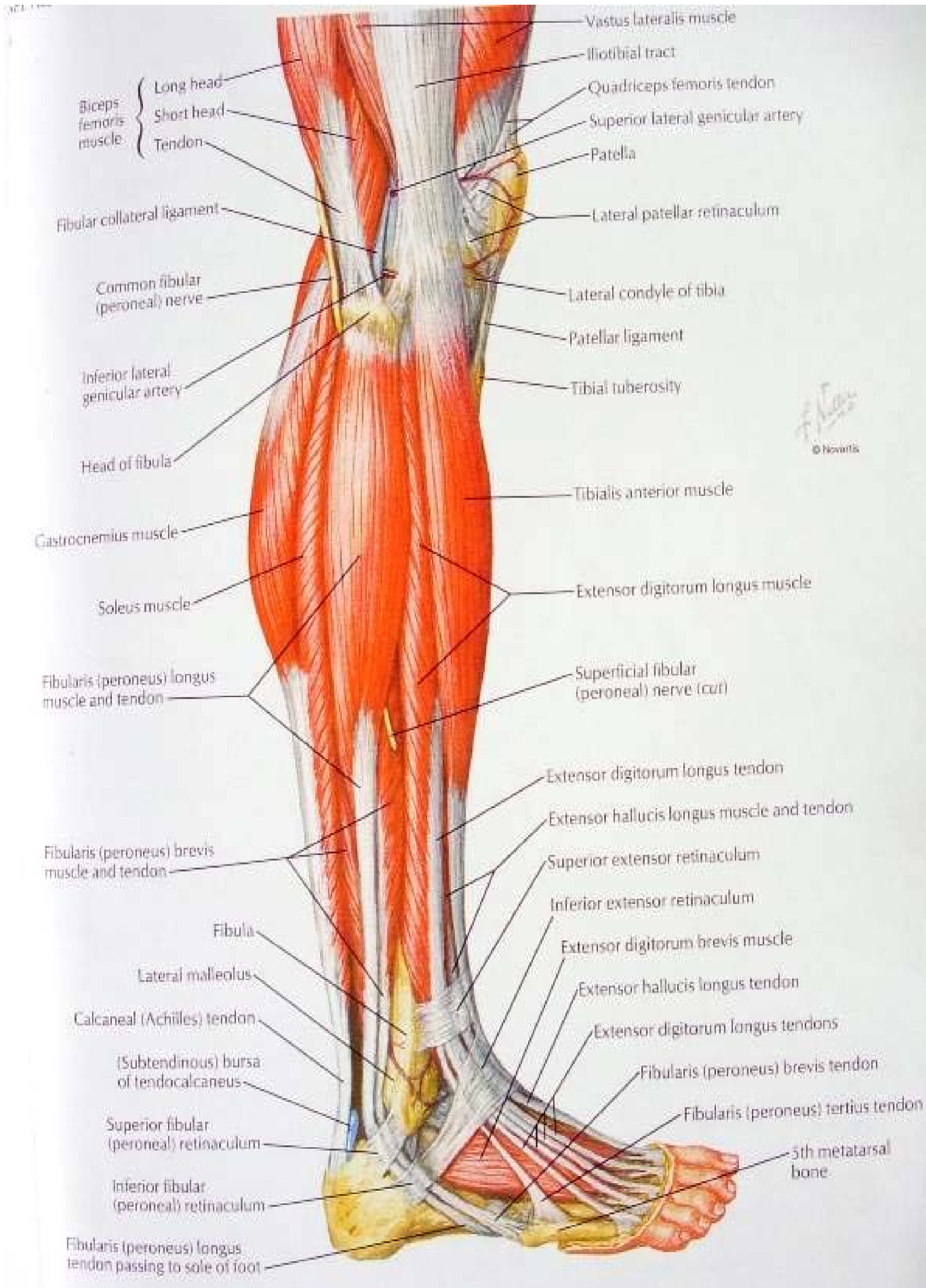
MUSCLES OF LEG: LATERAL VIEW



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The fibula owing to direct trauma are uncommon .The superficial peroneal nerve is in between the peroneal and the extensor digitorum longus in the intermuscular septum. Thus the nerve is rarely involved in fracture of the fibular shaft. It is at risk in fractures at fibular neck.

3.Posterior compartment

It is further divided into a superficial and a deep compartment.The muscles of this compartment are soleus, gastrocnemius, popliteus, tibialis posterior, flexor hallucis longus and flexor digitorum longus. The posterior tibial nerve, the posterior tibial artery and its large branch peroneal artery also run in the posterior compartment.

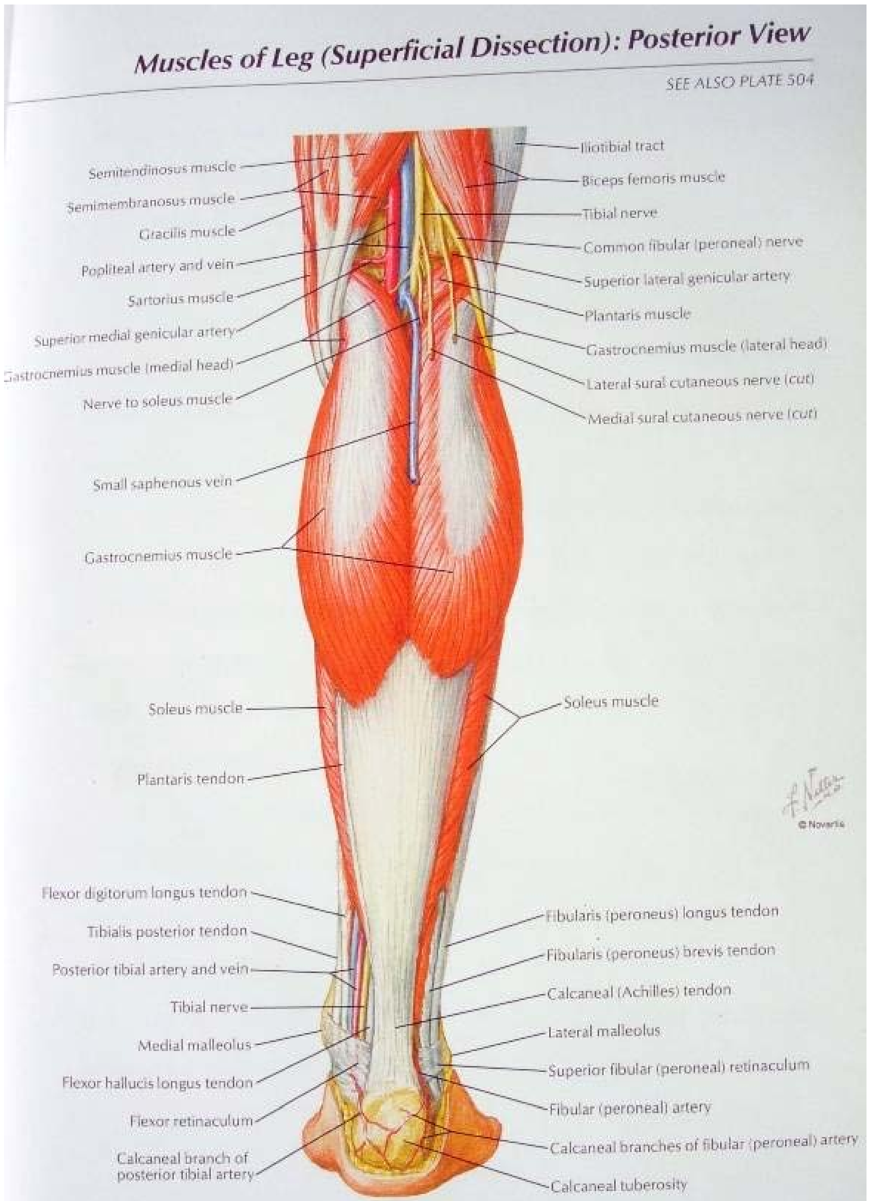
Tibial fractures in the upper third are complicated by the compartment syndrome. This may occur more commonly in the anterolateral compartment and also the posterior compartment. The superficial posterior compartment contains the gastrocnemius, soleus muscle serving as a source for local muscle flaps,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

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

INTEROSSEOUS MEMBRANE:

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

MUSCLES OF LEG (SUPERFICIAL DISSECTION): POSTERIOR VIEW



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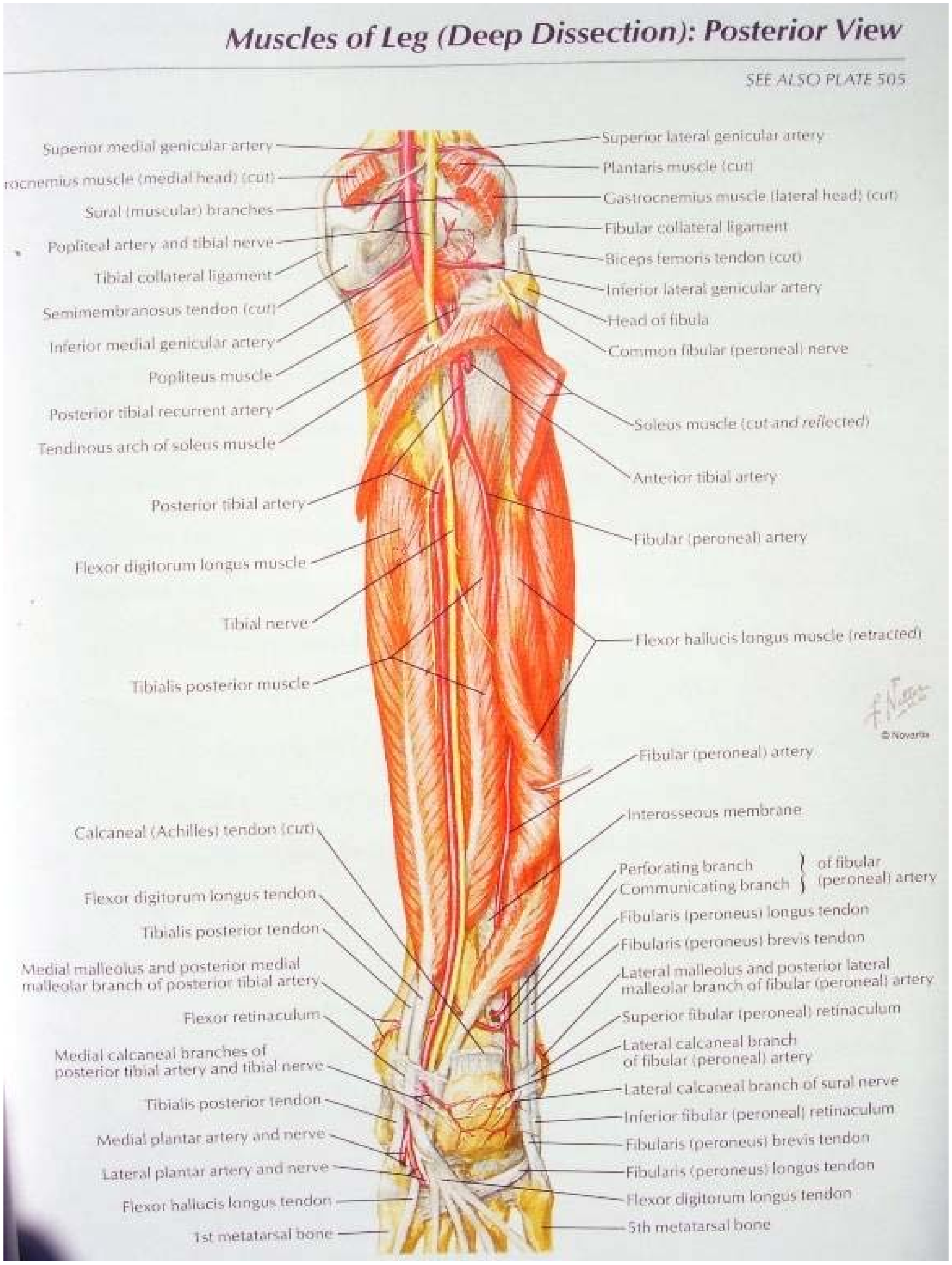
MUSCLES OF LEG (DEEP DISSECTION): POSTERIOR VIEW



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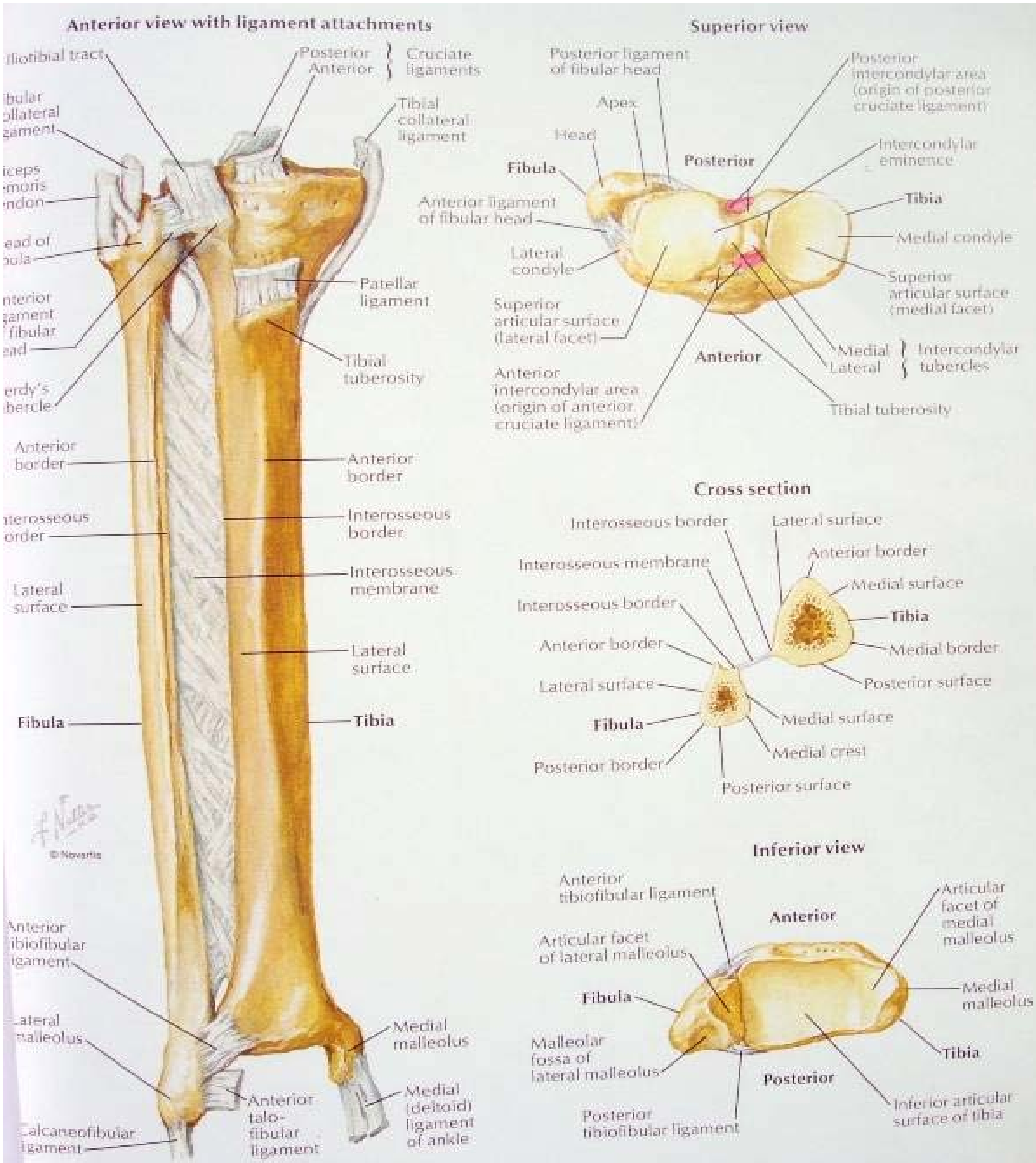
ANATOMY OF TIBIA AND FIBULA



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THE BLOOD SUPPLY:

The anterior and posterior tibial and peroneal arteries are the main blood vessels of the leg. The anterior tibial artery is one of the terminal branches of the popliteal artery and passes forward through the opening in the interosseous membrane to reach the anterior compartment, where it passes downwards on the interosseous membrane to terminate in the dorsalis pedis artery. The posterior tibial is the direct continuation of the popliteal artery . It passes downwards in the space between the deep flexor muscles and the calf muscle to terminate in the plantar arteries. The peroneal artery passes downward in close relation to the posterior surface of the tibia. Blood supply of the tibia as all other long bones is periosteal and endosteal .The periosteal blood supplies the outer third of the cortex , while the endosteal blood supplies the inner two –third of the cortex.

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

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

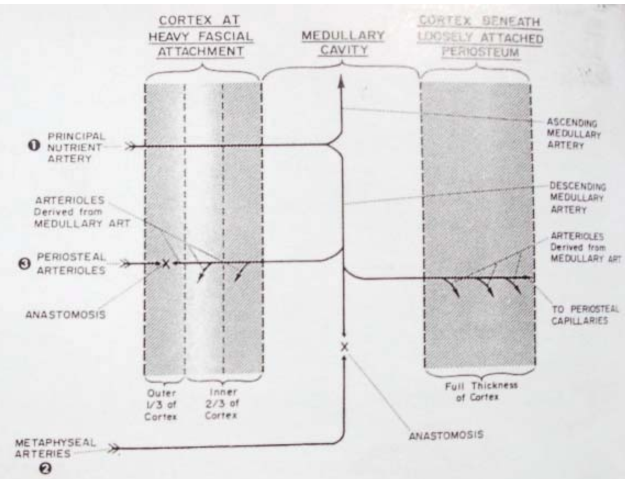

FIG. 5. Diagram showing the distribution of the *afferent vascular system* of a mature long-bone. Components (1), (2) and (3) are its sources of blood from the general arterial circulation of the animal or man. Observe the centrifugal direction of blood flow, from medulla to periosteum. (Reproduced from Rhinelander, F. W.[27])

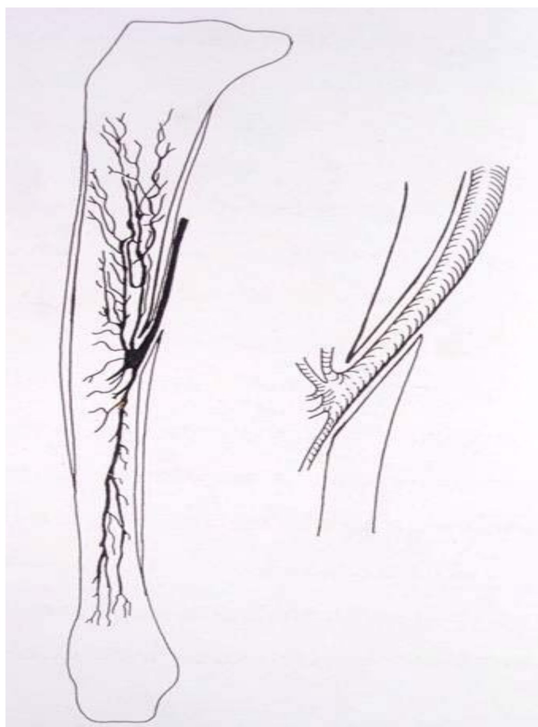

FIG. 1. Redrawn from Crock, made from a lateral radiograph of the tibial shaft of an 18-year-old male, showing the course of the nutrient artery. (Reproduced from Crock, H. V.[7])

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MEDULLARY CANAL

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

ROLE OF FIBULA

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

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

MECHANISM OF INJURY

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

(a) Tensional injuries are more common with low energy trauma where the foot becomes fixed and the body rotates about this fixed point.

(b) Three and four point bending forces produce short oblique transverse fractures As the points of bending are spread further apart and as the amount of energy implied increases, communition increases and even segmental fractures develop.

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

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

CLASSIFICATION OF TIBIAL SHAFT FRACTURES;

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

The most important morphologic varieties in classifying tibial fractures are:

1) anatomical location
2) pattern of fracture lines
3) associated injuries of fibula
4) position and number of fragments
5) extent of soft tissue damage

OTA (orthopaedic trauma association /AO classification)

This was initially described by the AO group.

This is a morphologic classification based on the initial A-P and lateral radiographs.

It consists of three types. Subdivided into three groups, each of which is further subdivided into three subgroups.

Type A fractures are –unifocal fractures. Their division into subgroups is based on orientation of the tibial factures and the presence or absence of fibular fractures.

A1-spiral fractures

A2 –oblique fractures

A3 – transverse fractures

If there is no fibular fractures, suffix .1 is used, with .2 being used for fibular fractures distant from the tibial fracture and .3 for fractures where tibial and fibular fractures are at the same level.

Type B fractures are wedge fractures

B1 –spiral wedge fractures

B2 –bending wedge fractures

B3- fragmented wedge fractures

Type C is classified on severity of tibial fractures, and not on position of fibular fractures.

C1-complex spiral fractures

C1.1-two intermediate fragments

C1.2 –three intermediate fragments

C1.3->three intermediate fragments

C2-segmental fractures

C2.1 –one segmental fragment

C2.2-segmental fragment and additional wedge fragment

C2.3 – two segmental fragments

C3- all communited fractures

C3.1- two or three intermediate fragments

C3.2- limited ommunition.(<4cms)

C3.3-extensive communition (>4cms)

Type A: unifocal fractures	
Group A1	**spiral fractures**
Subgroups	A1.1-intact fibula
	A1.2-tibia and fibula fractures at different level
	A1.3-tibia and fibula fractures at same level
Group A2	**oblique fractures(fracture line >30^o)**
Subgroups	A2.1-intact fibula
	A2.2-tibia and fibula fractures at different level
	A2.3-tibia and fibula fractures at same level
Group A3	**transverse fractures (fracture line <30^o)**
Subgroups	A3.1-intact fibula
	A3.2-tibia and fibula fractures at different level
	A3.3-tibia and fibula fractures at same level

Type B: wedge fractures	
Group B1	**intact spiral wedge fractures**
Subgroups	B1.1-intact fibula
	B1.2-tibia and fibula fractures at different level
	B1.3-tibia and fibula fractures at same level
Group B2	**intact bending wedge fractures**
Subgroups	B2.1-intact fibula
	B2.2-tibia and fibula fractures at different level
	B2.3-tibia and fibula fractures at same level
Group B3	**communited wedge fractures**
Subgroups	B3.1-intact fibula
	B3.2-tibia and fibula fractures at different level
	B3.3-tibia and fibula fractures at same level

Type C: complex fractures(multi fragmentary ,segmental ,communited fractures)	
Group C1	**spiral wedge fractures**
Subgroups	C1.1-two intermediate fragments
	C1.2- three intermediate fragments
	C1.3- > three intermediate fragments
Group C2	**segmental fractures**
Subgroups	C2.1-one segmental fragment
	C2.2-segmental fragment and additional wedge fragment
	C2.3-two segmental fragments
Group C3	**communited fractures)**
Subgroups	C3.1-two or three intermediate fragments
	C3.2-limited communition (< 4cms)
	C3.3-extensive communition (> 4cms)

GUSTILO ANDERSON’S CLASSIFICATION FOR OPEN FRACTURES (1976) [41,42,43]

Open fractures are classified into three major types (one of which has three subtypes 0, according to the mechanism of injury, the degree of which soft tissue damage, the configuration of the fracture, and the level of contamination.

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

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

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

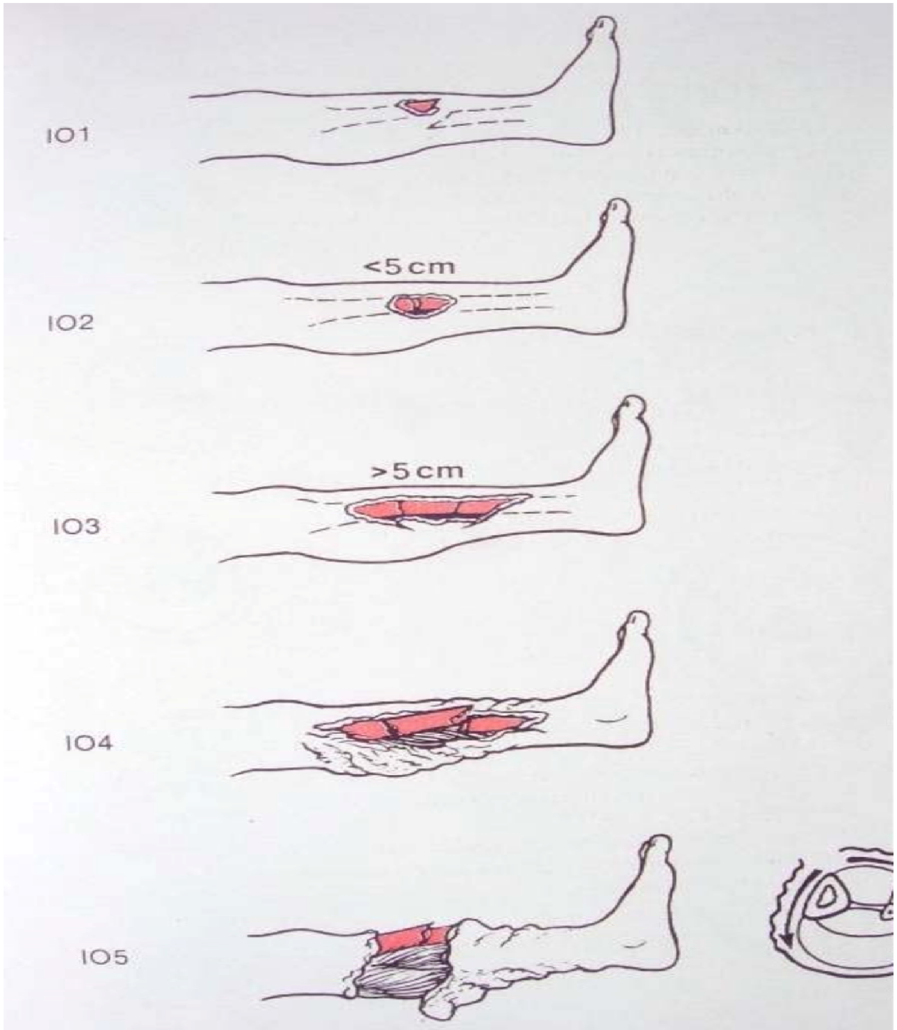
In type IIIA soft tissue coverage of the fractured bone is adequate, despite extensive laceration, flaps, or high energy trauma. This subtype includes segmental or severely communited fractures from high energy trauma, regardless of the size of the wound.

The type IIIB open fracture is associated with extensive injury to or loss of soft tissue, with periosteal stripping and exposure of bone, massive contamination and severe communition of the fracture from high velocity trauma. After debridement and irrigation is completed, a segment of bone is exposed and a local flap is needed for coverage.

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

CLASSIFICATION OF SOFT TISSUE INJURIES;

The AO/ASIF group has proposed an open fracture classification to grade soft tissue injury to be used along with the AO/ASIF alphanumeric classification system. The soft tissue grade incorporates the degree of injury to the integument (IO for open injuries), muscle tendon injury (MT), and neurovascular injury (NV).[44]



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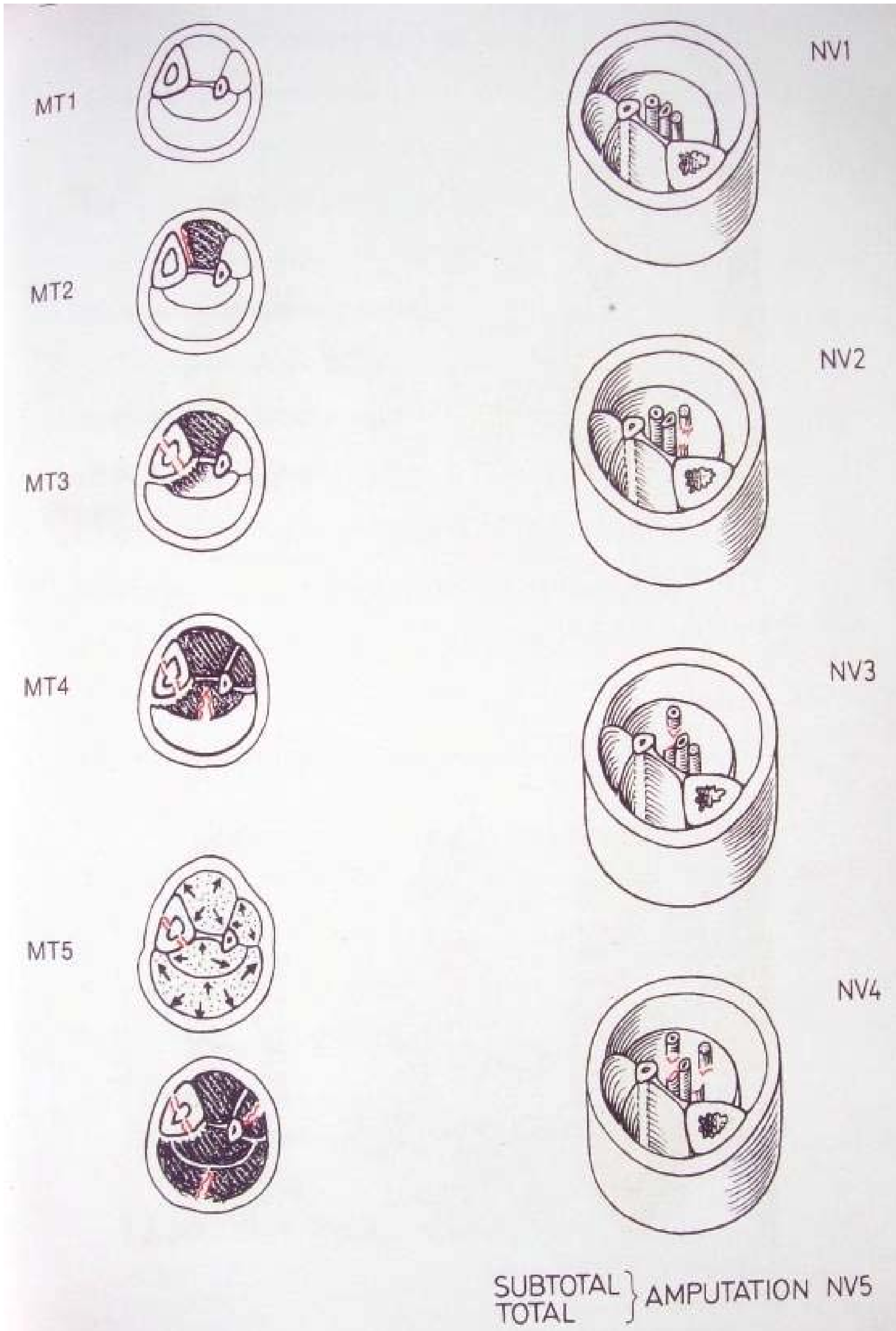

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SKIN LESIONS I O (OPEN FRACTURES);

101=skin breakage from inside out.

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

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

104=full thickness contusion, abrasion, skin loss.

105=extensive degloving.

MUSCLE /TENDON INJURY (MT);

MT1=no muscle injury

MT2 =circumscribed muscle injury, one muscle group only. MT3 =extensive

muscle injury, two or more muscle groups

MT4 =avulsion or loss of entire muscle groups, tendons laceration.

MT5=compartment syndrome /crush syndrome

NEUROVASCULAR INJURY (NV):

NV1=no neurovascular injury

NV2=isolated nerve injury

NV3=localized vascular injury

NV4=combined neurovascular injury

NV5=subtotal or total amputation.

GUDELINES FOR TIBIAL FRACTURE REDUCTION:

Regardless of the treatment method chosen, the most important consideration is an acceptable reduction .Acceptable reduction means a position of fracture fragments that minimize angulatory, rotational and length deviation from what is normal for the patient .The primary concern is, The effect malunion will have on gait and load bearing stresses on the knee and ankle joint. Cosmetic and radiographic appearance are of minimal concern and are never by themselves indications for operative treatment . Nicoll EA[3] (1964) stated that more than 10^0 angulation in an plane and shortening more than 2 cms was unacceptable .Dehne E[45] in 1961, 1976 and in 1969[5] reported satisfactory function when angulation was less than 10^o .None of these authors advocated reoperation for symptoms of malunion of 10^o or less. He prefers to set goal of 5^o for varus and valgus angulation, 10^o for anterior and posterior angulation and 10^o or less for rotation and 1 cm or less for leg length discrepancy, however, more deformity have to be accepted to obtain union but it is preferable to prevent a malunion than to correct it later. The most commonly used clinical guide for reduction is the second toe in the antero-posterior plane. Rotation and lateral alignment are best determined by comparison to opposite extremity.

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

BIOLOGY OF FRACTURE HEALING WITH INTRAMEDULLRY NAILING

Intramedullary fixation offers many advantages in fracture healing when compared to other methods. Union is usually rapid because unlike rigid plate fixation external callus is seldom completely suppressed .This is due to the fact that a nail can never be completely rigid. Movement at the fracture site along with axial micro motion in dynamically locked nails promotes the external bridging callus .This may also be due to the fact that as the medullary blood supply is lost the periosteal vascular supply increases .

Intramedullary nailing avoids “stress protection osteopenia” and so the risk of late refracture after nail removal is uncommon. Controversy exists regarding the damage to the vascular supply following reamed and nonreamed intramedullary nailing. Intramedullary nailing in any of its forms damages the blood supply .This blood supply is rapidly reestablished when a loose fitting nail is used .But when a reamed ,well fitting nail is used the viability of the bone depends on the alternative periosteal blood supply . If this blood supply is defective following some soft tissue damage the whole of the diaphysis may get devascularised specially in the tibia. This leads to two problems. Firstly, there may be a delayed union, as revascularization can occur only slowly and secondly, the dead bone is prone to infection .Considerable surgical judgement is required in choosing the type of intramedullary nailing.

BIO-MECHANICS OF INTER LOCKING INTRA MEDULLARY NAILS

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

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

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

MATERIAL;

In 1934 an inert alloy of chromium, molybdenum and nickel discovered and named it vitallium. Then came 18/12 S.M.O stainless steel, titanium and then super alloys .Most of the orthopedic nails are made of 318 L stainless steel.

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

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

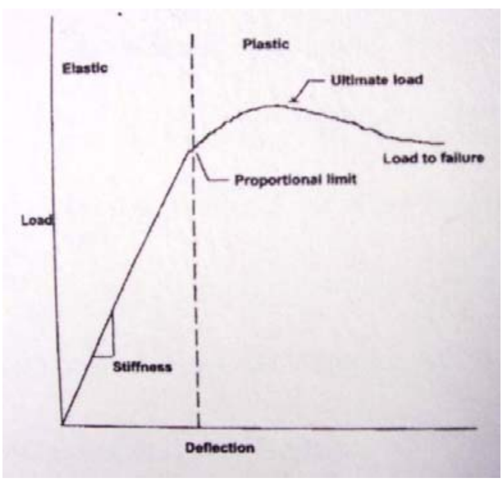
Clinically, bending strength and stiffness can be increased by using unslotted thick nail with large diameter.

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

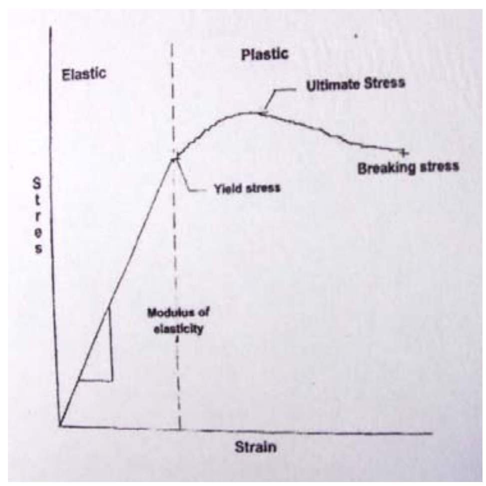
LOAD DEFLECTION CURVE:-

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

Material properties are defined geometrically in the stress-strain curve .The stress is defined as load per unit area and strain is the change in length divided by the original length.



LOAD DEFLECTION CURVE



STRESS STRAIN CURVE

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STRESS STRAIN CURVE:

The slope of this curve is called 'modulus of elasticity' (Young's modulus. It is the constant proportionality between the stress and strain .It is a material property. Ex: a material with a high modulus is stiff i.e. for high stress, little strain is produced. Titanium has more strength because of low modulus.

STRENGTH: is the stress at which the implant fails. The yield strength is at which the implant undergoes plastic deformation.

The structural characteristics and mechanical factors important in the design and evaluation of intramedullary implants are: strength, stiffness and rigidity.

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

Intramedullary nails are designed to share the load with the bone for a limited period.

Henley MB[30] showed that an unreamed solid nail (9mm) ,locked with good cortical contact at fracture site was 117% as stiff as intact tibia on axial loading and 6.5% stiff intorsion. Without cortical contact, tibial nail construct was only 55% stiff in axial loading and 3.1% stiff in torsion.

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

Working length[46] is defined as the length of a nail spanning the fracture site from its distal point of fixation in the proximal fragment to its proximal point of fixation in the distal fragment.

Thus, working length is the unsupported portion of the nail between the two major bone fragments and reflects the length of nail carrying the majority of the load across the fracture site.

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

Working length is affected by various factors. A nail has a shorter working length in fixation of a transverse fracture than in stabilizing a communited fracture. Two techniques which modified the working length are medullary reaming and interlocking. Medullary reaming prepares a uniform canal and improves the nail bone fixation towards the fracture, thus reducing the working length. Interlocking screws also modify the working length intorsion by fixing the nail to the bone at specific points. Weight bearing with an interlocked nail further improves the nail bone contact as the nail bends under axial load, reducing the working length and adding to the overall stiffness of the fixation. Interlocking nail can be locked in two modes-dynamic and static

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

2) **Static locking** refers to the placement of transfixing screws above and below the fracture .It controls the rotation, bending and axial loading .It is indicated when the

fracture is communited, unstable to compression or subject to rotational forces.

Dynamisation means removal of either the proximal or the distal locking to allow increased axial loading of the tibia . General guidelines for Dynamisation would be 6-8 weeks postoperatively if no signs of fracture healing on x-ray. Ultrasound can help for the early diagnosis of fracture healing.

REAMING

Reaming of medullary cavity ensures smooth passage of the nail.flexible reamers available are of two types:one is the end cutting and the other is side cutting reamer. End cutting reamer first makes the passage , after which the side cutting reamer expands the cavity to get the bigger sige nail into the bone. Reaming should be done with 0.5 increments

DESIGN OF TIBIAL NAILS

1) AO unreamed tibial rod (UTN)

The UTN is a solid nail made of cold worked implant steel /titanium alloy .Its surface has been roughened to enhance fatigue life .Its slightly flared proximal end has a diamond shaped cross section, where the anterior end is bevelled to prevent damage to the patellar ligament .The bend of the nail forms an angle of 9 degree, confirming to the anatomy of the tibia when correctly inserted.

The proximal end has two mediolateral locking holes ;one round for static and one elongated for dynamic locking .Further ,there are two holes for diagonal locking at 45^{o} each to the frontal plane for additional anchoring of fractures in the proximal diaphysis . The round holes are 4mm in diameter .Locking of the nails provides axial and rotational stability.

The threaded cannulation of the proximal end accepts a sealing screw, which can be inserted after locking, and left in place to prevent in growth of soft tissue. The distal two thirds are straight; with a cross section corresponding to a triangle with a semicircular posterior base line .The posterior tapered tip of the distal end guides the nail along the posterior wall during insertion, reducing the risk of penetration of the cortex.

The distal end has two mediolateral locking holes, and one between them in an A-P direction.

At present the UTN is available in 8mm and 9mm diameters in stainless steel. Titanium alloy (TAN) nails are available in 8mm ,9mm diameter nails in blue colour and 10 mm diameter nails in green colour .All nail lengths from 255mm to 360mm in 15mm increments and from 380 mm to 420mm in 20mm increments .

	Stainless steel		Titanium alloy (TAN)		
Nails	8.0mm dia	9.0mm dia	8.0mm dia (blue)	9.0mm dia (blue)	10mm (green)
Locking bolts	3.9mm dia	3.9mm dia	3.9mm dia (blue)	3.9mm dia (blue)	4.9 mm dia (green)
Drill bits	3.2mm dia	3.2mm dia	3.2mm dia	3.2mm dia	4.0mm dia

The 3.9mm locking bolts is available in lengths from 22mm to 64mm, in 2mm increments and from 68 mm to 80mm, in 4mm increments for stainless steel.

The 3.9mm locking bolts for titanium alloy nail is available in lengths from 20mm to 64mm, in 2mm increments and from 68 mm to 80mm, in 4mm increments. The 4.9mm locking bolts is available in lengths from 26mm to 64mm, in 2mm increments and from 68 mm to 80mm, in 4mm increments.

2) **Indian nail**.

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

The nail's conical proximal end has threads on the inner sides for the attachment of jig and extractor .Positioning grooves, precisely align the jig. The observation of stress distribution during insertion has resisted the curvature of 11^{o} at the junction of the proximal third and he distal two third of the nail. The nail has two proximal holes for locking in mediolateral direction and two distal holes in the antero-posterior direction. The hole diameter is 5mm for 9 and 10 mm tibial nails and 4mm for 8mm nails .The nails available lengths is from 240mm to 420mm in 10 mm increments.

The locking bolts are self tapping

For 8mm tibial nails 3.9mm diameter locking bolts are used For 9, 10,11mm tibial nails 4.9mm diameter locking bolts are used Locking bolts available lengths is from 18mm to 50mm in 2mm increments

INDIAN TUBULAR NAIL

3) Gross and Kempf small diameter nails

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

4) Russel-taylor delta tibial nail

It is a close sectioned stainless steel nail available in shaft diameters of 8, 9, and 10mm. The nail has a 15^{o} anterior bend 45mm from the top to allow the nail to enter the proximal portion the tibia. It has a 3^{o} anterior bend in the distal 64mm of the nail, which serves as ramp during insertion to reduce chances of posterior cortical communition. The proximal end of the nail is tapered to 12mm to give extra strength for nail insertion. There are 4 locking holes; all in the coronal plane.4.5mm screws are used.

COMPLICATIONS OF OPEN FRACTURE SHAFT OF THE TIBIA

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

Usual complications are:

FAT EMBOLISM;

Fat embolism can occur after tibial fracture, with signs and symptoms the same as after other fractures. Ganong has recorded an incidence of 19% in isolated tibial fractures from healthy young skiers. [47]

VASCULAR INJURIES;

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

NERVE INJURY:

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

Compartment syndrome:

The possibility that a compartment syndrome may develop after an open fracture of the tibia should not be over looked. While one or more compartments may be decompressed as a result of open injury, the remaining compartments are still at risk . Gustillo RB[43] reported 2.7percent of the patients who had an open tibial fracture have needed fasciotomy for compartment syndrome. Blick SS[48] reported a 9.1percent incidence of compartment syndrome in patients who had an acute open tibial fracture .For patient who have an altered mental status –that is those who have a head injury or have sustained multiple trauma that necessitated prolonged anesthesia – the risk that the diagnosis of compartment syndrome may be missed or delayed is particularly high. Decompressive fasciotomies of patient in whom the clinical diagnosis of compartment syndrome is made. The same is true for unconscious patients who have elevated intercompartmental pressure (thirty millimeters of mercury or more).

SKIN LOSS:

The subcutaneous position of the tibia makes the leg vulnerable to skin damage or loss at the time of fracture .Although open tibial fractures are common; many do not involve significant skin loss.

Infection;

The incidence of infection of the wound in patients who have an open fracture correlates directly with the extent of soft tissue damage .For type-I fractures, the rate of infection has ranged from 0-2 percent ;for type-II, from 2 to 7%;for type-III over all ,from 10-25percent,[43]

For type-III A, 7 percent

For type-III B, from 10-50 percent

For type-III C, from 25-50 percent[43,49]

(With a rate of amputation of 50 percent or more)

General management principles for infection include drainage of the infected area, debridement of all devascularised bone and soft tissues, stable fixation, appropriately timed soft tissue coverage, and judicious use of appropriate antibiotics.Tomograms may be helpful in identifying bony sequestrum and sinograms may delineate the extent of the infected area. If the fracture has not united and implants are holding well, the implants are kept in situ till union takes place, but if loose implants are removed, a change of fixation to external fixation is required.

JOINT STIFFNESS AND ANKYLOSIS;

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

BONE DEFECTS

Autogenous cancellous bone grafting is most frequently used to create a synostosis between the tibia and fibula, especially when there is anterior tibial bone loss with the posterolateral approach, as described by Harmon PH.[50]

The Ilizarov GA[51] technique using a circular tension wire external fixators has been advocated to induce regeneration of bone to fill defects. In this procedure a coticotomy is performed away from the nonunion site and a segment of bone is transported distally or proximally. The created defect away from the original site gradually fills in with new bone.

MALUNION AND SHORTENING;

The four most important criteria for judging alignment of the tibia are angulation in the anteroposterior and mediolateral planes, shortening, rotational Malalignment and displacement.[47] Malalignment more than $15\text{-}21^0$ may require corrective osteotomy if clinically symptomatic with ankle or knee pain. More external rotation is acceptable than internal rotation. Internal rotation of more than 10^0 may cause gait disturbances, whereas external rotation of as much as 20^0 usually does not cause a significant gait disorder.

A relatively high malunion rate has been reported for proximal third fracture of the tibia treated with interlocking intramedullary nails. Lang and coworkers experienced an 84% malunion rate in proximal third tibial fractures treated with intramedullary nails with angulation of 5^0 or greater in the frontal or saggital plane. Nineteen of the 32 fractures (59 %) and 1cm or more displacement at the fracture site. In 8 fractures (25

%), there was loss of fixation, most commonly associated with placement of a single proximal locking screw.

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

DELAYED UNION AND NONUNION;

Several factors have been implicated in the cause of delayed union and nonunion, most of which are inherent in the nature of the fracture. High-velocity, open fractures with skin or bone loss and fractures with 100% displacement are likely to become nonunion than that are low velocity injuries .There is an increased incidence of nonunion in fractures that develop an infection after either open fracture or open reduction. Distraction at the fracture site and an intact fibula that prevents weights bearing in the cast have also been suggested as causes of delayed union and nonunion. Inadequate external or internal fixation that allows excessive motion at the fracture site is another contributing factor.

Clinically delayed union and nonunion are characterized by pain and motion at the fracture site .Radiographically, there is an absence of bridging callus and persistence of the fracture lines. In hypertrophic nonunion sclerosis and occasionally flaring of the bone ends are noted at 6 months .In atrophic nonunion, osteopenia at the fracture site and an absence of callus formation may be the only radiographic findings.[47]

REFRACTURE;

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

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

CLAW – TOE DEFORMITY:

Claw-toe deformity rarely causes significant disability after tibial fracture but may be severe if caused by ischemia of the posterior compartment muscles .Tethering of the long extensor tendons by callus on the anterior aspect of the tibia is a rare cause of claw-toe deformity .Frequent flexion and extension of the toes should be encouraged, regardless of the treatment modality selected and passive stretching should be done at least once a day.[52]

AMPUTATION:

Amputation above or below the knee after tibial fracture is associated with massive soft tissue injuries resulting directly from the trauma that caused the tibial fracture .Most of these amputations are the result of open wounds and severe soft tissue crushing injuries from motorcycle or motor vehicle –pedestrian accidents[47] .Hansen[53] recommends consideration of primary amputation when open types IIIB and IIIC tibial fracture are associated with an in sensitive foot or major bony and soft tissue injuries of the foot. Amputation may be a life saving measure in the severely traumatized patient or in very elderly patients with poor renal and immunologic reserves .Several authors have called attention to improved quality of life by early amputation in severe open fractures and importance of gainful employment.[54,55]

Secondarily amputation may be required because of open wounds, vascular problems, or infection. Most secondary amputations are required because of infection, especially infected nonunion.

MATERIALS AND METHODS

The present study was undertaken at the Department of Orthopedics, Sri Devraju Urs Medical College and Research Institute after obtaining ethical clearance. This study involved both male and female patients with open fractures of tibia, who presented to.R,L.Jalappa hospital , attached to Sri Devraju Urs Medical College and Research Institute, Tamaka, Kolar. 60 patients who had open fractures of tibial shaft were treated with wound debridement and interlocking intramedullary nailing with or without reaming during the period from October 2009 to September 2011, All the patients were fresh fractures and were traumatic in nature.

All the patients were brought to the casualty.

The Criteria for selection of patients: Inclusion criteria:

1) Age more than 18 years
2) Open fractures type I,II,IIIA and IIIB according to Gustilo Anderson classification

Exclusion criteria:

1) Age less 18 years
2) Closed fractures and Gustilo type IIIC fractures.
3) Pathological fractures

60 patients who had 60 Open tibial fractures were available for valuation .The duration of follow-up was for 6-8 months .There were 54 men and 6 women ,ranging in age from 18 to 62 years old. 44 right and 16 left tibia were fractured .Most of the

fractures were caused by high –energy trauma. Road traffic accident-48, 08 by falls, occupational 04 .

The soft tissue injuries are classified according to the system of Gustilo et.al; 14 wounds were type I, 28 wounds were typeII, 15 were type IIIA, and 3 were type IIIB.

On admission general condition of the patient was assessed with regards to hypovolemia ,associated orthopedic or other systemic injuries and resuscitative measures were taken accordingly .All patients received analgesics in the form I.M injections ,Tetanus toxoid intramuscularly and antibiotics I.V . A thorough clinical examination was performed including detailed history relating to age, sex, occupation, mode of injury, past and associated medical illness.

Patients were taken to the operating room for emergency irrigation and debridement of the open fracture. culture Swabs were taken from the wound and were sent for culture and sensitivity, thorough saline wash was given to the wound and all the foreign bodies over the wound were washed out. Severity of the open fractures determined the subsequent wound care and antibiotic treatment. A sterile dressing was given for wounds and limb was immobilized in the form of above knee plaster of Paris slab or Thomas splint . Limb elevation over a pillow was given for all the patients.

Routine investigations were done for all the patients .All patients were evaluated clinically and radiographically to assess for any other injuries .Radiographs were taken in two planes ,A-P and Lateral views . I.V antibiotics Cephalosporins 1gram BID , Aminoglycosides 500mg BID and Metrinidazole 100ml TID were started for all the patients, patients were operated as early as possible, once the general condition of the patients was stable and fit for surgery.

Randomization of the patients for the surgical procedure was done blind folded by asking the patient to pick one of the chits, In which the procedures for surgery was mentioned.

Preoperatively the length of the nail was calculated by subtracting 3to 4 cms from measurement taken from knee joint line to tip of the medial malleous clinically and medullary canal was measured at the isthmus from the radiographs.

PREOPERATIVE PREPARATION OF THE PATIENTS

Patients were kept NPO for 6 hours before surgery with adequate amount of compatible blood if needed was arranged and preparation of whole extremity /private parts and back was done. Informed consent was taken. Tranquilizers were given at night, with IV antibiotics 1hr before the procedure shifting the patient 30 min before the surgery to operation theatre.

SURGICAL TECHNIQUE

Patient under supine position on a standard operating table (radiolucent) with knee flexed over a padded bolster hanging free,Under Aseptic conditions, after applying pneumatic tourniquet, thorough scrubbing of entire lower limb is done and painting and sterile drapping done.

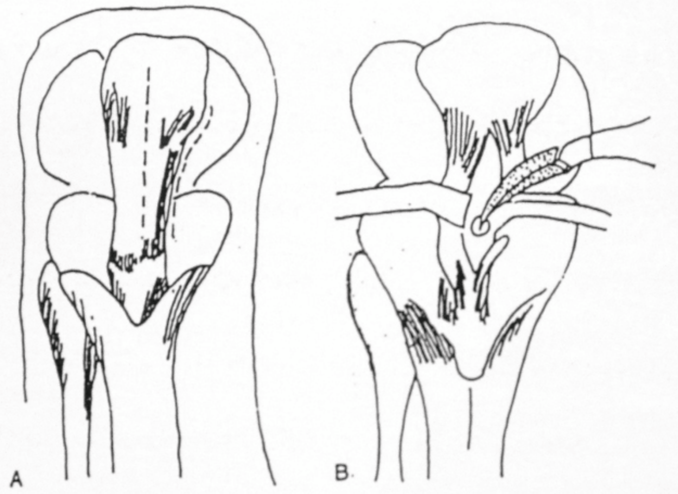
A vertical Patellar tendon incision made over skin extending from centre of the inferior pole of patella to the Tibial tuberosity about 5cms.Split Patellar tendon along with skin and subcutaneous tissue were retracted. Point of entry was selected, generally slightly distal to the tibial plateau, slightly medial and exactly in line with medullary canal and

Entry port was made using a Curved Bone Awl. Initially passed perpendicular and continued to become parallel to the shaft in a curved manner and entry point was confirmed under image intensifier and medullary canal is widened. After widening the Medullary canal 3mm Ball tipped guide wire (Plain guide wire in case of unreamed nailing) was passed through proximal and distal fragments after reducing and confirmed under image intensifier.

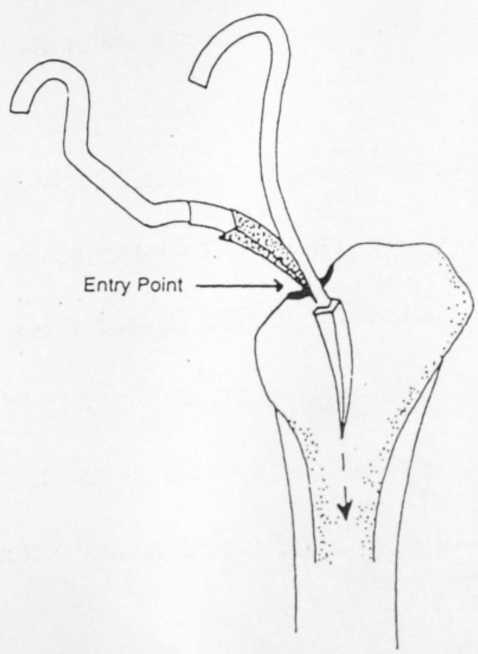
Serial reaming of 0.5mm increments done until 1.5cm more than nail diameter was achieved for reamed intramedullary nailing . Ball tipped gudie wire was exchanged with plain guide wire using exchange tube. Intramedullary Interlocking nail was assembled to the Jig handle and inserted through the entry port and checked under image intensifier, Gentle blows with a slotted hammer were given in order to sink the nail in to the bone if necessary.

Reduction at fracture site was confirmed under image intensifier and Proximal locking was done with the help of jig handle slots and drill sleeves. Both the cortices are drilled using drill bit and locking bolts were fit with Hexagonal screwdriver after measuring the bolt length with depth gauge.

After proximal locking, the jig was taken out and once the Rotational alignement of foot with the knee was checked ,distal locking done with free hand technique under image intensifier using K-wire. Under image intensifier using K-wire in line with the slot in ap and lateral views, the K-wire was hammered to bone until it pierces both the cortices. Through the same K-wire tract Drill was passed and drilled both the cortices. After checking the screw length using depth gauge appropriate locking bolt is screwed in to distal slots.



Insertion of IM nail through midpatellar approach. It can also be approached medial to the patella tendon retracting the patellar tendon laterally



Point of entry 1cm above the tibial tubercle and perforating awl is alined with the medullary canal of tibia avoiding the perforation of the posterior cortex

Printed with thanks from text book of " Interlocking nailing" by D Tanna

The entire leg and the fracture site visualized finally in both views for proper placement of nail . Incised wound is washed with betadine and saline. Skin is sutured. Sterile dressings were applied over the wound. Open wounds were debrided and through wound wash given ,skin approximated or left open based on wound condition and sterile dressing done and Compression bandage given .tourniquet is deflated .Capillary filling and peripheral arterial pulsations checked.

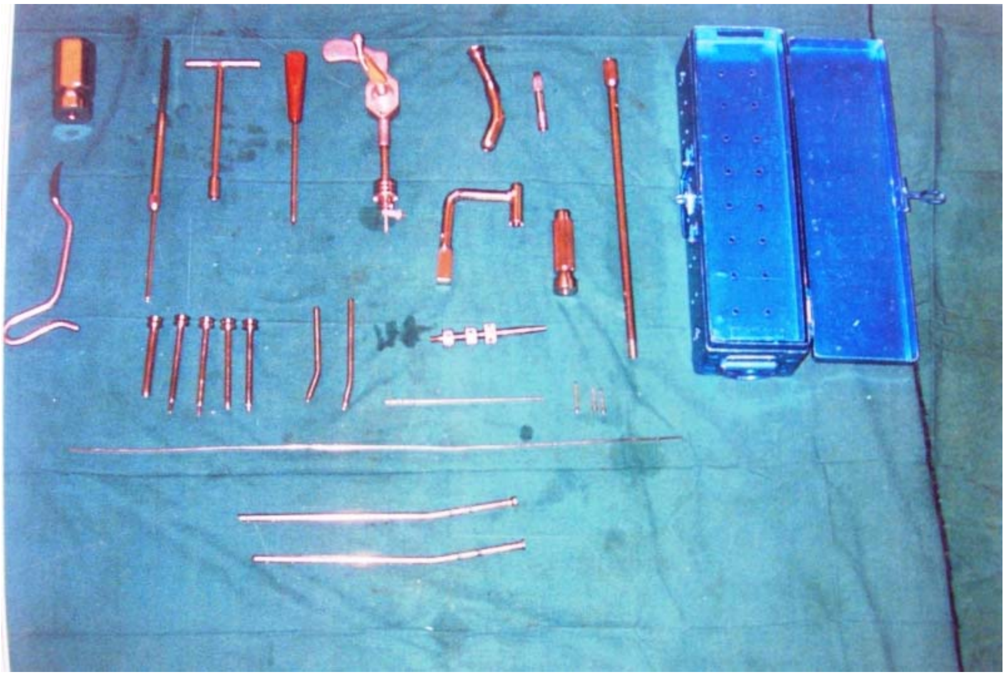
POSTOPERATIVE CARE

All patients where kept NPO 6hours postoperatively. Adequately I.V fluids /blood transfusions are done . I.V antibiotics and I.M analgesics , limb elevation over pillows. Watch for active bleeding, encourage active toe movements. TPR/BP chart was maintained hourly and regular input and output chart was maintained.

Check X-ray of the operated tibia full length including knee and ankle joints in both A-P and lateral views.

Postoperatively elastocrepe bandage applied and limb elevation given over pillows .I.V antibiotics given for 3 days post-operatively. Active knee, ankle and toe mobilization started after overcome from anesthesia. Patient was allowed non weight bearing crutch walking on next postoperative day. Skin sutures, were removed on 13th postoperative day .Depending upon the culture report and wound condition antibiotics are stopped /continued .Partial weight bearing crutch walking /walker commenced after 15 days ,depending upon the type of fracture and rigidity of fixation . Further follow up is done at monthly intervals and each patient was individually assessed clinically and radiographically. Efforts were made to obtain definitive coverage of the wound as the wound is healthy with split thickness skin grafting .

INDIAN TUBULAR NAIL INTERLOCKING INSTRUMENTS



PHOTOS OF OPERATIVE PROCEDURE

Type IIIB fracture –pre-op

Incision

Insertion of nail **completion of insertion**

Proximal locking **wound preparation for flap**

CASE NO. 6 (REAMED)

CASE NO. 11 (REAMED)

CASE NO. 9 (UN REAMED)



CASE NO. 4 (REAMED)






CASE NO. 22 (UNREAMED)



Pre op post op at 6 months


Pre op post op 1 mon


Satisfactory knee and ankle range of motions

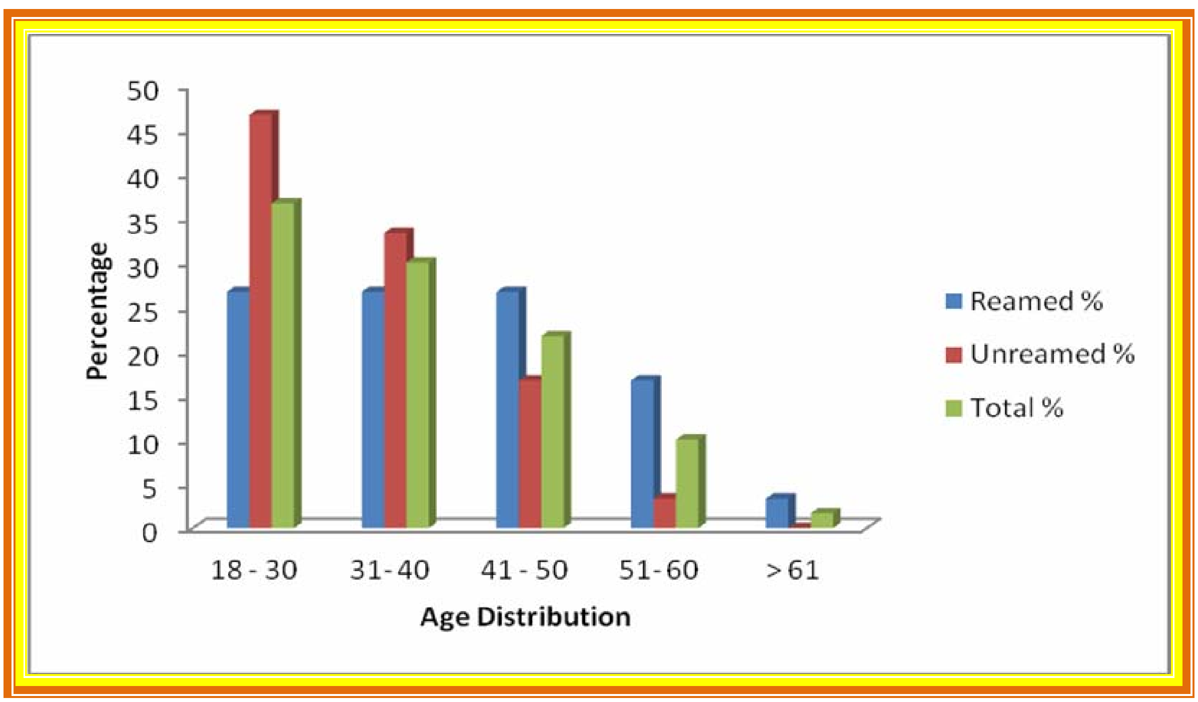
RESULTS

The present study includes 60 open fractures of the tibial shaft surgically treated with closed interlocking intramedullary nailing by reaming and without reaming from October 2009 to September 2011 the department of orthopaedics at R.L.Jalappa Hospital, Sri Devraj Urs Medical College and research institute, Tamaka, Kolar, Karnataka . The patients have been followed up for 6-8 months during this study. All these patients were available for follow up.

1. Age distribution

Age Group	Reamed group		Unreamed group		Total	
	No of Patients	%	No of Patients	%	No of Patients	%
18 - 30	8	26.67	14	46.67	22	36.67
31- 40	8	26.67	10	33.33	18	30.00
41 - 50	8	26.67	5	16.67	13	21.67
51- 60	5	16.67	1	3.33	6	10.00
> 61	1	3.33	0	0.00	1	1.67

Majority of the patients were from age group 18-30 years (36.67%) ,the youngest patient was 18 years old and the oldest patient was of 62 years .

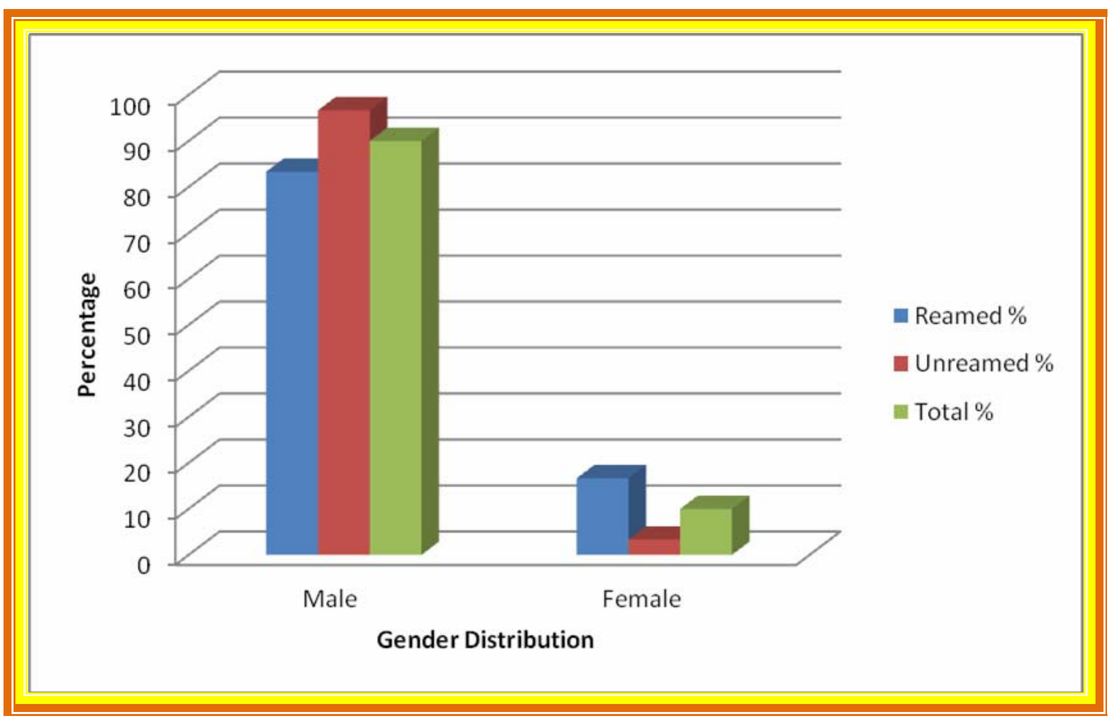


2 : Gender Distribution

Gender	Reamed group		Un reamed group		Total	
	No of Patients	%	No of Patients	%	No of Patients	%
Male	25	83.33	29	96.67	54	90.00
Female	5	16.67	1	3.33	6	10.00

Majority of the patients were male 54 (90%) and 06 (10%) were females.

In reamed group 25 (83.33%) male patients and 05 (16.67%) Female patients, whereas in undreamed group 29 (96.67%) were Male patients and 01(3.3%) Female patient.



3 : Side of Injury

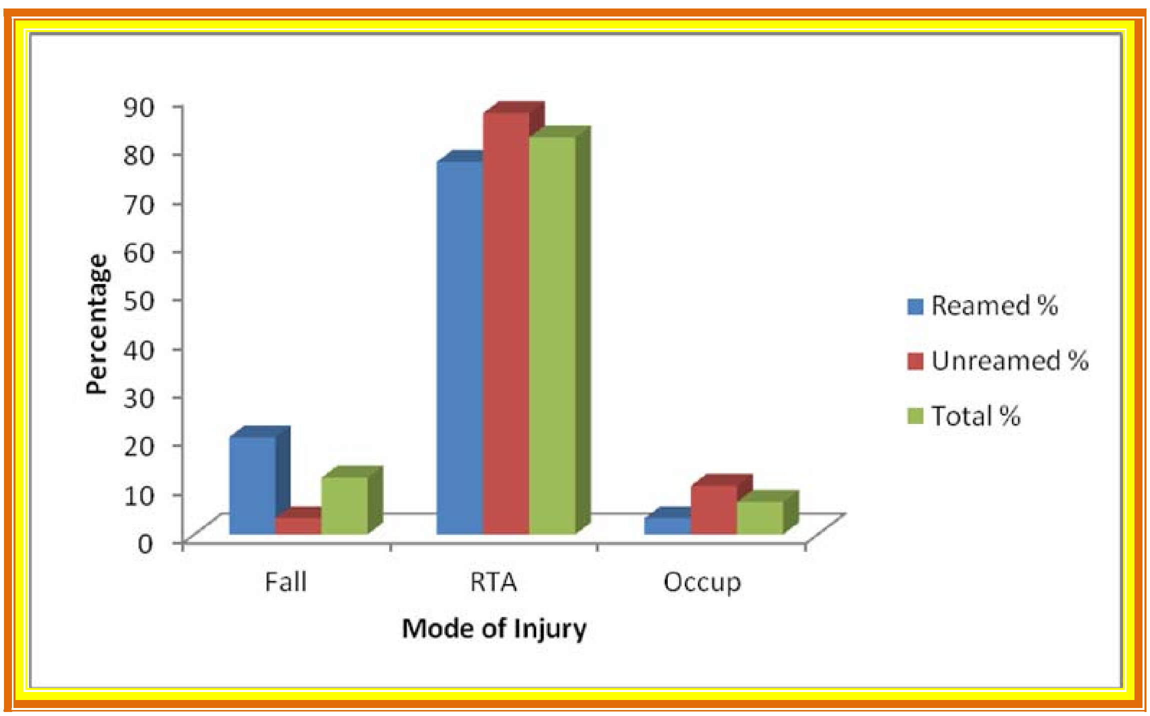
Side	Reamed group		Unreamed group		Total	
	No of Patients	%	No of Patients	%	No of Patients	%
Right	22	73.33	21	70.00	43	71.67
Left	8	26.67	9	30.00	17	28.33

Right tibial fracture constituted majority of the patients. In our study right sided fractures were 43 patients (71.67%) and left sided fractures were 17 patients(28.33%). In reamed right side were 22patients(73.33%) and left side were 08 (26.67%). Whereas in unreamed group right side fractures were 21 patients(70%) and left side were 09 patients (30%).

4. Mode of Injury

Mode of Injury	Reamed group		Unreamed group		Total	
	No of Patients	%	No of Patients	%	No of Patients	%
Fall	6	20.00	1	3.33	7	11.67
RTA	23	76.67	26	86.67	49	81.67
Occup	1	3.33	3	10.00	4	6.67

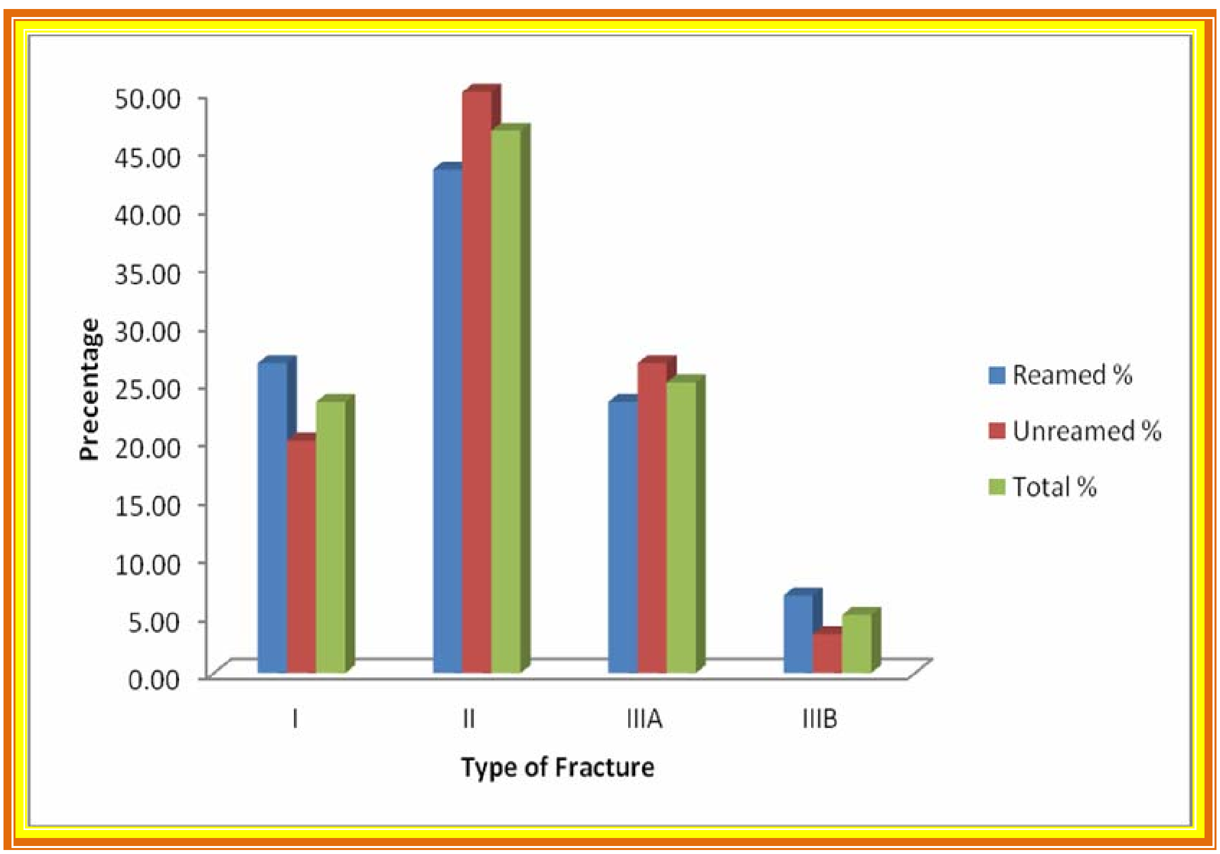
The major cause of fracture in our study was RTA 49 patients(81.67%) of which reamed were 23(76.67%) and unreamed 26(86.67%). Fall 7 (11.67%) patients of which 06 (20%)were reamed and 01 (3.33%) unreamed .occupational injuries were 04 (6.67%) of which reamed were 01 (3.33%) and unreamed are 04 patients(10%).



5. TYPE OF FRACTURE

Type of Fracture	Reamed group		Unreamed group		Total	
	No of Patients	%	No of Patients	%	No of Patients	%
I	8	26.67	6	20.00	14	23.33
II	13	43.33	15	50.00	28	46.67
IIIA	7	23.33	8	26.67	15	25.00
IIIB	2	6.67	1	3.33	3	5.00

Majority of the open fractures of the tibia were Gustilo type II (46.67%) in our study. Majority of the fractures occurred at middle distal third tibia (41.66%). The predominant tibial fracture pattern was communited (41.66) type.



6. Commencement of partial weight bearing (PWB)

In our study all patients were mobilised with non weight bearing crunch walking /walker on next day. For most of the patients partial weight bearing was started on 15-20 days postoperatively (88.33 %). In 07 patients partial weight bearing was delayed for more than 30 days (11.66%)

7. Commencement of full weight bearing (FWB)

27 patients were commenced to protective full weight bearing at 6 weeks postoperatively (45%) ,in our study most of the patients were commenced to protective at full weight bearing 8-12 weeks postoperatively in 33patients (55%)

8. Secondary procedure

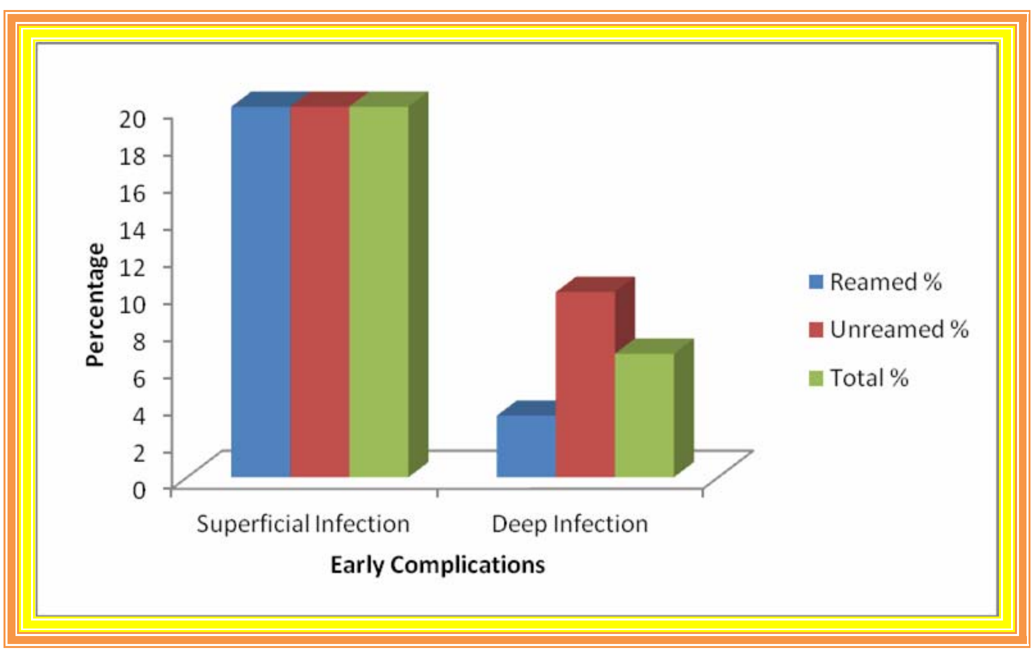
Dynamisation of the nails were done in 23 patients of them 10 were reamed and 13 were unreamed. Skin grafting was done in 20 patients after repeat wound debridement and wound was healthy. None of the patients in our study required the assistance of plastic surgeons. Bone grafting done in 05 patients.

9.Early Complications

Early Complication	Reamed group		Unreamed group		Total	
	No of Patients	%	No of Patients	%	No of Patients	%
Superficial Infection	6	20.00	6	20.00	12	20.00
Deep Infection	1	3.33	3	10.00	4	6.67

Superficial infection were 12 (20%) patients developed superficial infections out of which 06 (20%) where in reamed group and 06 (20%) were in unreamed group the infection found is Staphylococcus aureus and pseudomonas on culture and on sensitive intravenous Antibiotic treatment and regular sterile dressings infection resolved .

Deep infections were total 5 out of which reamed group were 01 and in unreamed group 04. None of the patients developed compartment syndrome , fat embolism.



10. Late Complications

Late Complications	Reamed group		Unreamed group		Total	
	No of Patients	%	No of Patients	%	No of Patients	%
Delayed Union	1	3.33	2	6.67	3	5.00
Non Union	1	3.33	1	3.33	2	3.33
Valgus Def	2	6.67	0	0.00	2	3.33
Knee Stiff	0	0.00	2	6.67	2	3.33
Valgus Def + Non Union	1	3.33	1	3.33	2	3.33

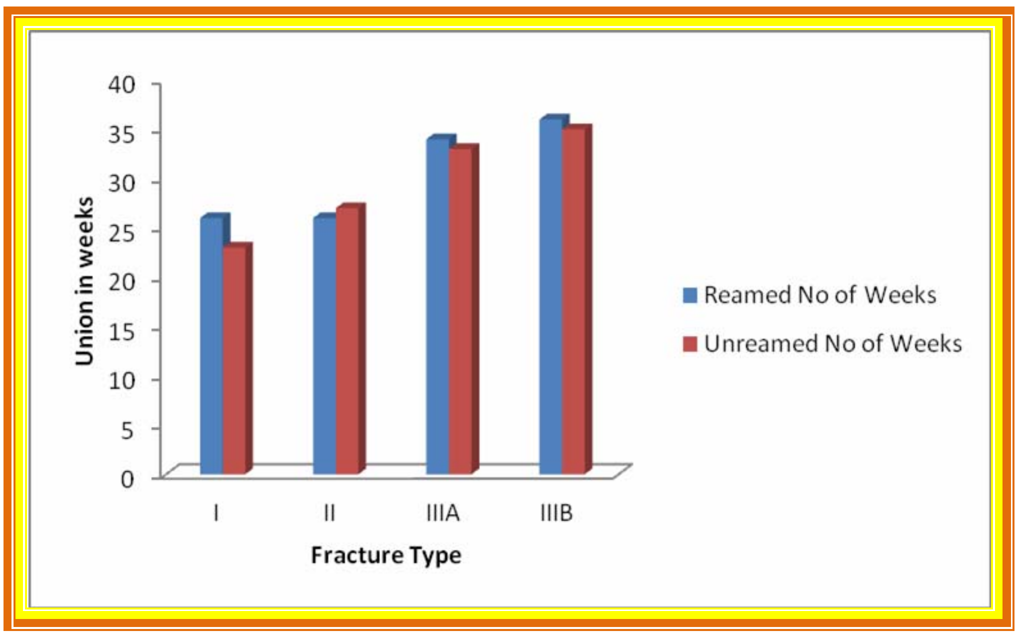
Backing of the distal locking screw is seen in 1patient , it didn't invovlve the bone union. None of the nails were broken or were bent. 2 patients (3.33%) noticed pain and knee stiffness in unreamed group with none of the patients in reamed group . valgus deformity noticed in 2 patients (6.67%) in reamed group and none in unreamed group.

Delayed union noticed in 03 patients(5.0%) in our study of which in reamed group 01 patient(3.33%) and in undreamed group 02 patients(6.67%) . Nonunion noticed 02 patients(3.33%) , 01 patient each in reamed and unreamed group.

Valgus deformity and Nonunion together noticed in 02 patients (3.33%), 01 patients in both reamed and unreamed group .

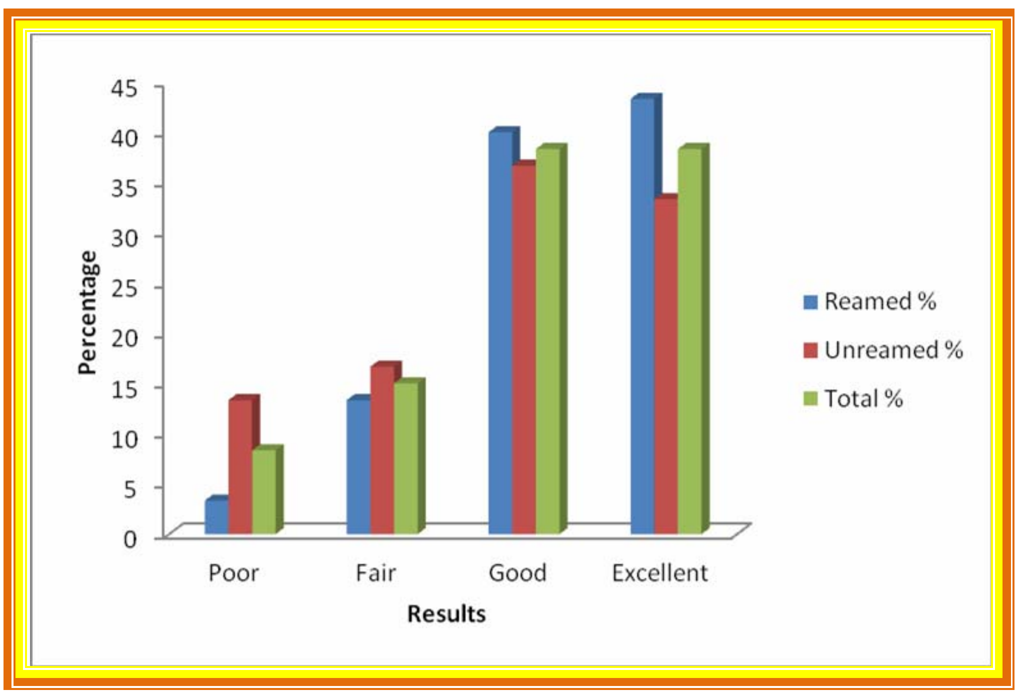
11.Union

Fracture Type	Reamed group No of Weeks	Unreamed group No of Weeks
I	26	23
II	26	27
IIIA	34	33
IIIB	36	35



12.Results

Result	Reamed group		Unreamed group		Total	
	No of Patients	%	No of Patients	%	No of Patients	%
Poor	1	3.33	4	13.33	5	8.33
Fair	4	13.33	5	16.67	9	15.00
Good	12	40.00	11	36.67	23	38.33
Excellent	13	43.33	10	33.33	23	38.33



FUNCTIONAL RESULTS

Detailed analysis of function of the patient was done on the basis of following criteria by Johner and Wruh's[56].

JOHNER AND WRUH'S CRITERIA FOR EVALUATION OF FINAL RESULTS

Sl .no	Criteria	Excellent (left =right)	Good	Fair	Poor
1.	Non-unions, osteitis, amputations	None	None	None	Yes
2	Neurovasculardisturbances	None	Minimal	Moderate	Severe
3	Deformity				
	Varus/valgus	None	2^o-5^o	6^o-10^o	>10^o
	Anteroversion/recurvation	0^o-5^o	6^o-10^o	11^o-20^o	>20^o
	Rotation	0^o-5^o	6^o-10^o	11^o-20^o	>20^o
4	Shortening	0-5mm	6-10mm	11-20mm	>20mm
5	Mobility				
	Knee	Normal	>80%	>75%	<75%
	Ankle	Normal	>75%	>50%	<50%
	Subtabular	>75%	>50%	>50%	----
6	Pain	None	occasional	Moderate	Severe
7	Gait	Normal	Normal	Insignificant limp	Significant limp
8	Strenuous activities	Possible	Limited	Severel limited	Impossible
9	Radiological union	consolidated	Consolidate	Union	Not consoli

The results of this series were as follows:

The average time of union in type 1 reamed group is 28wks ,in unreamed group is 25 wks.

Type 11 reaming group is 28wks and in unreamed group is 26wks. In type 111A reaming group is 36 wks whereas in unreamed group is 34 wks. In type111B in reamed group is 31 wks and in unreamed group is 33wks.

In **reamed group** 13 patients (43.33%) had excellent results, 12 patients had good results (33.33%), 4 fair (13.33%) and 1 case poor (3.33%).

In **unreamed group** 10 patients (33.33%) had excellent results, 11 patients had good results (36.67%), 5 fair (16.67%) and 4 case poor (13.33%).

Over all the study showed 23 patients (38.33%) excellent results, 23 patients (38.33%) good, 09 (15%) fair and 05 (8.33%) poor results with intramedullary nailing of open tibia fractures as a whole.

DISCUSSION

The optimal management of open tibial shaft fractures continues to be a problem with several unanswered questions. Those fractures, usually caused by high energy trauma, have numerous problems resulting from the poor soft tissue coverage and limited vascular supply of tibia, cause mal union, infection and sometimes resulting in amputation .Recent improvements in wound coverage techniques and fixation devices have decreased the prevalence of these complications, but the optimum management of open fractures of the tibial shaft is still evolving.[28]

There are two major factors related that alter the final out come of tibial shaft fractures. The first is the severity of the fracture, characterised according to the Nicoll EA[3] by the degree of initial displacement, comminution and soft tissue injury. Accordingly, the more severe the fracture, higher the rate of complications and longer the periods of healing whatever the method of fixation used.

The second factor is the damage of the tibial blood supply .In open fractures, not only is the endosteal circulation disrupted but also there is periosteal circulation disruption after severe soft tissue damage and periosteal stripping from the bone. This emphasises the necessity to preserve as much as possible the vascularity of the endosteal vessels, using stabilisation technique that avoid additional disruption of this blood supply.

Application of a plaster cast had been the most common method of treatment for open fractures of the tibia, but it has several disadvantages. Nicoll EA[3] reported a rate of infection of 15 percent after the treatment of 140 open tibial fractures with a cast .Brown PW [5] reported that 27 percent of 63 open fractures of the tibial shaft had healed with more than ten millimetres of shortening; and 6.3 percent, with more than thirty millimetres of shortening. More recently the author reported a 12.5 percent rate of malunions in a series of 24 open tibial fractures treated with cast .Immobilisation in a plaster cast, therefore, should be reserved for stable fractures with minimum injury to the soft tissue.

Unstable and open fracture can be treated with plaster casts in corporating transfixation pins.[16] This method has been valuable for distal tibial fractures, including those with joint extension, especially the rotation type Pilon fractures. This method has an advantage of maintaing the length, prevention of rotation and allows the mobilization of knee .This has the disadvantage of pin tract infection and pivoting of the bone and angulation at the fracture site.

Plate osteosynthesis provides rigid fixation of an unstable fracture, and that reduces the problem of non-union. The stripping of soft tissue required for application of a plate, however, has led to an unacceptable rate of infection in patients who have an open tibial factures . Smith JE[8] studied 219 open fractures treated by internal fixation on the day of injury, delayed union occurred in 48 % and infection in 20% and Ruedi T[7] reported a rate of 11 percent in their large series of open tibial fractures treated with a plate. The authors reported an increased incidence of infection in open tibial fractures treated with plating (35%) compared with those treated with external fixation.

Johner R[56] reported non-union was twice as common and infection five times more likely when open fractures were treated with plating. So use of plate becomes an unattractive treatment option.

External fixation techniques maintain several advantages in the treatment of severely communited open tibial shaft fractures (grade IIIB and C),thus providing early stabilization in patients with polytrauma ,improving the survival of injured tissues and permitting turning and mobility to prevent general complications in these patients. Currently, in grade I, II and IIIA open fractures, the use of external fixation has been reduced .Malunion and delayed union are common with this technique[57] . To avoid these complications, some authors have recommended the use of secondary intramedullary nailing after external fixation, but this procedure has an increased prevalence of deep infections after delayed conversion or previous pin tract infections.

Of the various intramedullary devices available, the unreamed unlocked nails have produced good results in open tibial fractures but the implant did not adequately stabilize the communited or segmental fractures. In a randomised, prospective study comparing external fixation with Ender nails, Holbrook et al[9] evaluated twenty eight open tibial fractures treated with external fixation and found a 14 percent deep infection, 21 percent pin tract infection, and a 36 percent malunions. For twenty nine comparable open fractures treated with Ender nails, they reported a 7 percent infection and a 21 percent malunion .The major limitation of ender’s nail fixation is lack of axial control.

Interlocking intramedullary nailing with reaming solves the problem of malunions because it provides the ability to control length ,angulation and rotation but are associated with high risk of infection in open tibial fractures .However, reaming result in destruction of all vessels in the medullary canal and increases in medullary pressure which leads to infiltration of medullary fat ,blood clots and bone debris into the vascular channels .This destruction of endosteal blood vessels along with already compromised vascular supply due to periosteal stripping and soft tissue damage causes considerable bone necrosis and accounted for high rate of infection and non-union in open tibial fractures[58] .

Smith JE[8] found a rate of infection of 33 percent in a series of 18 open tibial fractures treated with intramedullary nailing with reaming, most of the fractures associated with severe soft tissue injury.

Some truamatologists believe that intramedullary nailing with reaming may be used safely for fractures with less severe wounds .Klemm KW[59] reported that six infections (6.5 percent)developed after the use of interlocking intramedullary nailing with reaming in a large series of ninety-three grade –I open tibial fractures.

Intramedullary nailing without reaming is less damaging to the endosteal blood supply than nailing with reaming and historically it has resulted in lower rates of infection. Whittle AP[28],evaluated the cortical blood supply of canine tibiae after nailing with and without reaming .They found that reaming disrupts an average of 70 percent of the cortical blood supply ,while insertion of a nail without reaming disrupts the blood supply in only the inner third of the cortex. This is especially important in the treatment of open fractures in which the outer cortical blood supply may be damaged by periosteal stripping .Until recently, nails used without reaming could not be locked to the major fracture fragments because small diameter interlocking tibial nails were not available, and stability of communited fractures or more proximal or distal fractures of the tibial shaft could not be achieved.

Lottes JO[19] reported a 7.2 percent rate of infection after treatment of 256 open tibial fractures with the use of his nail without reaming .The 27 percent rate of malunions in the series ,Swanson TV[11] demonstrates that malunions can be a problem even for fractures that have been judged to be axially stable.

Christopher FG's[60] 2000, In a prospective randomized study of 123patients it was found that for open fractures of tibia shaft , no significant difference time to union or number of additional procedures performed to obtain union in patients with reamed nail insertion comparied with those without reamed insertion.

Mohith B's[61] 2000, In a randomized study it was found that tibial shaft fractures treated with reamed intra medullary nailing reduces rate of non union and implant failure as compared with non reamed nailing.

Keating's[62] JF1997, In a prospective randomized study of 91patients with open tibial shaft fractures found clinical & radiological results of nailing after reaming are similar to those of nailing without reaming. More screws had broken when reaming had not been done.

Mohit B's[63] 2008, In blinded randomized trial of 1319adults with tibial shaft fractures it was found that no difference between approaches in patients with open fractures and possible benefit for reamed intramedullary nailing in patients with closed fractures.

David LH's[63] 2010, In a blinded randomized controlled trial of 1319 patients with tibial shaft fractures it was found that unreamed intramedullary nailing may preserve the endosteal blood supply. Possibly improving fracture healing and decreased risk of infection were as the reamed intra medullary nailing will increase fracture stability.

In current series 60 patients of open fractures of shaft of the tibial were treated by reamed or unreamed interlocking intramedullary nailing over a period of two years. They were followed up for 6-8 months .The purpose of this study was to evaluate the end results of treatment in these patients.

These patients were of different age groups, occurred in both sexes and the open fracture were of different types.

Age distribution:

The average age of all patients in this series was 36.6 years .The fracture was more common in the age group of 28-37 years.

The average age in a study conducted by Court-Brown CM[64] (50 closed fractures of tibia) showed that the average age was 35 years.

Mohit B's[63] study of 1319 patients mean age was 39.5yr of which reaming group is mean age is 39.1yr and unreamed intramedullary nailing group mean age is 39.8yr for open fractures of tibia .

Finkemeier C G's[62] in his study of 123 patients the average patients age was 33.8yr

Sex distribution:

There were 54 male and 06 female patients showing male preponderance. The sex distribution in a Mohit B's[63] study 2008 showed that there were 904 men and 322 women. In a study by Finkemeier C G[62] there were 74 males and 16 females.

Nature of violence:

Majority of the patient sustained fractures from road traffic accidents . In our study, with RTA 49 patients(81.67%) of which reamed were 23(76.67%) and unreamed 26(86.67%). Fall 7 (11.67%) patients of which 06 (20%)were reamed and 01 (3.33%) unreamed .occupational injuries were 04 (6.67%) of which reamed were 01 (3.33%) and unreamed are 04 patients(10%).

In a Mohit B's[63] study RTA 711 patients (57.1%) , fall 355 patients (29%),twist 57 patients (4.6%) , direct trauma 102 patients (8.4%), snow mobile accident were 1 case (0.1%). In a study by Finkemeier C G[62] there were 37 RTA patients, 26 patients of fall ,10 patients of assault and 3 patients of gunshot wounds.

Results

In our present study we operated on 60 open tibial shaft fractures. In reamed group of 30 patients , 13 patients (43.33%) excellent results, 12 patients had good results (33.33%), 4 fair (13.33%) and 1 case poor (3.33%). In unreamed group of 30 patients, 10 patients (33.33%) had excellent results, 11 patients had good results (36.67%), 5 fair (16.67%) and 4 case poor (13.33%). Over all results of the study showed 23 patients (38.33%) excellent results, 23 patients good results (38.33%), 09 fair (15%) and 05 case poor (8.33%) results.

Christopher FG's[60] in 2000 showed in his study union rate of 41% in reamed group and 58% in unreamed group. Screw breakage in unreamed group in 9 patients and non in reamed group. Infections in 2 patients of reamed and 2 patients of unreamed group, compartment syndrome of 3 patients in each group, 1 case with valgus deformity in unreamed group.

Keating JF's[62] 2011 in his study average time of union in reamed group in type I was 28weeks, type II 28weeks, type III A 34weeks, type III B 30weeks were has unreamed group type I 21weeks, type II 27weeks, type III A 31weeks, type III B 35weeks with 2 superficial infections in reamed group and 1 in unreamed group. Deep infections 1 in reamed group nil in unreamed group, screw breakage 4 in reamed group, 12 in unreamed , mal union 2 in reamed group, 1 in unreamed group, plumonary embolism 1 in reamed group 2 in unreamed group. Compartment syndrome 1 in reamed and 2 in unreamed group, fat embolism of 1 in reamed group and 2 in unreamed group.

In David LH's[64] study non union rate from un reamed intramedullary nailing in this study was 10.2% reamed nailing would reduce the incidence of non union in low risk population from 6% to 2%.

With Court Brown CM's[65] study the Mean time of union with reamed intramedulary nail was 15.4 weeks which was significantly less than the 22.8 weeks for unreamed group.

Anglen JO's[66] 1995 in a study showed average time of union in reamed group as 21weeks were as in unreamed group 35.8weeks with mal union of 4 patients in reamed group & 6 patients in unreamed group. 2 superficial infections and 1 deep infection in unreamed group, 1 broken locking screw in reamed group. 5 non unions in reamed and 1 in unreamed group.

Borge LL[67]in 2003 in his study results were average time of union in reamed group is 16.7weeks unreamed group is 25.7weeks. Mal union in 2 patients of reamed group 4 patients of unreamed group, broken locking screw 1 in reamed group, 3 in unreamed group. Non union of 3 patients in unreamed group and non in reamed group.

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

In our study patients who required wound closure was achieved by repeated wound debridement and once the wound was healthy split thickness skin grafting was done. In our study there was no requirement for plastic surgeon's assistance for wound coverage, as no flaps were used . Coverage of wound was done by debridement and later skin grafting.

CONCLUSION

This study reinforces earlier studies that use of both reamed and unreamed intra medullary inter locking nails is feasible in open diaphyseal fractures of tibia. Rigid intra medullary stabilization helps in healing of the fracture. The presence of the wound upto type IIIB may not increase the chances of spreading the infection. Intra medullary stabilization helps in early mobilization of the patient, preventing joint stiffness, minimal hospital stay and early return to activity. Repeat wound debridement allows the wound to granulate well. Skin grating was all that was required in our series.

Reaming or unreaming for the intra medullary nailing of open tibial fractures marginally altered the union rate, but had no deleterious effect for the wound management.

SUMMARY

Sixty patients who had 60 open fractures of the tibial shaft were treated with wound debridement and interlocking intramedullary nailing without reaming during the period from October 2009 to September 2011, at Sri Devraj Urs Medical College, Tamaka , Kolar .All the patients were fresh fractures and traumatic in nature. All the sixty patients with fractures of the tibial shaft were available for the study.

They were followed for a period of 6-8 months. Our aim was to treat these fractures by closed interlocking intramedullary nailing with or without reaming, and to assess the outcome of both reamed and unreamed intramedullary interlocking nailing in the treatment of these fractures.

The mean age of patients with these fractures was 36.6 years and the maximum patients were in the age group of 18to 30 years .Males predominated in our study. Road traffic accidents are the main cause of these fractures followed by motor cycle accidents. In our series most of them are Gustlio type II 28 fractures (46.6%), type I 14 fractures, type IIIA 15 fractures and type IIIB 03 fractures. All the patients were examined clinically and radiographically, including detailed history of premorbid status and occupation at the time of admission. Patients fulfilling the inclusion criteria were included in the study. Randomization of patients for surgery was done, As per the statistician advise. Immediate irrigation and debridement of the open fracture done. Patients were operated as early as possible once the general condition of the patients was stable and fit for surgery. Most of the patients surgery was performed within 24 hours of Injury.

In all patients midline patellar tendon splitting approach was used for nail insertion site. Our mean operating time was 90 minutes (range 60 min to 120 min).

All the patients were mobilized post operatively as early as possible depending upon the fracture stability, general condition, and tolerance of the patient. In 44 patients (58.33%) full range of knee motion at 12 weeks. More than 80%of knee motion was seen in 15 patients. In 01 case less than 75% of knee motion was achieved. In 40 patients (66.66%) full range of ankle motion at 12 weeks, more than 75% of ankle motion in 16 patients (26.6%).In 04 case more than 50% of ankle motion (6.66%).

In two patients valgus angulation was noticed less than 7.5^{o} . Shortening noticed in four patients, less than 1 cm of shortening.

12 patients developed superficial infection of which 06 were in reamed group and 06 patients in unreamed . All were healed with antibiotics. Four patient developed deep infection one in reamed group and three in unreamed group.

Distal locking screw is jetted out from from fixation in one case , but this did not result in a loss of reduction and union occurred within 20 weeks of trauma. Two patients were noticed with pain at the knee joint. Results were In reamed group 13 patients (43.33%) had excellent results, 12 patients had good results (33.33%), 4 fair (13.33%) and 1 case poor (3.33%).

In unreamed group 10 patients (33.33%) had excellent results, 11 patients had good results (36.67%), 5 fair (16.67%) and 4 case poor (13.33%).

Overall results of the study showed 23 patients (38.33%) with excellent results, 23 patients good results (38.33%), 09 fair (15%) and 05 case poor (8.33%) .

The present series shows that open fractures of the tibial shaft are managed well with both reamed and unreamed interlocked intramedullary nails. Reamed interlocking intramedullary nailing group gave better results . It provides the advantages of early stabilization, lower rates of infection and delayed union / non-union compared to other treatment modalities .To achieve these goals ,we recommend early extensive/adequate debridement and stabilisation with reamed or unreamed interlocked nail followed by early wound coverage if required .Fracture should be dynamised at 8-10 weeks ,if union does not progress. A significant advantage of interlocking in addition to early joint motion, early weight bearing allows earlier return to work. In our series we found that interlocking nailing by reaming or unreaming in open fractures of tibial shaft is feasible. We also had excellent and good results in 83.33% of reamed group and 70% of unreamed group. There were no wound complications and bony union was achieved in an average of 30.5 weeks in reamed group and average of 29.5 weeks in unreamed group. There were no serious wound complications.

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PROFORMA

PG: DR. CHANDRA MOULI G THIESIS GUIDE: PROF. N.S.GUDI

Name:

Age/sex:

Address:

Hosp.no :

Date of Admission:

DOD:

Mode of injury: RTA/Assault/Domestic/Occupational/Misc.

Time period between injury and Arrival to Hospital:

Time period between Arrival to hospital and surgery:

Chief complaints:

History of presenting illness:

Past history:

Family and Personal History:

General Physical Examination:

Built and Nourishment:

Pulse: BP:

Pallor: Cyanosis: Clubbing:

Level of Consciouness:

Systemic Examination:

CVS: RS:

P/A: CNS:

Local Examination:

Laterality: Inspection:

-Description of open Wound:

-Attitude:

-Swelling:

-Deformity:

Palpation:

-Tenderness:

-Crepitus:

-Abnormal Mobility:

-Peripheral Neuro Vascular Examination:

Associated Injuries:

-Vascular Injury:

-Nerve Injury:

-Other Injuries:

Provisional Diagnosis:

Initial Treatment (Done in CASUALTY):

-Initial Stabilization Measures:

-Initial Antibiotics Started:

-Culture and Sensitivity from open wound:

-Wound irrigation and Debridement:

-Immobilization:

Radiography:

Final Diagnosis:

Investigations:(Pre-op assessment):

HB: PCV: TC: DC: ESR:

RBS: B.Urea: S.creat: BT: CT:

Blood grouping:

HIV: HBsAG:

For patients more than 45 years of Age –

CXR: ECG:

Treatment:

Procedure: REAMED / UNREAMED

Type of Anaesthesia:

Nail length : Diameter:

Type:

Interlocking Screws-Length :

Proximal- Distal:

Intra-op: C-Arm

Post-op : Antibiotics:

X-ray:

Culture/Sensitivity from open wound:

Complications : Infection:

Any other:

Time of Starting Active Range of Movements:

Duration of Hospital stay:

Range of Movements at Discharge:

Advice at Discharge Regarding Wt. Bearing:

Post-Op Follow up

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

Final deformity: Angulation: Varus/Valgus

Anterior/Posterior

Rotation:

Shortening:

Final Result: Excellent/Good/Fair/Poor.

KEY TO MASTER CHART

M	-	Male
F	-	Female
Rt	-	Right
Lt	-	Left
RTA	-	Road Traffic Accident
Occup	-	Occupational
Sup.inf	-	Superficial infection
Dep.inf	-	Deep infection
Valgus.def.	-	Valgus deformity
Del.union	-	Delayed union
#	-	Fracture
Mc	-	Metacarpal
Med.cond#	-	Medial condyle fracture
Med.malleoli#		Medial malleoli fracture
Lat.mal.#	-	Lateral malleoli fracture
Kneestiff	-	Knee stiffness

MASTER CHART REAMED

Sl.no	name	Hos.no	dop	Age	sex	side	Nat.voil	Type	Ass.inj	Reamed	Early.comp	Late.comp	Result
1	Venkataramappa	543845	7/10/2009	55	M	Rt	RTA	IIIa		Reamed			Good
2	Korappa	558841	7/12/2009	41	M	Lt	RTA	I		Reamed	Sup.inf		Excellent
3	Sekhar	560620	13/12/09	50	M	Lt	RTA	IIIa		Reamed		Del.union	Fair
4	Thahera	598241	28/4/10	38	F	Rt	RTA	II		Reamed			Fair
5	Venkataramappa	595000	5/5/2010	55	M	Rt	Fall	I		Reamed			Excellent
6	Parshamurthy	595915	5/5/2010	37	M	Rt	RTA	I		Reamed	Sup.inf		Fair
7	Umapathy	596320	12/5/2010	42	M	Rt	RTA	IIIa	Med.cond.#	Reamed	Dep.inf		Good
8	Susheelamma	601236	13/5/10	62	F	Rt	Fall	II		Reamed			Excellent
9	Govinda	581578	17/3/10	30	M	Rt	RTA	II		Reamed			Good
10	Pillamuniyamma	588226	7/4/2010	55	F	Lt	RTA	I	Colles#.lt	Reamed			Excellent
11	Ramappa	546986	2/12/2009	40	M	Rt	RTA	IIIb	Rib#	Reamed	Sup.inf		Good
12	Changalrayappa	596321	6/5/2010	34	M	Rt	RTA	IIIb		Reamed			Fair
13	Ramakrishnappa	596511	18/3/10	53	M	Rt	Fall	IIIa		Reamed			Good
14	Narayanappa	570937	14/12/09	35	M	rt	RTA	IIIa		Reamed			Good
15	gantlappa	549968	3/11/2009	45	M	rt	RTA	II		Reamed	Sup.inf		Good
16	Dinesh kumar	549334	30/10/09	18	M	rt	RTA	IIIa		Reamed			Excellent
17	narayanappa	510937	14/12/09	35	M	rt	RTA	II	Colles# (lt)	Reamed			Excellent
18	venkataramanappa	543845	7/10/2009	55	M	rt	RTA	IIIa		Reamed	Sup.inf	Nonunion	**Poor**
19	Venkat reddy	624224	31/8/10	50	M	Lt	Occup	I	Rt tibia	Reamed	Sup.inf		Excellent
20	padmavathi	632721	15/9/10	27	F	Lt	Fall	II		Reamed			Good
21	**Byra reddy**	**647473**	**4/11/2010**	**43**	M	**rt**	RTA	II		Reamed			Good
22	Muniyappa	661418	27/12/10	46	M	Rt	Fall	I		Reamed			Good

23	Raghu	660997	20/12/10	23	M	Lt	RTA	II		Reamed			Excellent
24	Yasmeen taj	659390	20/12/10	21	F	Lt	Fall	II	Med.malleoli#	Reamed		Valgus.def.	Good
25	Chinappa reddy	656757	7/12/2010	42	M	Lt	RTA	I		Reamed			Excellent
26	Ravi kumar	669616	19/1/11	35	M	Rt	RTA	II		Reamed		Valgus.def.	Good
27	Girish	672714	29/1/11	21	M	Rt	RTA	II	2nd mc#	Reamed			Excellent
28	Shankarappa	674900	7/2/2011	40	M	Rt	RTA	I		Reamed			Excellent
29	Prasanth	684070	28/2/11	29	M	Rt	RTA	II		Reamed			Excellent
30	shashiraj	690735	11/3/2011	26	M	Rt	RTA	II		Reamed			Excellent

MASTER CHART UNREAMED

Sl.no	name	Hos.no	dop	Age	sex	side	Nat.voil	Type	Ass.inj	Unreamed	Early.comp	Late.comp	Result
1	Sriramappa	551400	7/11/09	38	M	Rt	RTA	II	Med.malleoli#	**Unreamed**			Excellent
2	Gangappa	564905	13/12/09	60	M	Rt	RTA	IIIA		**Unreamed**		Non.union	Poor
3	**Krishnappa**	**562950**	**23/12/09**	**40**	**M**	Rt	RTA	II		**Unreamed**			Excellent
4	Naranayanarao	579019	5/2/2010	45	M	Rt	occu	I		**Unreamed**	Sup inf.		Excellent
5	Imranpasha	591145	21/4/10	23	M	Lt	RTA	II		**Unreamed**			Excellent
6	Narayana swamy	551685	9/11/2009	35	M	Rt	RTA	II		**Unreamed**			Excellent
7	Surendra	526931	2/6/2010	25	M	Rt	RTA	II		**Unreamed**	Deep.inf	Delayed.	**Fair**
8	**srinivas**	**571216**	**25/1/10**	**40**	**m**	Lt	occu	**IIIB**		**Unreamed**	Sup inf.		Good
9	Udaykumar reddy	555406	23/11/09	23	m	Rt	RTA	IIIA		**Unreamed**	Sup inf.	Valgus Non union def	Poor
10	Mohan	544559	19/11/09	50	m	Lt	RTA	II		**Unreamed**		Del.union	**Fair**
11	Manjunath	604778	8/6/2010	24	m	Rt	RTA	II	Lat. Mal. # (rt)	**Unreamed**			Good
12	Babu reddy	601340	16/6/10	28	M	Rt	RTA	II	#shaft femur,#patella	**Unreamed**	Deep.inf		Poor
13	**Periya swamy**	**629427**	**2/9/2010**	**37**	**m**	Rt	RTA	IIIA	**2&3 meta tarsal#**	**Unreamed**			Good
14	Ganga raju	632131	12/9/2010	28	M	Rt	RTA	II		**Unreamed**			Excellent
15	Sheik suleman	632090	14/9/10	35	M	Rt	RTA	I	Rt femur	**Unreamed**		Knee stiff	**Fair**
16	Gopi	634344	21/9/10	27	M	Rt	RTA	I		**Unreamed**			Excellent
17	Chinna venkata reddy	640439	14/10/10	48	M	Rt	RTA	I		**Unreamed**			Good
18	Shivanna	640396	28/10/10	22	M	Rt	RTA	II		**Unreamed**			Excellent
19	Srinivas	644425	26/10/10	27	M	Lt	RTA	IIIA		**Unreamed**			Good
20	Manjunath	639748	2/11/2010	33	M	Rt	RTA	IIIA		**Unreamed**	Sup inf.		Good
21	Babu reddy	649658	15/11/10	33	M	Rt	RTA	I		**Unreamed**	Deep.inf		Poor
22	Suresh	652204	20/11/10	26	M	Lt	RTA	II		**Unreamed**			Good

23	Devraj	652353	21/11/10	38	M	Rt	RTA	II		**Unreamed**				Good
24	Mohan	666616	8/1/2011	28	M	Lt	RTA	II		**Unreamed**				Good
25	srinivas	663572	30/12/10	25	M	Rt	RTA	IIIA		**Unreamed**				**Fair**
26	Bhargav	668865	19/1/11	25	M	Lt	RTA	I		**Unreamed**				Excellent
27	Prakash	669944	24/1/11	36	M	Lt	occu	II		**Unreamed**	Sup inf.			Excellent
28	prabhavathy	672059	27/1/11	29	F	Rt	RTA	IIIA		**Unreamed**	Sup inf.			Good
29	Shivappa	676531	13/2/11	45	M	Lt	RTA	II	Shaft femur #	**Unreamed**		Knee stiff		**Fair**
30	Venkatesh	678461	21/3/11	44	M	Rt	Fall	IIIA		**Unreamed**		Valg.def		Good