STUDY OF MANAGEMENT OF DISTAL TIBIA FRACTURES BY MINIMALLY INVASIVE LOCKING PLATE OSTEOSYNTHESIS AT SDUMC, SDUAHER, KOLAR, FROM DECEMBER 2011 TO MAY 2013

A Dissertation submitted to the Sri Devraj Urs Academy Of Higher Education and Research, Kolar in partial fulfillment of the regulations for the award of the Master's Degree in

ORTHOPAEDICS

(M.S.)

2010 -2013

Dr Singh Shikhar Dalbir

DEPARTMENT OF ORTHOPAEDICS

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Tamaka,Kolar,

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SRI DEVRAJ URS MEDICAL COLLEGE AND RESEARCH INSTITUTE, Tamaka, Kolar.

Recognized by Medical Council of India, New Delhi in 1986 as private Medical College, Kolar and renamed as Sri Devraj Urs Academy of Higher Education and Research Institute in 2006.

Sri Devraj Urs Academy of Higher Education and Research

Kolar, Karnataka.

"STUDY OF MANAGEMENT OF DISTAL TIBIA FRACTURES BY MINIMALLY INVASIVE LOCKING PLATE OSTEOSYNTHESIS"

BY
Dr Singh Shikhar Dalbir M.B.B.S.,

Dissertation submitted to the Sri Devraj Urs Academy of Higher Education and Research, Kolar, Karnataka.

In Partial fulfillment
Of the requirements for the degree of

MASTER OF SURGERY
IN
ORTHOPAEDICS

Under the guidance of

Dr PV Manohar M.S.orthopaedics
Head of the Department,
SDUMC,Kolar

DEPARTMENT OF ORTHOPAEDICS

Sri Devraj Urs Academy of Higher Education and Research
KOLAR.

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PLACE: KOLAR

DATE: (Dr Singh Shikhar Dalbir)

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PLACE: KOLAR

DATE:

(Dr PV Manohar)

M.S. ORTHO

Professor and Head

Department of Orthopedics

Sri Devraj Urs Medical College,

Kolar.

ENDORSEMENT BY

HEAD OF THE DEPARTMENT AND PRINCIPAL

This is to certify that this dissertation titled "STUDY OF MANAGEMENT OF DISTAL TIBIA FRACTURES BY MINIMALLY INVASIVE LOCKING PLATE OSTEOSYNTHESIS" is a bonafide research work done by Dr Singh Shikhar Dalbir under the guidance of Dr PV Manohar, M.S. Ortho, Professor and Head, Department of Orthopedics,Sri Devraj Urs Medical College, Kolar.

Dr P V MANOHAR,

M.S.Orthopaedics,
Professor and Head
Department of Orthopaedics,
Sri Devraj Urs Medical College,
Tamaka,
Kolar -583104

DATE: Principal,

Sri Devraj Urs Medical College,
Kolar –583104

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Member Secretary

Date:

Place: Kolar

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Date: Dr Singh Shikhar Dalbir

Place: Kolar

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

1	Locking Compression Plate	LCP
2	Minimally Invasive Percutaneous Plate Osteosynthesis	MIPPO
3	Patients	Pts
4	Anterior Talofibular Ligament	ATFL
5	Calcaneofibular Ligament	CFL
6	Posterior Talofibular Ligament	PTFL
7	Anterior Inferior Tibiofibular Ligament	AITFL
8	Posterior Inferior Tibiofibular Ligament	PITFL
9	Olerud and Molander Score	OAMS
10	Road Traffic Accident	RTA

LIST OF TABLES

LIST OF GRAPHS

Abstract

Introduction:

Distal tibia fractures are one of the common fractures. It results from indirect coronal or direct axial compressive forces. These fractures encompass many and varied fracture configurations that involve medial, lateral or both sides with many degrees of articular depressions and displacements. Each fracture type has its own characteristic morphology and response to the treatment.

Despite many advances in the care of these fractures, distal tibia fractures continue to be a difficult surgical problem. A survey of the literature indicates that many authors report nearly 50 % satisfactory results with either closed or operative methods of treatment.

In view of these considerations present study of functional outcome of distal tibia fractures treated by minimally invasive locking plate osteosynthesis is being taken up.

Review of literature:

There are many techniques for the treatment of distal tibia fractures and Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO) with Locking Compression Plate (LCP) is one of the most acceptable methods today.

Many previous investigators found favourable outcome for MIPPO with LCP. It was observed to be a reliable method of stabilisation for distal tibia

fractures. There were less complications related to soft tissues, bone healing and functional outcome with this technique.

Materials and Methods:

Thirty patients with distal tibia fractures satisfying inclusion criteria admitted in R. L. Jalappa Hospital attached to Sri Devraj Urs Medical College, Tamaka, Kolar were studied during the period of Dec. 2010 to May 2013.

Results:

In our study we achieved 47% excellent results, 30% good results , 13% fair and 10% poor results. These results were comparable to other studies.

Conclusion:

Various studies have shown 85% of patients had excellent, good and satisfactory outcome. 15% of patients had moderate and poor categories of outcome.

AIMS AND OBJECTIVES

To study the anatomical and functional outcome of distal tibia fractures treated by minimally invasive locking plate osteosynthesis.

INTRODUCTION

Modern age of industrialization has brought along with it a virtual race against time and thus accidents are becoming epidemiologically one of the largest killers and the most dreadful enemy or human beings all over the world. Today's trauma surgeon is witnessing a complete change in the pattern of injuries in terms of severity, soft tissue damage and the accompanying complications. Polytrauma patients are no longer a rarity and long bone fractures associated with severe soft tissue damage and contamination are a common occurrence which put the skills of the most experienced orthopaedic surgeon to test.

Fracture of distal tibia is one of the common problems seen in orthopaedic practice with accidents involving tibia in over 15% of the cases. Because of long period of total recumbency and severe socioeconomic burden imposed by these fractures there have been constant efforts to develop methods of treatment which reduce period of hospitalisation and recumbency.

As for the tibia, its subcutaneous nature and lack of adequate musculature makes it more prone for soft tissue damage and bone loss. Depending on the pattern, level and soft tissue damage of the tibia, various methods of management have been described. The key to handle these troubling fractures is to skillfully preserve and reconstruct the soft tissues, early mobilization and functional use of the extremity with the maintenance of satisfactory length and alignment of the fracture.

Distal tibia fractures are caused by either direct violence (as in motor vehicle accidents), penetrating trauma, or indirect stress (Falls with the foot fixed). Direct violence accounts for an increasing number of tibial fractures.

However the treatment of distal tibia fractures has remained a subject of vigorous debate for several decades. No other fracture has inspired such a broad spectrum of opinion as regards to optimum treatment.

Sir John Charnley in 1961 stated that "We have still a long way to go before the best method of treatment of a fracture of tibia can be stated with finality".

Tibial fractures are one of the most complicated ones to treat, this is especially for comminuted tibial fractures. The factors contributing to complications in management of fractures of distal tibia include a high incidence of open and infected fractures as tibia lies superficially just beneath the skin;
tendency for redisplacement of fragments when swelling subside, particularly in comminuted, oblique and spiral fractures; cosmetic and sometimes functional disability if alignment or rotational position of the fragments is imperfect because the knee and ankle joint normally move in the same parallel axis.; conspicuous disfigurement if opposition of fragments is imperfect because the tibia lies subcutaneous; slow union as a result of severity of the fractures, poor blood supply to one fragment and sometimes distraction of bone fragments; occasional limitation of joint movement in the knee, ankle and the foot, usually caused by associated joint soft tissue and vascular injury.

Various treatment modalities have been used in the treatment of distal tibial fractures. Sarmiento et al (1939), demonstrated that treatment by closed reduction and cast immobilization could prevent serious complications of open reduction and internal fixation. His method of functional bracing in the form of patellar tendon bearing cast is the method of cast treatment used most popularly for tibial fractures. But owing to difficulties of mal-alignment, shortening wound management inside the plaster cast, this method is restricted only to low energy tibial fractures.

External fixation devices became the method of treatment of open tibial fractures in 1980's. These were the main stay of stabilization of these fractures as these also facilitated the soft tissue care and wound dressing. These devices had certain disadvantages in the form of pin tract infections, longer union time, poor patient compliance and increased complications like infection, mal-union and non-union.

The disadvantages seen with external fixators led to the usage of internal fixation devices for stabilization of tibial fractures as intramedullary nail, plates and screws. The problem with intramedullary nail is that if the fracture is too distal, the fixation is compromised and the placement of distal screws becomes difficult.

The management of fractures with traditional plating techniques has undergone a paradigm shift over the past 20 years. For many fractures, anatomic reduction using a dynamic compression plate has been the gold standard. However, minimally invasive approaches combined with biologically friendly internal fixation have become accepted methods of complex fracture treatment. The orthopedic literature has demonstrated advantages when comparing locking plate techniques with traditional compression plating techniques.

The advantages of locking plates apply most directly to cases of highly comminuted fractures, unstable metadiaphyseal segments, and osteoporotic fractures. Compression plating requires absolute stability for bone healing. In contrast locking plates function as "internal fixators" with multiple anchor points. This type of fixed-angle device converts axial loads across the bone to compressive forces across fracture sites, minimizing gap length and strain.

In highly comminuted, segmentally deficient, or porotic bone, bone quality is poor and "absolute rigidity" does not exist. Furthermore, soft-tissue stripping adds a biologic insult to the poor bone quality. The literature demonstrates low rates of nonunion and overall complication rates with locking plates in difficult metaphyseal and diaphyseal fractures. Anatomic reduction of the articular surface remains paramount. Hybrid techniques that combine the benefits of compression plate fixation with the biological and biomechanical advantages of locking plates are the most likely end result of current locking plate applications. The shaft holes on the Locking compression plate are oval allowing for the options of a compression screw or a locking screw. This leads to a more precise placement of the plate, as it is able be compressed more closely to the bone.

It has been rightly said, "Those who do not know the history are doomed to repeat it". So it becomes imperative to look into the history to understand the problem better and to reach some definite conclusion.

REVIEW OF LITERATURE

Kempf et al(1980) conservatively treated 77 tibial fractures according to salmiento's principles of functional bracing which needed a functional below the knee brace which ends on the knee like PTB prosthesis and found results to be satisfactory. But as orthopaedic science evolved with newer concepts and implants, operative interventions in fractures of distal tibia started gaining popularity. [4]

For the past decade, plating after fracture reduction has been successful in treating complex fractures of the lower extremity especially distal tibia. The goal of this technique is to apply stable plate fixation while maintaining the fracture biology and minimizing soft tissue problems.[7,8,9]

Thompson et al(2000) reviewed 15 patients retrospectively with distal tibia fractures treated with reamed I.M nail. All patients had returned to normal activities of daily living. Eleven patients could perform all leisure activities with no symptoms and 3 had only minor discomfort. 3 patients had mal-alignment defined as varus-valgus angulation or recurvatum of 5 degrees or greater. [10]

Compared with a conventional plate, a locking plate imparts a higher degree of stability and provides better protection against primary and secondary losses of reduction.[11,12]

With the introduction of locking compression plate (LCP), minimally invasive percutaneous plate osteosynthesis (MIPPO) has become widely used.[13]

Hasenboehler et al(2006) evaluated the healing pattern and clinical evolution of distal tibia fracture over 2 and a half yrs in 32 patients was done. 10 patients at 3 months, 23 at 6 months and 27 at 9 months met the criteria for healed fracture. MIPO is more advantageous for soft tissue and bone biology.[13]

Hazarika S et al(2006) performed MIPPO in 20 patients with distal tibia fractures between March 2003 and Dec 2004. Average time to full weight bearing in the closed fracture group was 18.1 weeks (8-44 weeks). In the open fracture group, 4 fractures united within 6 months, 1 within 6-12 months and 1 after 12 months after surgery. MIPO reduces surgical tissue trauma and helps preserve the periosteal vascular integrity and osteogenic fracture haematoma.[14]

Bedi et al(2006) studied surgical treatment of non articular distal tibia fractures. They concluded that intramedullary canal anatomy at this level prevents intimate contact between the nail and endosteum and found plate fixation to be effective in stabilizing distal tibia fractures. [15]

Recently, there has been an increasing trend toward use of a locking plate for treatment of complex fractures of the distal part of the tibia .[16]

Minimally invasive lateral plating will restore limb alignment and yield successful clinical outcomes for high-energy metaphyseal fractures of the distal tibia. Despite the significant re-operation rate and prolonged time to union, most patients can expect a predictable return of function. Strong consideration should be given to adjunctive measures in at –risk patients, including those with highly comminuted fracture patterns , bone loss, or Type II or III open fractures.[17]

Bahari et al(2007) reported a series of 42 patients reviewed at a mean of 19.6 months after treatment of distal tibia fractures using AO distal tibia locking plate with MIPPO technique. Mean time to union was 22.4 weeks. All fractures united with acceptable alignment and angulation. Two cases of superficial infection were noted, with 1 case of deep infection. Mean SF36 score was 85 and mean AOFAS score was 90 at a mean of 19 months follow-up. 89% of the patients felt that they were back to their pre injury status and 95% back to their previous employment. [18]

Vallier et al(2008) studied outcome of plating versus intramedullary nailing as radiographic and clinical comparisons of tibial shaft fractures (4-11cms proximal to plafond). In 111 patients with 113 extra-articular distal tibia fractures and concluded that delayed union, malunion, non union, angular malalignment osteomyelitis, painful hardware and secondary procedures were more frequent after nailing. [19]

Chen et al(2008) studied 13 patients with tibial fractures treated with indirect reduction and MIPPO. All fractures were closed and according to the AO classification 4 cases were type A, 7 type B and 2 Type C. The time between fractures and operation was from 5 hours to 5 days (2.5 days on average). All patients were followed up for 10-18 months (13 months on average). All fractures reached clinical healing and the healing time was 12-20 weeks (16 weeks on average). There was no delayed fracture healing, non union, infection and internal fixation failure. No complications such as rotational malalignment and loosening of hardware were observed. According to AOFAS ankle hindfoot scoring, the function of the ankle joint was graded 80-95 (92.4 on average). [20]

The MIPPO technique for distal tibia has shown good results. Early mobilization without risk of secondary displacement helps to prevent stiffness and contracture.[21]

Minimally invasive plating technique reduces iatrogenic soft tissue injury and damage to bone vascularity, in addition to preserving the osteogenic fracture haematoma.[22]

MIPPO with LCP was observed to be a reliable method of stabilisation for distal tibia fractures. There were less complications related to soft tissues, bone healing and functional outcome with this technique.[23]

Locking plates (LPs) have the biomechanical properties of internal and external fixators, with superior holding power because of fixed angular stability through the head of locking screws .[24]

Maffulli et al(2009) assessed the bone union rate, deformity, leg-length discrepancy, ankle range of motion, return to pre injury activities, infection and complication rate in 21 selected patients who underwent MIPPO for closed distal tibia fractures. According to the AO classification, there were 12 Type A, 5 Type B AND 4 Type C fractures. The minimum follow up was 2 years (average 2.8 years range 2-4 years). 2 patients were lost to follow up. Union was achieved in all but 1 patient by the 24th post operative week. 4 patients had angular deformity less than 7 degrees. No patient had a leg-length discrepancy more than 1.1cm. They judged that the locking plates as reasonable device for treating distal tibia fractures. [25]

Gupta et al(2009) studied locking plate fixation in distal metaphyseal tibial fractures in a series of 79 patients. The 4.5 mm limited contact locking compression plate (LC-LCL) was used in 33 fractures, the metaphyseal LCP in 27 fractures and distal medial tibial LCP in remaining 20 fractures. There were 2 cases of delayed wound breakdown in fractures fixed with the 4.5 mm LC-LCP. 5 pts required primary bone grafting and 3 pts required secondary bone grafting. All cases of delayed union and non union were observed in cases where plates were used in bridge mode. MIPPO with LCP was observed to be a reliable method of stabilization for these fractures. [26]

Leung et al(2009) recruited 62 subjects from august 2002 to august 2007 at mean age of 44 yrs old (range 21-87 yrs old). According to AO classification, there were 8 cases of Type A1, 15 cases of Type A2, 9 cases of Type A3, 7 cases of Type B3, 11 cases of Type C1 and 12 cases of Type C2. Of them 52 pts had closed fractures and 10 had open fractures. 10 open fractures included 6

Grade 1 fracture and 4 Grade 2 fracture. The x-ray films were taken after 3 months of operation. Near anatomical reduction was achieved in 56 fractures and acceptable reduction in 6 fractures. According to Teeny and Wiss ankle scoring system, 30 patients got excellent results, 25 good and 7 fair. The excellent and good rate was 88.7% at 12 month follow up.[27]

Mario R et al(2010) treated 21 patients with MIPPO. Union was achieved in all pts except for 1 by the 24th post-op week. 2 patients were lost to follow up.[28]

Mohamed S et al(2010) treated 27 patients. Mean time to union was 4 months. All patients were fully weight bearing at 8 weeks. It was concluded that MIPPO technique is an effective method of treatment of distal tibia fractures. It is technically demanding but reduces surgical trauma to soft tissues.[29]

Feng Chen Kao et al(2010) treated 28 patients with conventional plate, and the locking compression plate (LCP) group included 24 pts. Clinical outcomes, radiographic outcomes, and medical costs were compared between the two fixation groups. Complete union was achieved in all patients. Good or excellent outcomes were achieved in 86% of the conventional plate cases and 79% of the LCP cases (p ¼ 0.716). The infection rate was 18% in the conventional plate group and 8% in the LCP group (p¼ 0.430). The malalignment rates in the sagittal plane of the tibia were 7.1% and 8.3% in the conventional plate and LCP groups, respectively. [30]

Shrestha D et al(2011) treated 20 patients with closed distal diametaphyseal tibia fracture with or without intra articular extension (AO classification: 12 type 43A1, 4 type 43A2, 2 type 43A3 and 2 type 43B1) using MIPPO with LCP and were prospectively followed for average duration of 18.45 months (range 5-30 months). All fractures got united with an average duration of 18.5 weeks (range14-28weeks) except 1 case of delayed union which was managed with percutaneous bone marrow injection. Two patients had union with valgus angulation < 5 degees but no nonunion was found. There were two superficial and one deep post operative wound infection. All infections healed with extended period of intravenous antibiotics besides repeated debridement for deep infection. Implants were removed in eight patients among whom six (30%) had malleolar skin irritation and pain due to prominent hardware. It was concluded that MIPPO with LCP is an effective treatment method in terms of union time and complications rate for distal diametaphyseal tibia fracture. Malleolar skin irritation is common problem because of prominent hardware. [31]

Aksekili et al(2012) operated 35 patients (23 males and 12 females) for distal tibia fractures with MIPPO using LCP. 28 were closed and seven were open fractures. Clinical and radiological evaluations were made at four to six week intervals after surgery. Full weight-bearing was allowed after an average of 14.43 (range: 12 to 20) weeks and 15.39 (range: 8 to 32) weeks in open and closed fractures, respectively. The mean duration of the union was 20.7 (range: 16 to 28) weeks and 17.96 (range: 10 to 36) weeks in open and closed fractures, respectively. All cases showed union except one who had an implant failure. Necrosis at the wound developed in one case and infection in another. It was concluded that MIPPO is an effective alternative treatment for tibial diaphyseal and distal tibia fractures with low complication and high union rate. [32]

HISTORICAL SURVEY

Metallic devises have been used to repair and replace parts of human body for centuries, prior to the introduction of antiseptic surgical techniques about 100 years ago. However their success was very limited owing to complications with post surgical infections. As the incidence of infection was brought under control, the relationship between material properties and success of implant surgeries became clearly apparent. Tissue compatibility, corrosion, resistance and strength were the critical characteristics found to be necessary. Noble metals Gold, Silver met the first two criterion but lacked strength for applications with high stress. Metals such as brass, copper, steel had adequate strength for many applications but exhibited poor corrosion resistance and tissue compatibility. Most of the pure metals tested-in in vivo experiments were not found suitable to manufacture bio-implants.

During 1930's stainless, steel containing 18% chromium and 8% Nickel (304L) were first used for surgical implants. They had good strength and corrosion resistance and were well tolerated biologically. Subsequent addition of molybdenum further improved corrosion resistance and formed the basis for 316 L stainless steel alloy in common use today. Also in 1930's a Coblat-Chromium-molybdinum casting alloy previously used for dental application began to be used for surgical implants.

Titanium became commercially available in 1950, it was very soon evaluated as surgical implant material.

Today these three alloys

1) Stainless Steel (316 L)
2) Chromium Cobalt Alloy
3) Titanium Alloys

are the ones most widely used for manufacturing orthopaedic implants and prosthesis. Each of these calls for special processing and fabrication techniques.

BONE PLATES

Bone Plates are internal splints holding together fracture ends of the bone. Bone plates are available in all sizes, thickness and shapes. Early in the 20th century surgeons such as Lane and Lambote applied plates to fix two bone fragments in an approximate alignment. Mechanical failures are frequent owing to metal reaction and inadequate design of screws and plates 1949 Danis of Belgium was the first surgeon to report the inter fragmentary compression by applying plates under tension in the longitudinal axis of the bone. The concept was further explored and perfected by Muller.P. and AO group.

A bone plate has two mechanical functions. It transmits forces from one end of the bone to the other, bypassing and thus protecting area of fracture. It also holds the fracture ends together while with the proper alignment of fragments through out the healing process.

Classification

According to their function they are classified into 4 groups:

1. Neutralisation plate
2. Compression plate
3. Buttress plates
4. Condylar plates

Neutralisation Plate

It acts as a bridge. It transmits various forces from one end of the bone to other bypassing the area of fracture. It acts as a mechanical line between the healthy segments of bone above and below the fracture site. The plate used in combination with a lag screw is also neutralisation plate countering the torsional, bending and shearing forces that tend to disrupt the screw. The key screw contributes inter-fragmentary compression and stability. Neutralisation plate is a protection plate in its function. This plate does not produce any compression at the fracture site. They are commonly used

In conjunction with interfragmentary lagscrew in short oblique fractures. In fractures with butterfly (or) wedge type fragments after interfragmentary fixation of wedge portion.

Compression Plate

A compression plate produces a locking force across a fracture site to which it is applied. The effect occurs according to Newton's third Law (action and reaction are equal and opposite). The plate is attached to a bone fragment. It is then pulled across the fracture site by a device, producing tension in the plate. As a reaction to this tension, compression is produced at the fracture site across which the plate is fixed with the screws. The direction of the compression force is parallel to the plate.

Role of compression

What does a compression plate achieve? Any one or all of the following effects may results:

a. Compaction of the fracture to force together the interdigitating spicules of bone and increase the stability of the construct.

b. Reduction of the space between the bone fragments to decrease the gap to be bridged by the new bone.

c. Protection of the blood supply through enhanced fracture stability.

d. Friction, which at the fracture surfaces resists the tendency of the fragments to slide under torsion or shear. This is advantageous, as plates are not particularly effective in resisting torsion.

Furthermore a compression plate can also achieve superior fracture immobilisation to that obtained with a neutralisation plate alone because it generates axial interfragmentary compression.

Static and dynamic compression

Compression may be static or dynamic. A plate applied under tension produces static compression at a fracture, site; this compression constantly exists when the limb is at rest or is functioning. Dynamic compression is a phenomenon by which a plate can transfer or modify functional physiological forces into compressive forces at the fracture site. Figure 4.2 shows a compression plate on the lateral side of the shaft of the femur exerting static compression both when the limb is at rest and when it is functioning. When functional activity begins, the physiological forces, which are normally destabilising for a fracture, are converted to a stabilising and active force by the same plate, which now acts as a tension band. A dynamic compression is thus exerted at the fracture site. With cessation of physiological activity, this dynamic compression force will cease but the static compression force will continue to act.

Methods of achieving compression:

Compression may be produced by one of three techniques:

1. Self-compressing Plate

This is a device that converts torque (turning force) applied to the screw head to a longitudinal force, which compresses the fractured bone ends. The screws and plates are designed to facilitate this conversion.

As the screw advances in a self-compressing plate it slides down on an inclined plane that is part of the plate's screw hole (fig. 4.3). The effect is to create a tension force in the plate and compression force in the plate and compression force across the fracture fragments. One or both ends of a screw hole may be sloped, thus making it possible for compression to be produced in either direction.

2. Tensioning device

A special tensioning device can be attached between the bone plate and the adjacent bone cortex. A bolt is then tightened to pull the plate across the fracture site. This produces tension in the plate and large compressive forces across the fracture. The attachment of the device to the bone necessitates a larger surgical exposure.

In certain situations, for example in a smaller bone a Verbrugge forceps may be used as a tensioning device. One jaw of the forceps is fixed in the terminal hole of the plate and the other jaw abuts against the specially inserted screw. Closing the jaws produces tension in the plate and compression across the fracture site.

3. Eccentric screw placement

Eccentric placement of a screw in a plate hole creates considerable shear stress in the screw. The same force is transmitted to the plate and can be used to produce interfragmentary compression. To achieve this, a screw is eccentrically placed in the hold of a plate. The technique of eccentric screw placement, however, is mechanically inefficient. The screw head is at risk and may break. Eccentric screw placement can be used to simulate a self-compressing plate, but the technique has definite limitations and should not be used as a planned procedure.

Buttress Plate

The mechanical function of this plate, as the name suggests, is to strengthen (buttress) a weakened area of cortex. The plate prevents the bone from collapsing during the healing process. It is usually designed with a large surface area to facilitate wider distribution of the load.

A cancellous lag screw has conventionally been used to produce compression forces across the cancellous surfaces of fractures passing through the wide metaphyseal-epiphyseal ends of the long bones. This fixation, however, is insufficient to resist the axial loading forces that are applied to joint surfaces during weight bearing period other muscular activities. To prevent shearing at the fracture site, or displacement of the fracture fragments bringing about widening of the articulator surface, it is necessary to apply a plate that extends from the diaphysis across the outer surface of the metaphyseal-epiphyseal fragment. Such a plate acts as a buttress plate, applies a force to the bone which is perpendicular (normal) to the flat surface of the plate.

A buttress plate must be firmly anchored to the main fragment. It must fit the underlying bone cortex snugly, or the deformity could recur. A buttress plate should first be contoured accurately to the segment of bone. The fixation to the bone should begin in the middle of the plate, i.e. closest to the fracture site on the shaft. The screws should then be applied in an orderly fashion, one after the other, towards both ends of the plate.

A buttress plate is used to maintain the bone length or to support the depressed fracture fragments. It is commonly used in fixing epiphyseal and metaphyseal fractures. A representative clinical example of a buttress plate is the T-plate used for the fixation of fractures of the distal radius and the tibial plateau (Fig. 4.6). A buttress plate is also used to fix fractures of the tibial pilon and the distal humerus.

A special application of the buttress plate is termed 'anti-glide plating'. In this mode a one -third tubular plate is so applied as to prevent the displacement of the tip of an oblique fracture.

Condylar Plate

The condylar plate differs from the plates described above because of its distinct mechanical function. Its main application has been in the treatment of intra-articulator distal femoral fractures. It has two mechanical functions. It maintains the reduction of the major intra-articular fragments, hence restoring the anatomy of the joint surface. It also rigidly fixes the metaphyseal components to the diaphyseal shaft, permitting early movement of the extremity. This plate functions both as a neutralisation plate and as a buttress plate. Since the plate can be attached to a tensioning device and has specially designed screw holes, it also functions as a compression plate.

A Condylar plate is used to fix a proximal femoral osteotomy and intercondylar fracture of the femur. Special instrumentation is required for the application of a condylar plate. Its use is diminishing with the advent of the 'condylar screw' which is relatively easy to apply.

General principles of plate fixation

Successful use of a bone plate depends on the properties of the plate, the screws, the bone and on the correct application bio mechanical principles.

The strength of a plate depends on its cross section; thickness is the most important contributing factor. The strength varies with the cube of the thickness. The plate should be made from a material of adequate strength and its stiffness should be close to that of the bone. The stiffness of titanium is closer to that of bone, whereas stainless steel is stiffer than titanium. Very stiff plates can weaken the bone after fracture healing is complete. The contact surface of the plate is also a significant factor. The surface of the conventional plate causes reduction of blood supply under the plate, leading to immediate post-fixation osteoporosis. The new design of contact surface minimises this effect. The length of the plate is another important factor. Too short a plate may make a construct unstable, while application of a very long plate may cause unnecessary damage to the soft tissues.

Screw related factors

The screws fasten a plate to the bone. The effectiveness of a screw greatly depends on the design of its threads and its head. Well-designed threads are easy to insert and hold well in all circumstances. A well-designed slot for the placement of a screwdriver ensures ease of screw insertion. An adequate number of screws are essential to hold the plate. A minimum of two in each fragment is necessary to prevent rotation. The total number of screws needed for a fixation depends on the site and type of fracture. The ratio of the pilot hole to depth of the screw thread is crucial; the holding power of the screw depends on this ratio. Strength of the plate fixation depends in turn on the holding power of the screws. The screws should be made of strong material, which can withstand heavy loads. Screws and plate should be of the same material to minimise corrosion.

The success of bone plate fixation depends on :

- Plate thickness, dimensions, geometry, material used
- Screw design, material, number and hold in the bone
- Bone - mechanical properties and the health of the bone
- Construct - placement of plate and direction of load

- Compression between the fragments.

Bone related factors

The health of the bone is a factor, which is usually overlooked while fixing a fracture. A young bone is dense in consistency and a screw is dependent on the elastic force provided by the bone, it is obvious that the denser the bone, the stronger the hold. In the elderly, the bone is porotic, being less dense than young bone. The holding elasticity of porotic bone is of a lower magnitude and leads to inferior screw hold. Thus, the health and mechanical properties of the bone are of importance in this context.

The interaction of the bone and the plate is important, since the two are combined in a composite structure that becomes a crucial entity in the strength of a fixation. The strength of a plate-bone construct is its ability to withstand load without structural failure. This entity can be described as a bending strength or a torsion strength, depending on the load application. A bone plate is a load-sharing device. Loads can be transmitted between plate and bone through the bone screws and through friction-type forces between the plate surface and the bone, some of the load is supported by the plate and some load passes between the bone fragments. The reconstructed bone must support a certain load.

Construct related factors

A plate may be applied to a bone in various positions. The strength of the construct will depend will depend on the direction of the load and the position of the plate. The plate is applied on the side of the bone which is under compression during bending. The bending forces are acting in the direction of the plate. The effect of loading is to open up the fracture; this situation is also referred to as the 'bending open' configuration. This is an example of a weak construct.

The plate is applied on the side of the bone which would come under tension during bending. The bending forces are active in the opposite direction of the plate. The fracture surfaces are closely opposed. This is a strong construct, and represents a 'bending close' configuration.

In an another variation, the plate may be applied at right angles to that in the above situation then construct is weaker but is still stronger than applying on compression side.

The plate-bone construct becomes strongest when two plates are applied at right angles to each other.

Effect of compression will increase rigidity in all these cases by ensuring closer contact and increase in friction between the bone ends. An attempt should also be made to apply a plate on the tension side of the bone and makes compression to achieving good bone apposition.

The strength of the reconstructed bone depends on :

1. Strength of the plate and screw - design, dimension and material and purchase.

2. Configuration of the fracture - comminution and placement of plate

3. Properties of the plate-bone construct - working length and load sharing.

In a bone-plate construct, each component plays its part. A broken bone needs to be held together if it has to support the load of the limb. The plate holds the ends together, but on its own cannot support the load of the limb indefinitely. If it does so, it may break due to repeated overloading. The plate will endure only if the bone shares some of the load of physiological activity. Thus, a plate is a load-sharing device and not a load-bearing device.

Despite the strength and rigidity of a plate-bone construct, problems remain, and some may crop up. Whenever a gap exists between the bone ends a plate will first bend under the load until the bone fragments make contact. The load would be shared by the plate and the bone once the contact is made, but until that time it is the plate that bears all the load.

When a plate is not rightly set against the bone by the screws the screws are subjected to bending forces.

The presence of a butterfly fragment or a more extensive comminution in the bone provides the worst instance. The bone does not support any load. The entire load falls on the plate, resulting in high bending forces on the metal. The plate or the screws may break: this eventuality can be salvaged by achieving a near perfect reduction of the butterfly fragment to create a unified plate-bone unit. Such a unit will then share the load. Another way to reduce the forces in a plate is to provide an additional external support.

In fixation of spiral fractures, bending and rotational forces should be considered. These fractures occur as a result of torsional forces; the fracture line follows a helical path. a plate placed at right angles to the fracture line counteracts the rotational forces effectively but fails to resist the bending forces.

When a plate is placed along the shaft, i.e. parallel to the bone, it efficiently resists bending but not the torsional force. In practice, the torsional strength of a plate depends on the holding power of the screws as well as on the frictional forces acting between the bone ends; compression increases the friction.

A spiral fracture can be stabilised by two methods, (fig. 4.18). the first necessitates the use of a long plate to hold the bone beyond the fracture line. The second method utilises a lag screw to achieve interfrgmentary compression and a plate to protect this fixation from the disruptive forces. This method is more effective and is therefore preferred.

Prebending of plate

When a straight bone plate is applied to a straight bone surface under static compression, the near cortex is brought under compression but the far cortex opens up. This gap may result in micro movements with subsequent bone resorption and loss of fixation. If a plate is bent sharply opposite the fracture site before application, it firsts brings the far cortex under compression and then the near cortex. The prebent plate results in more uniform compressive contact across the fracture site without gaping than is achievable with a straight plate.

When fixing a prebent plate to the bone, the innermost screws should be applied first, followed by the outer screws. If the outer screws are applied first, the near-cortex opens up because the plate is then too long in relation to the bone spanned between the outer screw holes.

Prebending can be used only when dealing with a simple, two-fragment fracture. In a comminuted fracture, prebending will often jeopardise the reduction.

When fixing a straight plate to a curved surface, the outer screws should be applied first. This limits the length of the bone. Tightening of the screws from outside towards the fracture bends the plate, shortens the distance between the outer screws and thereby compresses the fracture.

Plate bending

Plate bending and twisting is a skill that is often required. Special instrument such as a bending pres, bending pliers, and bending irons are needed to contour the plate to the curves of a bone. Malleable aluminum templates are useful aids. These are easy to mould to copy the bone curves and serve as a model for plate bending and checking the outcome.

Bending is more accurate and effective if the plate is held by an assistant while the surgeon bends the plate. A plate should be bent between the screw holes. Bending in small increments avoids over bending. Reverse bending of a plate substantially weakens it and is not recommended. Kinking of the plate is to be avoided.

Minimising stress concentration at the plate-bone junction

Stainless steel is twelve times as stiff as cortical bone. The rigidity of a plate-bone construct is greater than the bone alone. The rigidity suddenly changes in the zone around the end of the plate and stresses become concentrated. This sudden change of forces can cause a fracture of the bone just below or near the plate (stress shielding).

To reduce the change of such a happening, the last screw should engage only one cortex. The stiffness of the plate-bone complex is lower when the end screw grips only one cortex as compared to the situation when the grip is on both the cortices. There is a gradual change in the rigidity of the bone when the mechanical characteristics are altered less abruptly. The practice of the terminal screws engaging a single cortex should be judiciously followed in the lower extremity, so that the stress relief provided by the plate to the adjacent bone segment is gradually terminated.

How many screws?

A plate must be sufficiently long and strong, and should be fixed with an adequate number of screws to provide rigid fixation for successful treatment of a fracture. This number depends on the individual bone, the type of plating bone quality, fracture comminution, length of the plate, and the anticipated forces exerting on the fixation. Hands on experience suggests that in Tibia screws must grip six cortices on each side of fracture.

A non-comminuted acute fracture plated in compression with lag screw fixation requires fewer screws than a non-union with bone loss. Osteoporosis, depending on its severity, requires a corresponding increase in the number of screw. There is no needed to fill every hole of the plate with a screws. The failure of the plate does not depend on the presence or absence of the screw from a hole but rather on the presence and extent of a bony defect. The plate is more likely to fail when the bone defect is short, as this results in considerable stress concentration. In the presence of a longer defect, the stresses are distributed over a large segment and the stress per unit area is correspondingly low.

How close to the fracture site?

When there is comminution or obliquity of the fracture, a screw should not be inserted too close to the fracture line because it may split the pilot hole into the fracture and cause additional comminution. Sometimes such a split may cause complete loss of fixation. A screw, as a rule, should not be placed closer than one centimetre from the fracture line.

Plate removal

It is essential to remove the plate as soon as healing is complete; this particularly applies to patients with normal bones. Once the bone is fully healed, the plate has no further function. When the screws remain tight the plate supports a part of the load and the bone cortex tends to atrophy from disuse. It turns osteopenic and becomes weaker than the normal bone. The changes occur primarily directly beneath the plate. This is the so-called 'stress shielding' phenomenon. Re-fracture is therefore most likely in the bone immediately adjacent to the edge of a plate as a result of stress concentration and the osteopenic changes. Stress shielding is manifested by an increase in the diameter of the medullary cavity.

Another reason for plate removal is the possibility of corrosion, either directly or because of fretting between the plate and the underside of screw heads; such an effect is more likely when the implants are made of stainless steel.

It is difficult to tell if a fracture has healed when held under rigid compression. A plate should be removed after an arbitrary period based on clinical judgement and experience. The guidelines cited in table, for removal of plates are widely accepted. In the upper limb, a metallic implant can be left in place. Removal should be considered in the presence of inflammatory reactions or if the implants bother the patient mechanically. Plate removal from the humerus or the proximal radius may jeopardise the radial nerve and should only be undertaken if significant clinical symptoms or complications are present.

In the lower limb a plate must be removed; however, isolated screws may be left permanently.

Timing of plate removal, recommendations for removal of plates in the lower limb.

Bone/fracture	Time after implantation in months
Malleolar fractures	8-12
The tibial pilon	**12-18**
The tibial shaft	12-18
The tibial head	12-18
The femoral condyles	12-24
The femoral shaft:	
Single plate	24-36
Double plate	from month 18, in 2 steps (interval 6 months)
Pertrochanteric and	12-18

femoral neck fractures	
upper extremity	Optional
Shaft of radius/ulna	24-28
Distal radius	8-12
Metacarpals	4-6

Bone re-fracture following removal of a plate is a recognised possibility unless steps are taken to limit weight bearing for a reasonable time. Plate-induced osteopenia can predispose the bone to re-fracture after plate removal as remodelling of the cortices during healing leads to a bone of lower strength. Other discontinuities are also present because of removal of screws. Discontinuous structures under load give rise to concentrations of stress. The presence of drill holes weakens the bone; the weakening effect of the holes is much greater than would be expected. The resistance to torsional loading is reduced by 50%. The capacity of bone to absorb energy to prevent fracture is reduced to 25% of normal. The resistance to bending loads is similarly reduced. Once the screw holes are filled by radiolucent bone, they stop being a weak spot. In experimental animals, the screw holes fill up in about eight weeks.

Following plate removal, the bone should be protected from excessive stress until the post-healing cortical osteopenia gradually disappears as the bone takes the total load of the limb and remodelling of the bone occurs to normal dimensions. The screw holes fill up and the concentration effect is eliminated.

There is more need for protection of the patient at the time of plate removal than after plating because (a) the re-fracture strength of the bone is less than the initial plate bone strength, and (b) the injury is no longer acute and therefore the functional level must be tempered by planned treatment, rather than the patient's symptoms. It takes a long time before the bone recovers from the weakening effects of plate removal. The factors which affect recovery area:

- The age of the patient
- the location of the bone
- the nature of the associated injuries

Since muscle actions associated with physiotherapy or functional activities load the bones enhancing blood supply, the recovery phase may extend from three to four months. This recovery can be sufficient for an unprotected return to the activities of daily living.

Plate removal of a double – plated fracture should be staged over a time to reduce the risk of re-fracture. The removal should be done at two operations, 4-6 months apart, with cancellous bone grafting recommended at each operation.

The Tibia

Plating is absolutely indicated for the tibia shaft fractures associated with a displaced intra-articular fracture of the ankle. The tibial pillion fracture require accurate reduction and fixation. Indirect reduction techniques are used to plate these fractures.

Plating is employed to fix fractures of the tibial diaphysis. Narrow plates are used; heavy-duty broad are never used. Plates are usually applied on the subcutaneous surface of the tibia, mainly for the operator’s convenience. Plates may also be applied on the lateral surface. It is essential to engage six cortices on either side of the fracture.

TIBIA ANATOMY FOLLOWED BY ANKLE ANATOMY

The Tibia

(Shin Bone)

The tibia (Figs. 1, 2) is situated at the medial side of the leg, and, excepting the femur, is the longest bone of the skeleton. It is prismoid in form, expanded above, where it enters into the knee-joint, contracted in the lower third, and again enlarged but to a lesser extent below. In the male, its direction is vertical, and parallel with the bone of the opposite side; but in the female it has a slightly oblique direction downward and lateralward, to compensate for the greater obliquity of the femur. It has a body and two extremities.

The Body or Shaft (corpus tibiae).—The body has three borders and three surfaces.

Borders.—The anterior crest or border, the most prominent of the three, commences above at the tuberosity, and ends below at the anterior margin of the medial malleolus. It is sinuous and prominent in the upper two-thirds of its extent, but smooth and rounded below; it gives attachment to the deep fascia of the leg.

The medial border is smooth and rounded above and below, but more prominent in the center; it begins at the back part of the medial condyle, and ends at the posterior border of the medial malleolus; its upper part gives attachment to the tibial collateral ligament of the knee-joint to the extent of about 5 cm., and insertion to some fibers of the Popliteus; from its middle third some fibers of the Soleus and Flexor digitorum longus take origin.

The interosseous crest or lateral border is thin and prominent, especially its central part, and gives attachment to the interosseous membrane; it commences above in front of the fibular articular facet, and bifurcates below, to form the boundaries of a triangular rough surface, for the attachment of the interosseous ligament connecting the tibia and fibula.

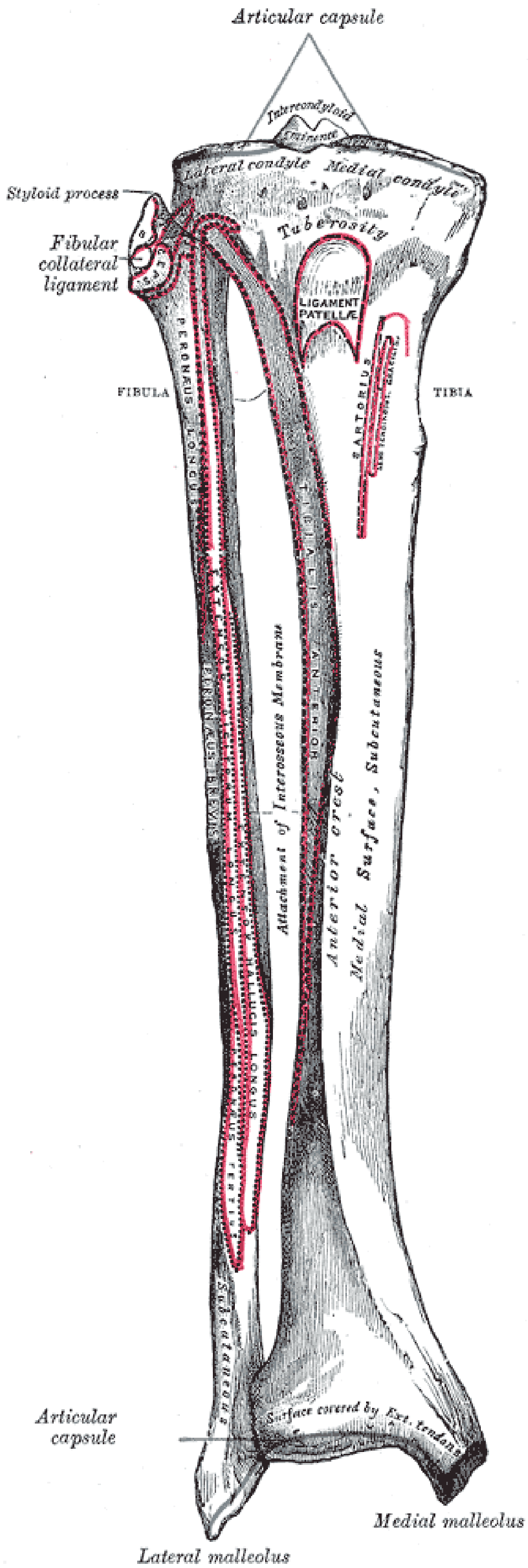


Fig. 1: Bones of the right leg. Anterior surface.

Surfaces.—The medial surface is smooth, convex, and broader above than below; its upper third, directed forward and medialward, is covered by the aponeurosis derived from the tendon of the Sartorius, and by the tendons of the Gracilis and Semitendinosus, all of which are inserted nearly as far forward as the anterior crest; in the rest of its extent it is subcutaneous.

The lateral surface is narrower than the medial; its upper two-thirds present a shallow groove for the origin of the Tibialis anterior; its lower third is smooth, convex, curves gradually forward to the anterior aspect of the bone, and is covered by the tendons of the Tibialis anterior, Extensor hallucis longus, and Extensor digitorum longus, arranged in this order from the medial side.

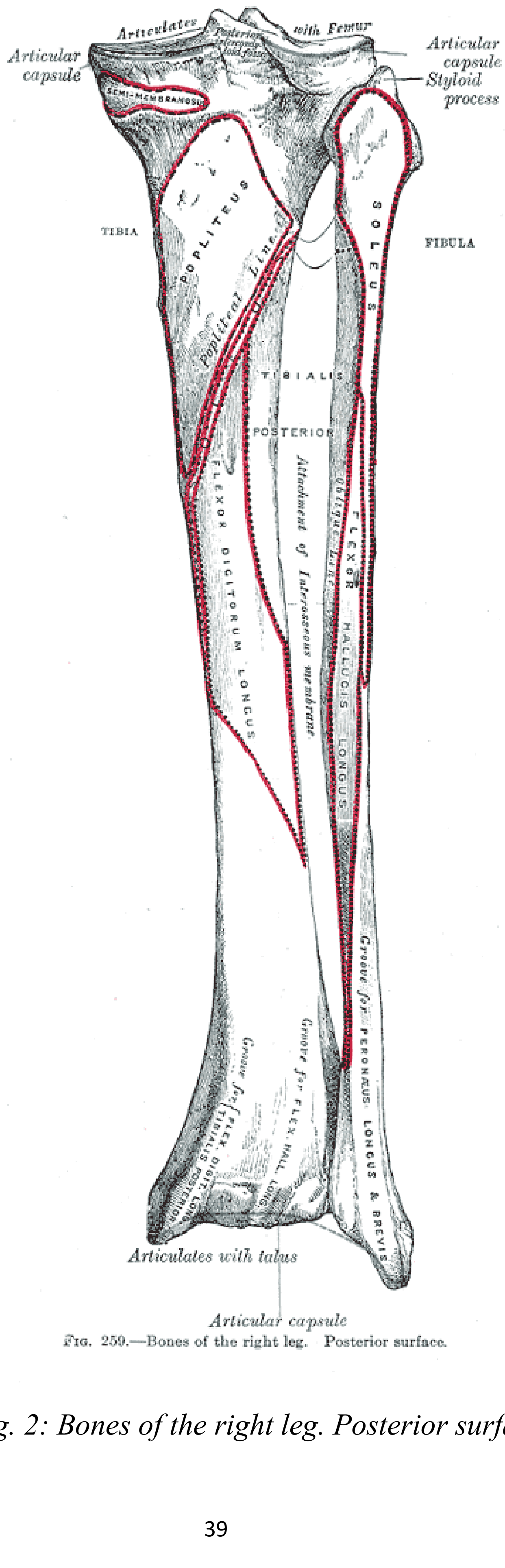


FIG. 259.—Bones of the right leg. Posterior surface.

Fig. 2: Bones of the right leg. Posterior surface.

The posterior surface (Fig. 2) presents, at its upper part, a prominent ridge, the popliteal line, which extends obliquely downward from the back part of the articular facet for the fibula to the medial border, at the junction of its upper and middle thirds; it marks the lower limit of the insertion of the Popliteus, serves for the attachment of the fascia covering this muscle, and gives origin to part of the Soleus, Flexor digitorum longus, and Tibialis posterior. The triangular area, above this line, gives insertion to the Popliteus. The middle third of the posterior surface is divided by a vertical ridge into two parts; the ridge begins at the popliteal line and is well-marked above, but indistinct below; the medial and broader portion gives origin to the Flexor digitorum longus, the lateral and narrower to part of the Tibialis posterior. The remaining part of the posterior surface is smooth and covered by the Tibialis posterior, Flexor digitorum longus, and Flexor hallucis longus. Immediately below the popliteal line is the nutrient foramen, which is large and directed obliquely downward.

The Lower Extremity (distal extremity).—The lower extremity, much smaller than the upper, presents five surfaces; it is prolonged downward on its medial side as a strong process, the medial malleolus.

Surfaces.—The inferior articular surface is quadrilateral, and smooth for articulation with the talus. It is concave from before backward, broader in front than behind, and traversed from before backward by a slight elevation, separating two depressions. It is continuous with that on the medial malleolus.

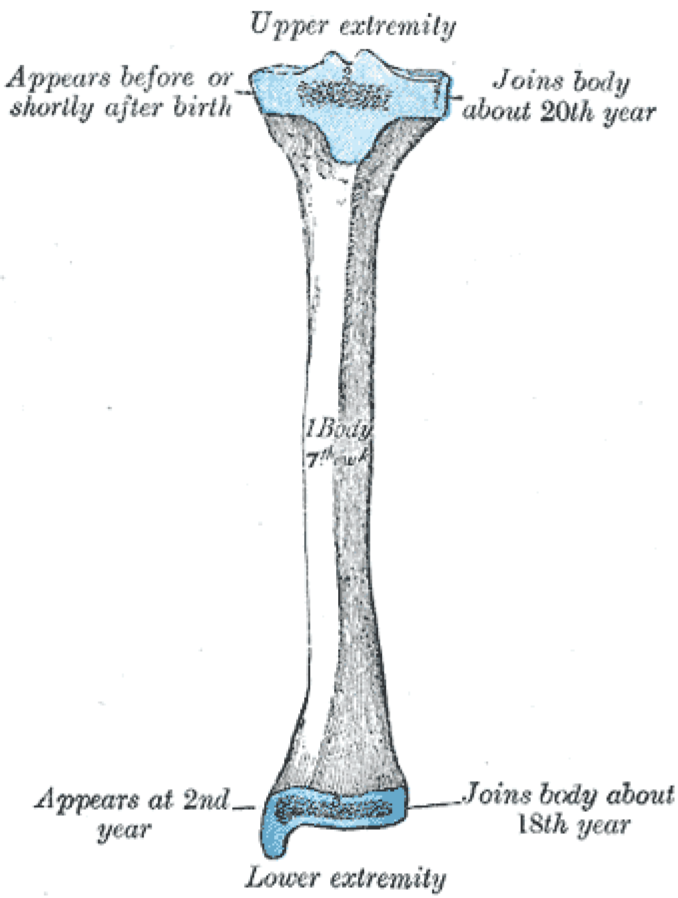


Fig. 3: Plan of ossification of the tibia. From three centers.

The anterior surface of the lower extremity is smooth and rounded above, and covered by the tendons of the Extensor muscles; its lower margin presents a rough transverse depression for the attachment of the articular capsule of the ankle-joint.

The posterior surface is traversed by a shallow groove directed obliquely downward and medialward, continuous with a similar groove on the posterior surface of the talus and serving for the passage of the tendon of the Flexor hallucis longus.

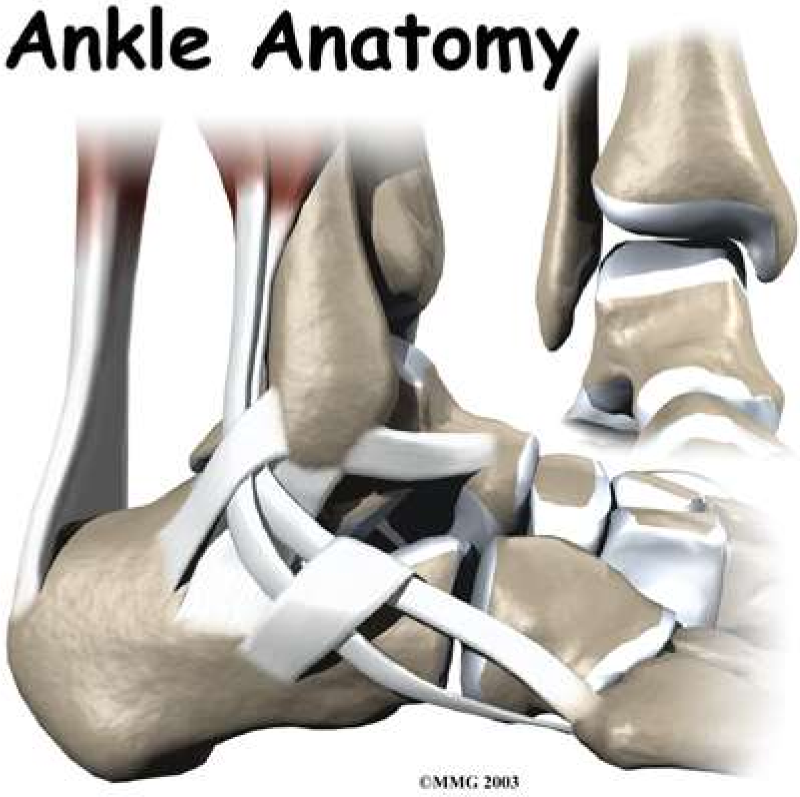
The lateral surface presents a triangular rough depression for the attachment of the inferior interosseous ligament connecting it with the fibula; the lower part of this depression is smooth, covered with cartilage in the fresh state, and articulates with the fibula. The surface is bounded by two prominent borders, continuous above with the interosseous crest; they afford attachment to the anterior and posterior ligaments of the lateral malleolus.

The medial surface is prolonged downward to form a strong pyramidal process, flattened from without inward—the medial malleolus. The medial surface of this process is convex and subcutaneous; its lateral or articular surface is smooth and slightly concave, and articulates with the talus; its anterior border is rough, for the attachment of the anterior fibers of the deltoid ligament of the ankle-joint; its posterior border presents a broad groove, the malleolar sulcus, directed obliquely downward and medialward, and occasionally double; this sulcus lodges the tendons of the Tibialis posterior and Flexor digitorum longus. The summit of the medial malleolus is marked by a rough depression behind, for the attachment of the deltoid ligament.

Structure.—The structure of the tibia is like that of the other long bones. The compact wall of the body is thickest at the junction of the middle and lower thirds of the bone.

Ossification.—The tibia is ossified from three centers (Figs. 3): one for the body and one for either extremity. Ossification begins in the center of the body, about the seventh week of fetal life, and gradually extends toward the extremities. The center for the upper epiphysis appears before or shortly after birth; it is flattened in form, and has a thin tongue-shaped process in front, which forms the tuberosity (Fig. 4); that for the lower epiphysis appears in the second year. The lower epiphysis joins the body at about the eighteenth, and the upper one joins about the twentieth year. Two additional centers occasionally exist, one for the tongue-shaped process of the upper epiphysis, which forms the tuberosity, and one for the medial malleolus.

Ankle Anatomy



The ankle joint acts like a hinge. But it's much more than a simple hinge joint. The ankle is actually made up of several important structures. The unique design of the ankle makes it a very stable joint. This joint has to be stable in order to withstand 1.5 times your body weight when you walk and up to eight times your body weight when you run.

Normal ankle function is needed to walk with a smooth and nearly effortless gait. The muscles, tendons, and ligaments that support the ankle joint work together to propel the body. Conditions that disturb the normal way the ankle works can make it difficult to do your activities without pain or problems.

This guide will help you understand

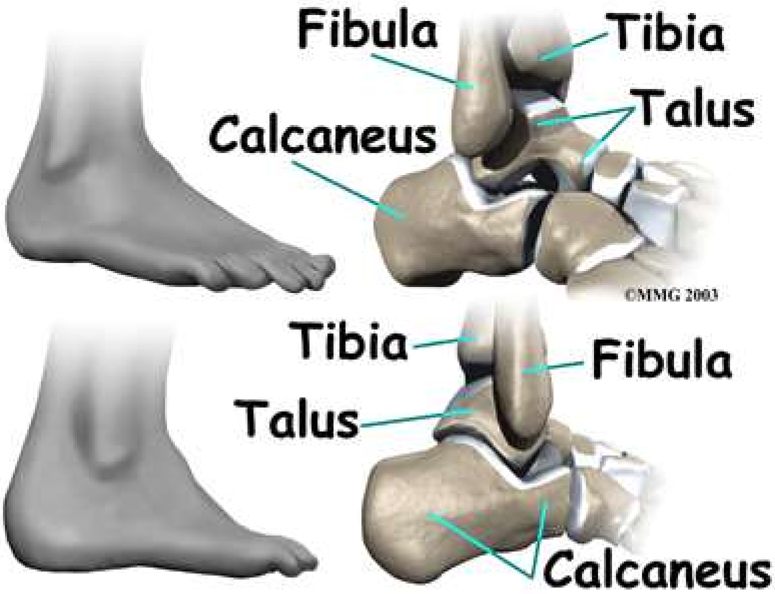
- what parts make up the ankle
- how the ankle works

Important Structures

The important structures of the ankle can be divided into several categories. These include

- bones and joints
- ligaments and tendons
- muscles
- nerves
- blood vessels

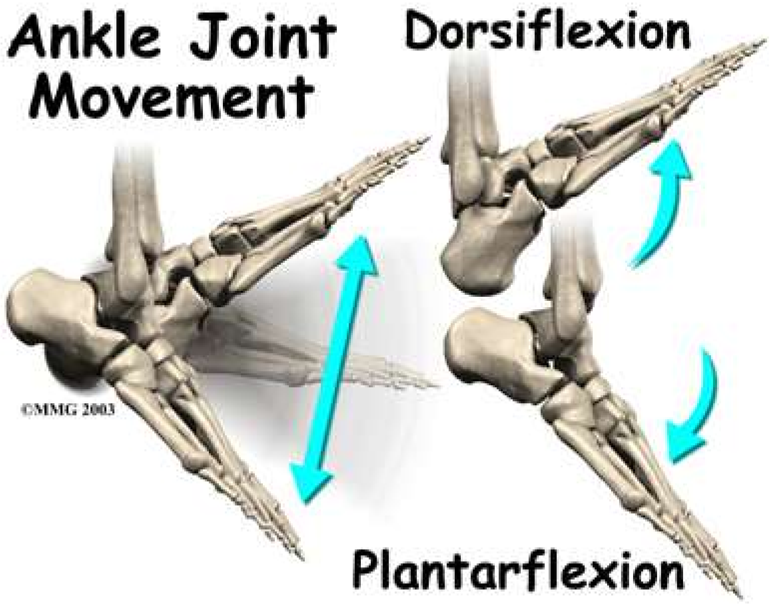
The top of the foot is referred to as the *dorsal* surface. The sole of the foot is the *plantar* surface.

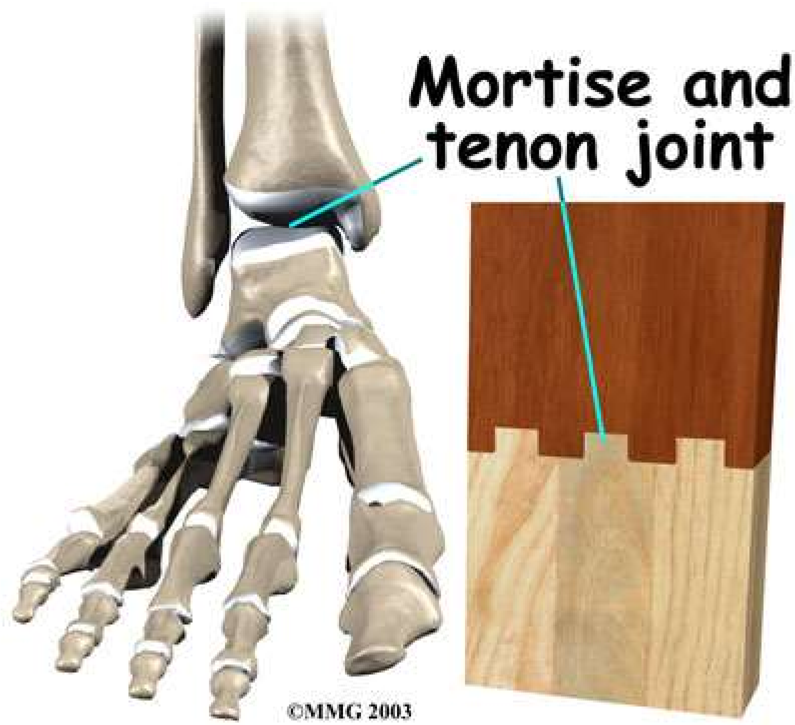


Bones and Joints

The ankle joint is formed by the connection of three bones. The ankle bone is called the *talus*. The top of the talus fits inside a socket that is formed by the lower end of the *tibia* (shinbone) and the *fibula* (the small bone of the lower leg). The bottom of the talus sits on the heelbone, called the *calcaneus*.

The talus works like a inside the socket to allow your foot to move up (*dorsiflexion*) and down (*plantarflexion*).



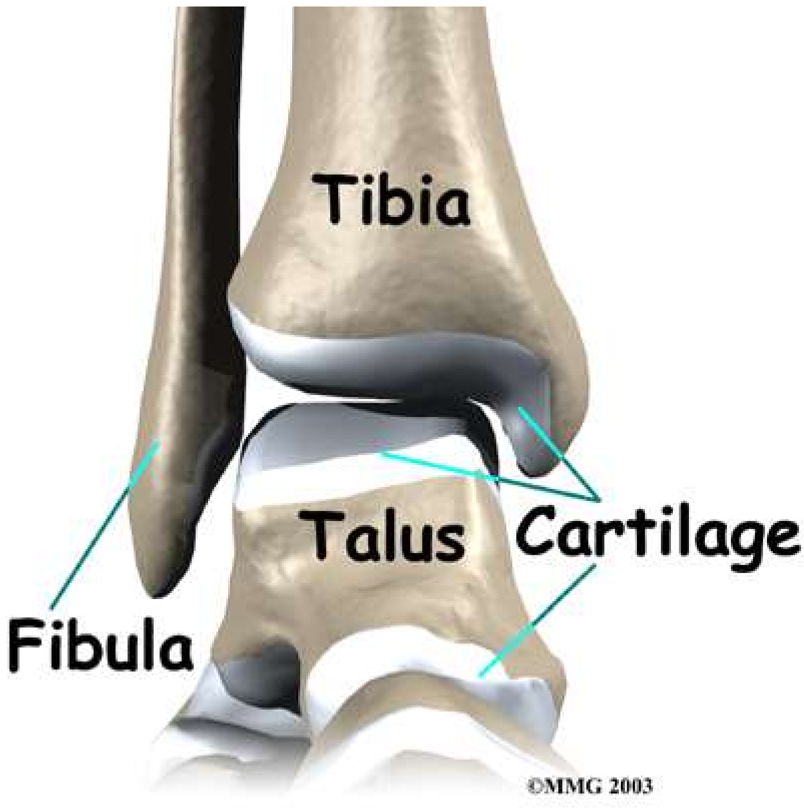


Woodworkers and craftsmen are familiar with the design of the ankle joint. They use a similar construction, called a *mortise and tenon*, to create stable structures. They routinely use it to make strong and sturdy items, such as furniture and buildings.

Inside the joint, the bones are covered with a slick material called *articular cartilage*. Articular cartilage is the material that allows the bones to move smoothly against one another in the joints of the body.

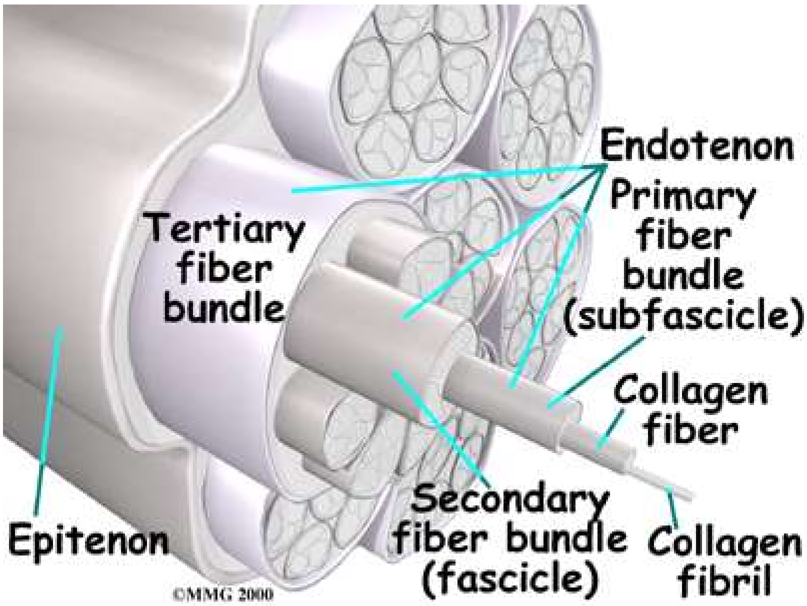
The cartilage lining is about one-quarter of an inch thick in most joints that carry body weight, such as the ankle, hip, or knee. It is soft enough to allow for shock absorption but tough enough to last a lifetime, as long as it is not injured.

Ligaments and Tendons

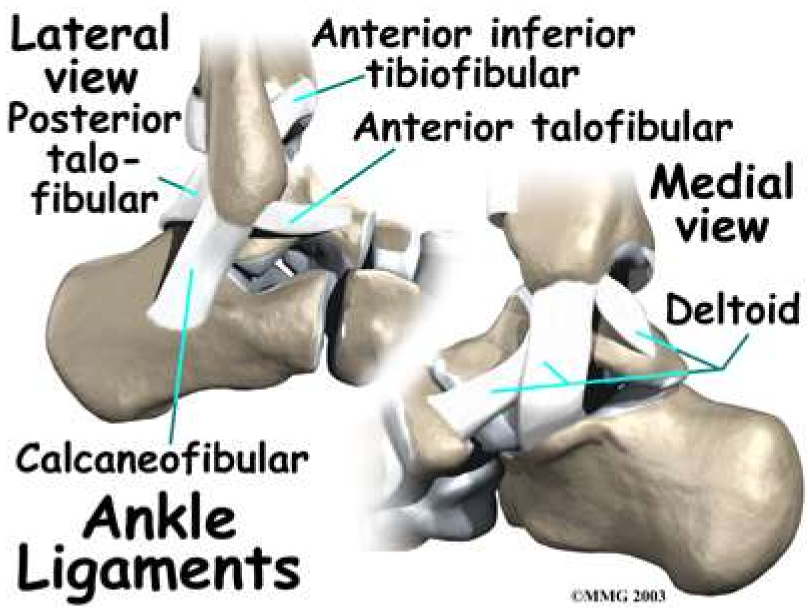


Ligaments are the soft tissues that attach bones to bones. Ligaments are very similar to *tendons*. The difference is that tendons attach muscles to bones.

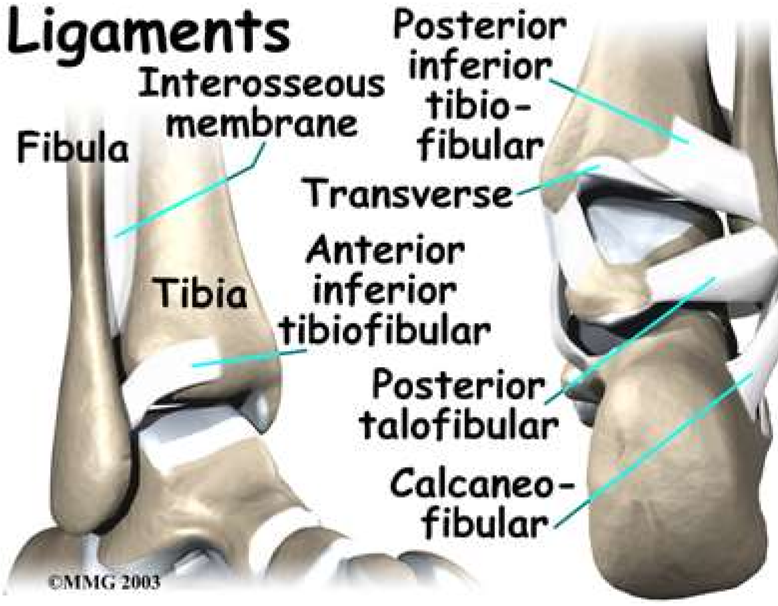
Both of these structures are made up of small fibers of a material called *collagen*. The collagen fibers are bundled together to form a rope-like structure. Ligaments and tendons come in many different sizes and like rope, are made up of many smaller fibers. Thickness of the ligament or tendon determines its strength.



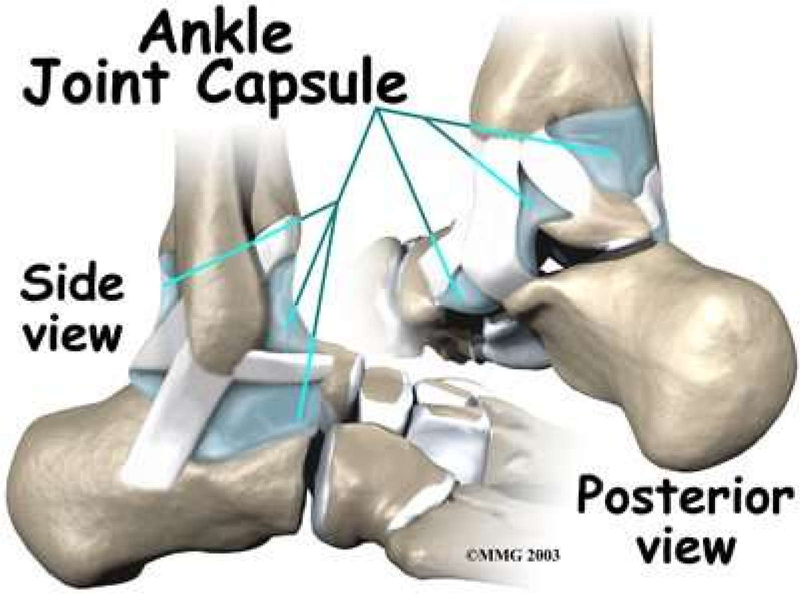
Ligaments on both sides of the ankle joint help hold the bones together. Three ligaments make up the *lateral ligament complex* on the side of the ankle farthest from the other ankle. (*Lateral* means further away from the center of the body.) These include the *anterior talofibular ligament* (ATFL), the *calcaneofibular ligament*(CFL), and the *posterior talofibular ligament* (PTFL). A thick ligament, called the *deltoid ligament*, supports the *medial* ankle (the side closest to your other ankle).



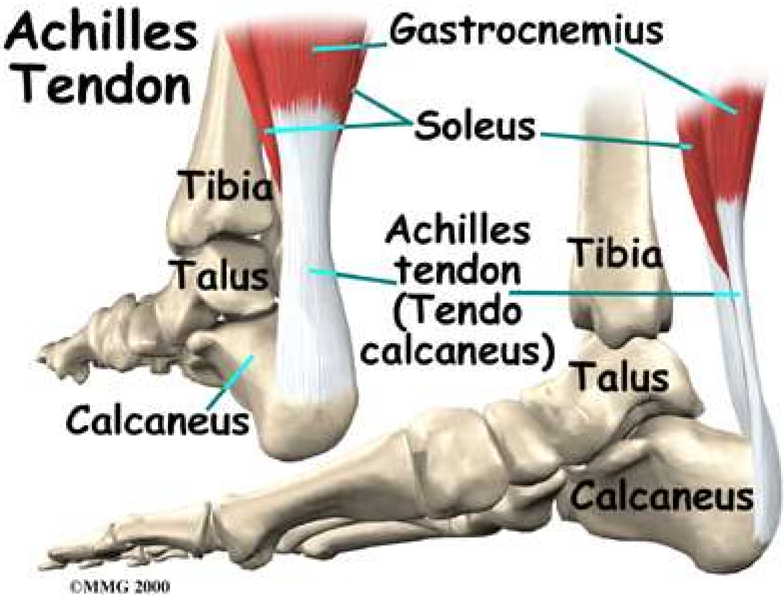
Ligaments also support the lower end of the leg where it forms a hinge for the ankle. This series of ligaments supports the ankle *syndesmosis*, the part of the ankle where the bottom end of the fibula meets the tibia. Three main ligaments support this area. The ligament crossing just above the front of the ankle and connecting the tibia to the fibula is called the *anterior inferior tibiofibular ligament* (AITFL). The *posterior fibular ligaments* attach across the back of the tibia and fibula. These ligaments include the *posterior inferior tibiofibular ligament* (PITFL) and the *transverse ligament*. The *interosseous ligament* lies between the tibia and fibula. (*Interosseous* means between bones.) The interosseus ligament is a long sheet of connective tissue that connects the entire length of the tibia and fibula, from the knee to the ankle.

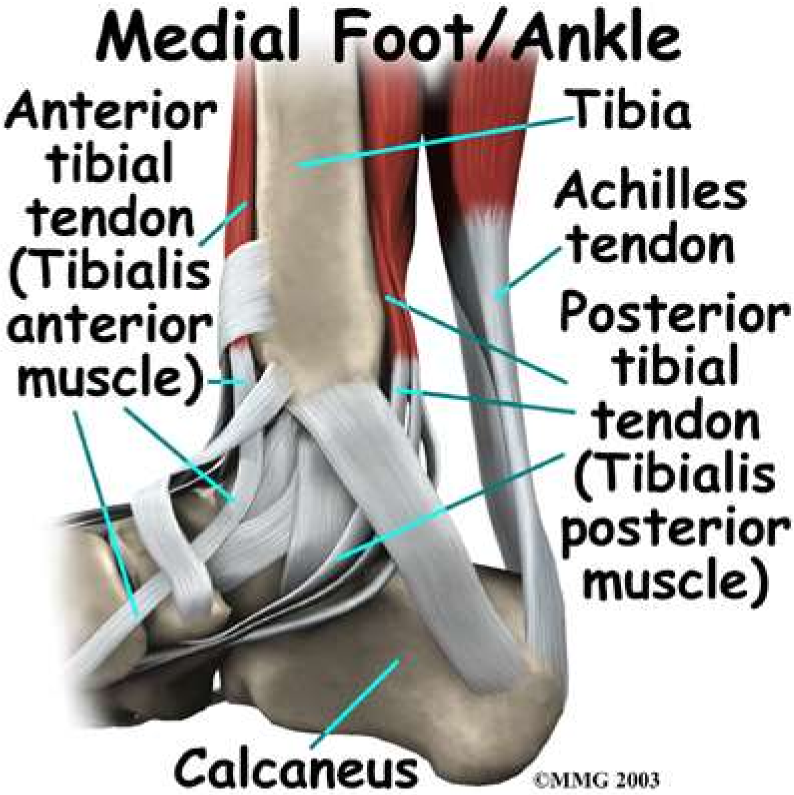


The ligaments that surround the ankle joint help form part of the *joint capsule*. A joint capsule is a watertight sac that forms around all joints. It is made up of the ligaments around the joint and the soft tissues between the ligaments that fill in the gaps and form the sac.



The ankle joint is also supported by nearby tendons. The large *Achilles tendon* is the most important tendon for walking, running, and jumping. It attaches the calf muscles to the calcaneus (heelbone) and allows us to raise up on our toes. The *posterior tibial tendon* attaches one of the smaller muscles of the calf to the underside of the foot. This tendon helps support the arch and allows us to turn the foot inward. The *anterior tibial tendon* allows us to raise the foot. Two tendons run behind the outer bump of the ankle (the *lateral malleolus*). These two tendons, called the *peroneals*, help turn the foot down and out.




Medial Foot/Ankle
Anterior tibial tendon (Tibialis anterior muscle)
Tibia
Achilles tendon
Posterior tibial tendon (Tibialis posterior muscle)
Calcaneus
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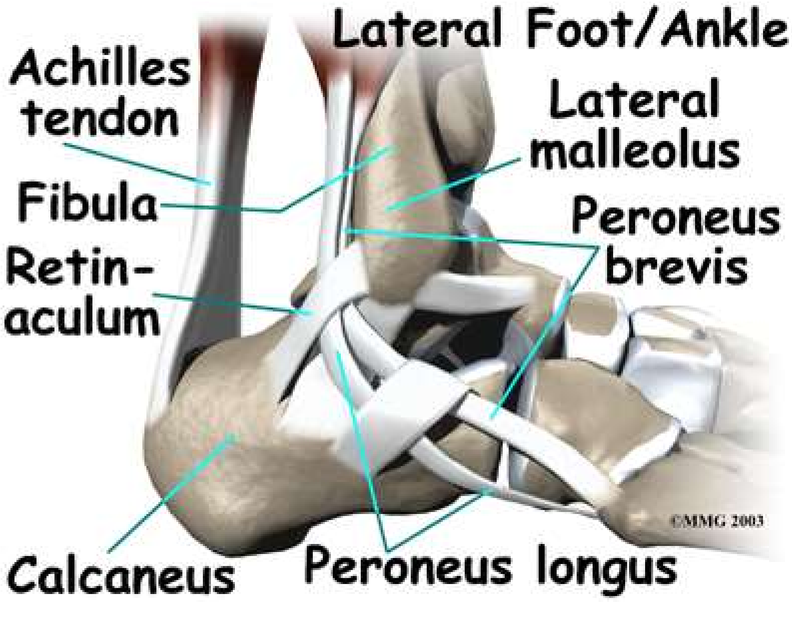
Lateral Foot/Ankle
Achilles tendon
Lateral malleolus
Fibula
Peroneus brevis
Retin-aculum
Calcaneus
Peroneus longus
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Muscles

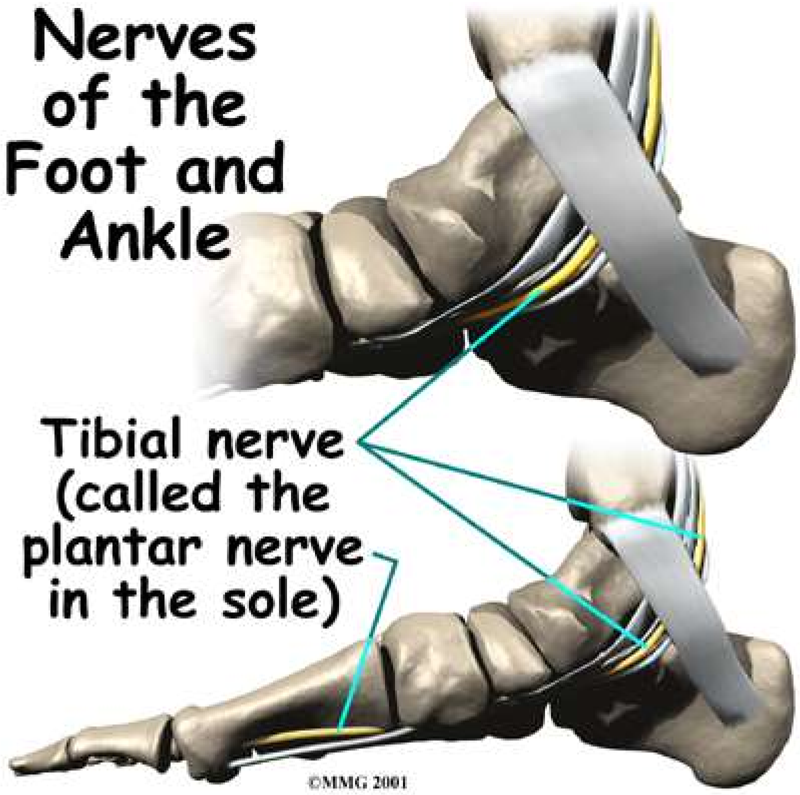
Most of the motion of the ankle is caused by the stronger muscles in the lower leg whose tendons pass by the ankle and connect in the foot. Contraction of the muscles in the leg is the main way that we move our ankle when we walk, run, and jump.

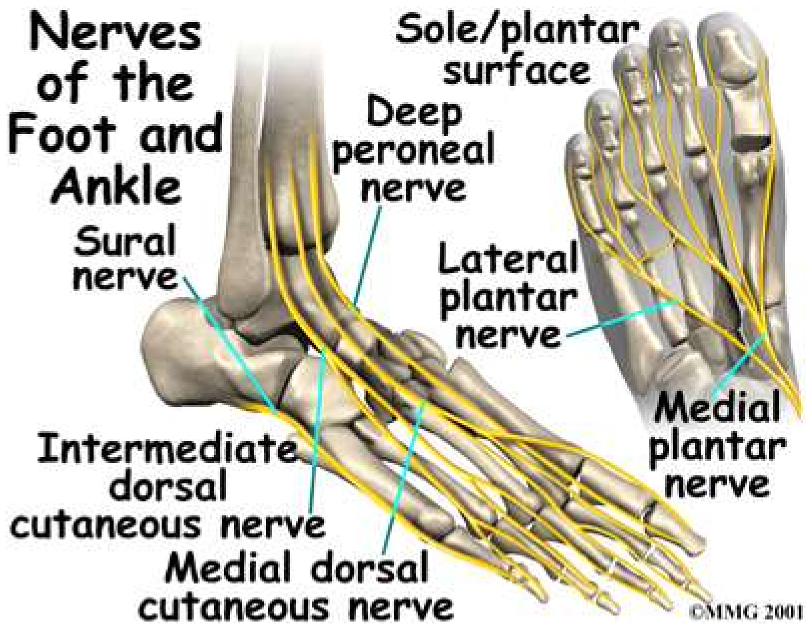
The key ankle muscles have been discussed earlier in the section on ligaments and tendons. These muscles and their actions are also listed here.

- The peroneals (*peroneus longus* and *peroneus brevis*) on the outside edge of the ankle and foot bend the ankle down and out.
- The calf muscles (*gastrocnemius* and *soleus*) connect to the calcaneus by the Achilles tendon. When the calf muscles tighten, they bend the ankle down.
- The posterior tibialis muscle supports the arch and helps turn the foot inward.
- The anterior tibialis pulls the ankle upward.

Nerves

The nerve supply of the ankle is from nerves that pass by the ankle on their way into the foot. The *tibial nerve* runs behind the medial malleolus. Another nerve crosses in front of the ankle on its way to top of the foot. There is also a nerve that passes along the outer edge of the ankle.

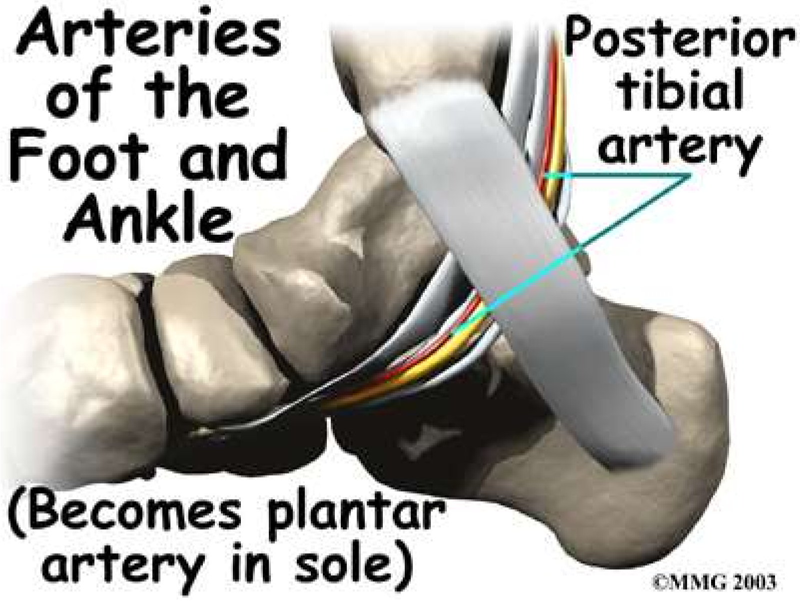


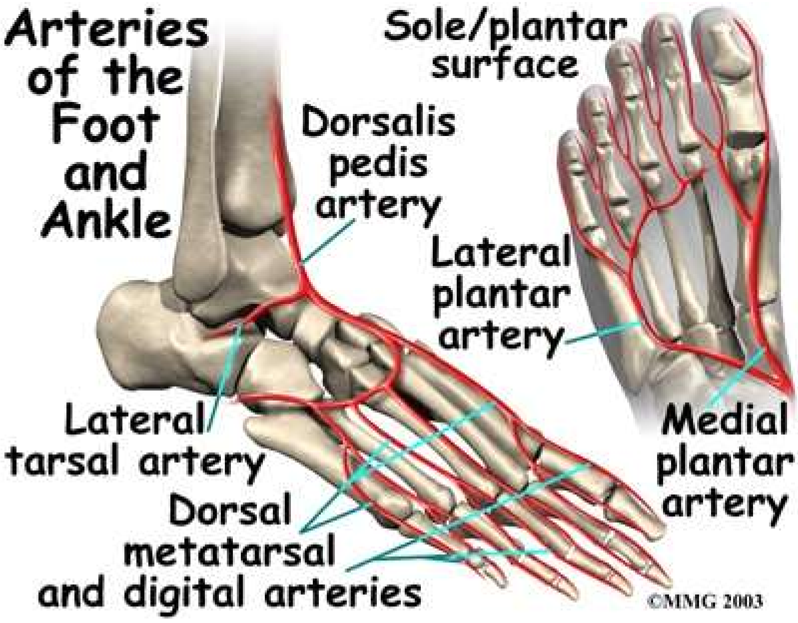


The nerves on the front and outer edge of the ankle control the muscles in this area, and they give sensation to the top and outside edge of the foot.

Blood Vessels

The ankle gets blood from nearby arteries that pass by the ankle on their way to the foot. The *dorsalis pedis* runs in front of the ankle to the top of the foot. (You can feel your pulse where this artery runs in the middle of the top of the foot.) Another large artery, called the *posterior tibial artery*, runs behind the medial malleolus. It sends smaller blood vessels to the inside edge of the ankle joint. Other less important arteries entering the foot from other directions also supply blood to the ankle.





Summary

As you can see, the anatomy of the ankle is very complex. When everything works together, the ankle functions correctly. When one part becomes damaged, it can affect every other part of the ankle and foot, leading to problems.

MATERIALS AND METHODS

Patients with distal tibia fractures satisfying inclusion criteria admitted in R. L. Jalappa Hospital attached to Sri Devaraj Urs Medical College, Tamaka, Kolar.

Cases satisfying the inclusion criteria admitted in R.L. Jalappa Hospital during the study period of Dec 2010 to Oct 2012 will be included. Minimum of 30 patients will be included in the study.

Inclusion criteria

Patient >18 years.

Closed and Open tibia type I and II fractures.

Intra-articular extension of the fracture.

Exclusion criteria

Pathological fractures.

Patients with co-morbid conditions posing a risk for surgery.

PRE-OPERATIVE REGIMEN:

The patients shall be resuscitated in emergency room and a complete examination of the patient for other associated injuries as well will be done. Neurological and vascular assessment of the involved limbs will be done. Wound lavage, dressing and splintage will be done as per the initial assessment and injury to the patient. Analgesics, Antibiotics, I.V fluids will be administered as per protocol and tetanus prophylaxis as per requirement will be given.

Basic blood parameters will be evaluated. Gram positive and gram negative antibiotic cover will be given for closed fractures. Anaerobic antibiotic cover will be given to patients with open fractures along with the above mentioned antibiotics. The patient will be taken for surgery after initial resuscitation, stabilization of vital parameters and after getting pre anaesthetic check-up and clearance.

INVESTIGATIONS:

Routine investigations for all cases like

Haemoglobin %

Total WBC count, Differential WBC count.

Blood grouping and Rh typing.

Bleeding time and Clotting time.

Random blood sugar

Blood urea

Serum creatinine

HIV I&II

HBsAg

ECG

Plain x-ray AP and LATERAL views

Preparation of the patient in operation theatre:

All the patients will be operated in supine position on a radiolucent table. The unaffected limb will be kept in extended position. Pneumatic tourniquet will be applied. The patient will be prepared and draped leaving the leg exposed as required, for surgical incision and intraoperative evaluation of fracture alignment and in case of open fractures debridement of the wound and thorough irrigation will be done with copious amount of normal saline.

Operative procedure:

Once the patient is prepared and draped, intraoperative antibiotics will be given before the inflation of tourniquet. By traction and manipulation reduction will be attempted. The provisional reduction will then be confirmed by image guidance under C-ARM (IITV). After adequate reduction and alignment is achieved, plate size will be selected under image guidance so as to provide adequate fixation and stabilization of fracture.

In MIPPO technique, incision will be made obliquely at the tip of medial malleolus and extended proximally to create easy passage. The medial malleolus will be exposed, with care taken to protect the great saphenous vein. Percutaneous elevators will then be inserted to create a submuscular, extraperiosteal tunnel for the plate. The passage of the plate till fracture site will be confirmed with C-ARM imaging. An incision will be made proximally at the estimated proximal edge of the plate. The anterior and posterior borders of the medial tibia will then be palpated, and incision will be extended longitudinally exposing the periosteum. Sub-muscular plane is developed in proximal incision and tunnel developed till fracture site and the plate will be pushed by the surgeon's opposite hand. The plate is palpated in the proximal incision and confirmed to be well seated. The plate shall then be fixed on the tibial surface with a Kirschner wire inserted through a fixation bolt. Adequate positioning will then be confirmed with anteroposterior and lateral imaging. The proximal position of the plate will then be checked to ensure central placement of the tibial shaft (using the C-Arm).

This will then be followed by insertion of fixation screws following the standard procedure for non locking cortical screws and locking screws. All the non locking screws shall be inserted first as decided pre-operatively and after attaining adequate reduction, locking screws shall be inserted. A minimum of four screws should be used in each main fracture fragment. Osteopenic bone may require more screws. After the plate is inserted with the screws, the stabilization bolt will be removed from the middle distal hole and screw will be inserted in its place. The principles of fixation using LCP shall be adhered to at every stage of fixation.

This will be followed by irrigation of all the incisions with normal saline and wound closure in layers. The technical problems/complications during the procedure (if any) will be recorded.

Post operative regimen:

Post operative X-ray will be done to document proper reduction and fixation of fracture fragments. Ankle mobilization will be started from 2^{nd} or 3^{rd} post operative day according to the tolerance of patients or associated injuries. Antibiotics (Intravenous /oral) will be continued till the wound condition necessitates. Progressive weight bearing will be allowed according to the callous formation as assessed in follow up X Rays. Secondary procedures if any shall be done.

Regular follow up of the patient in OPD with X-rays and functional outcome evaluated as per OLERUD AND MOLANDER SCORING SYSTEM (ANNEXURE-1) will be done. All long term complications like non union, malunion, angular deformity, implant breakage, shortening or infection will be recorded. Secondary surgical procedures which were done in the patients will also be analysed. The patient shall be under follow up till the bony union of the fracture / upto 6 months, which ever is earlier. The final result shall be based on the functional and radiological outcome. The results shall be compiled and compared with literature.

The outcome of distal tibial fracture management with locking plates will be assessed in terms of:

Time of bony union

Ankle range of movement

Malunion

Infection

Secondary procedures performed (if any)

Implant failure

ANNEXURE- I

OPERATED PATIENTS WERE FOLLOWED UP USING OLERUD AND MOLANDER SCORING SYSTEM

Please indicate when you experience **pain**:

☐ Never [25]

☐ Only while walking on an uneven surface [20]

☐ Only while walking on an even surface outdoors [10]

☐ Only while walking indoors [5]

☐ Constant and severe [0]

Please indicate the degree of **stiffness** you are experiencing:

☐ None [10]

☐ Stiffness [0]

Please indicate the degree of **swelling** you are experiencing:

☐ None [10]

☐ Only evenings [5]

☐ Constant [0]

Please indicate the degree of difficulty you are having with **stair-climbing**:

☐ No problems [10]

☐ Impaired [5]

☐ Impossible [0]

Please indicate the degree of difficulty you are having with **running**:

☐ Possible [10]

☐ Impossible [5]

Please indicate the degree of difficulty you are having with **jumping**:

☐ Possible [10]

☐ Impossible [5]

Please indicate the degree of difficulty you are having with **squatting**:

☐ No problems [10]

☐ Impossible [5]

Please indicate the type of **supports** you are currently using:

☐ None [10]

☐ Taping, wrapping [5]

☐ Stick or crutch [0]

How is this injury affecting your work and activities of daily life?

☐ Same as before injury [20]

☐ Loss of tempo [15]

☐ Change to a simpler job/part-time work [15]

☐ Severely impaired work capacity [0]

PATIENTS WERE GRADED AS EXCELLENT, GOOD, FAIR AND POOR ON SCORES. [MAXIMUM SCORE BEING 100]

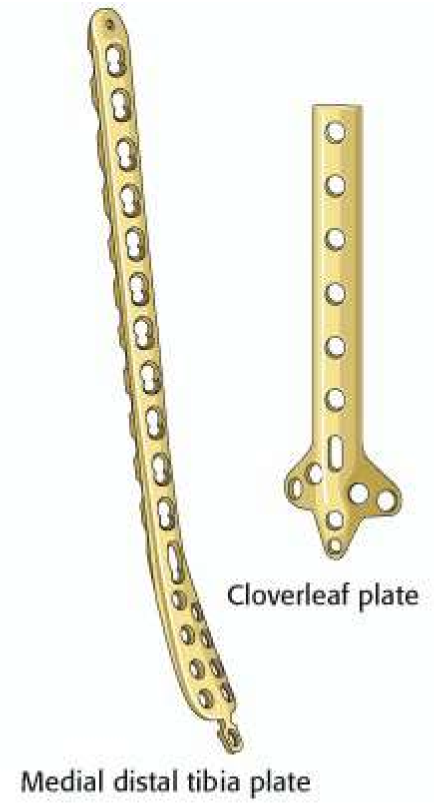
GRADING WAS DONE AS FOLLOWS:

EXCELLENT: >85

GOOD: 70-80

FAIR: 55-65

POOR: <50



DISTAL TIBIAL PLATES

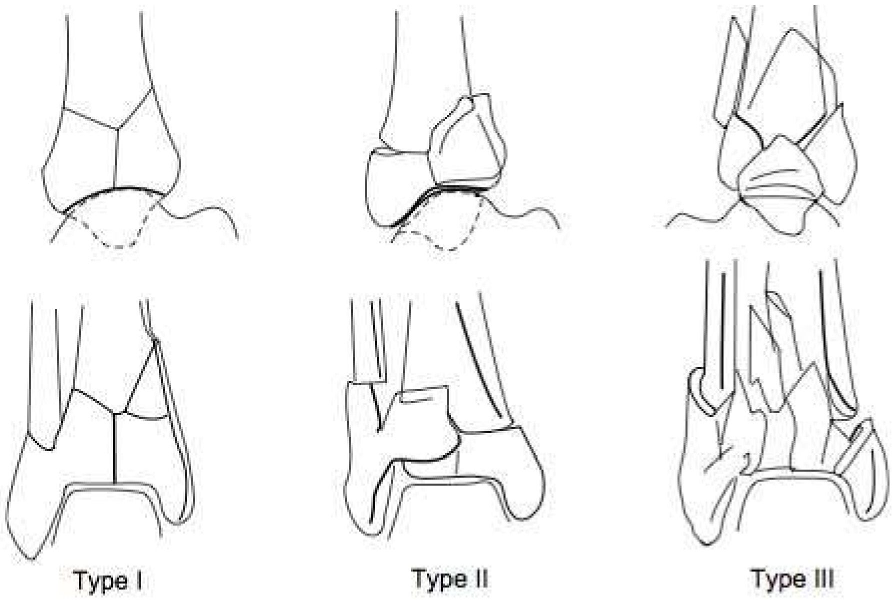
Medial distal tibia plate was used in 18 cases and Cloverleaf plate was used in 12 cases.

LCP and locking screws with sleeve

DISTAL TIBIA FRACTURE CLASSIFICATION:

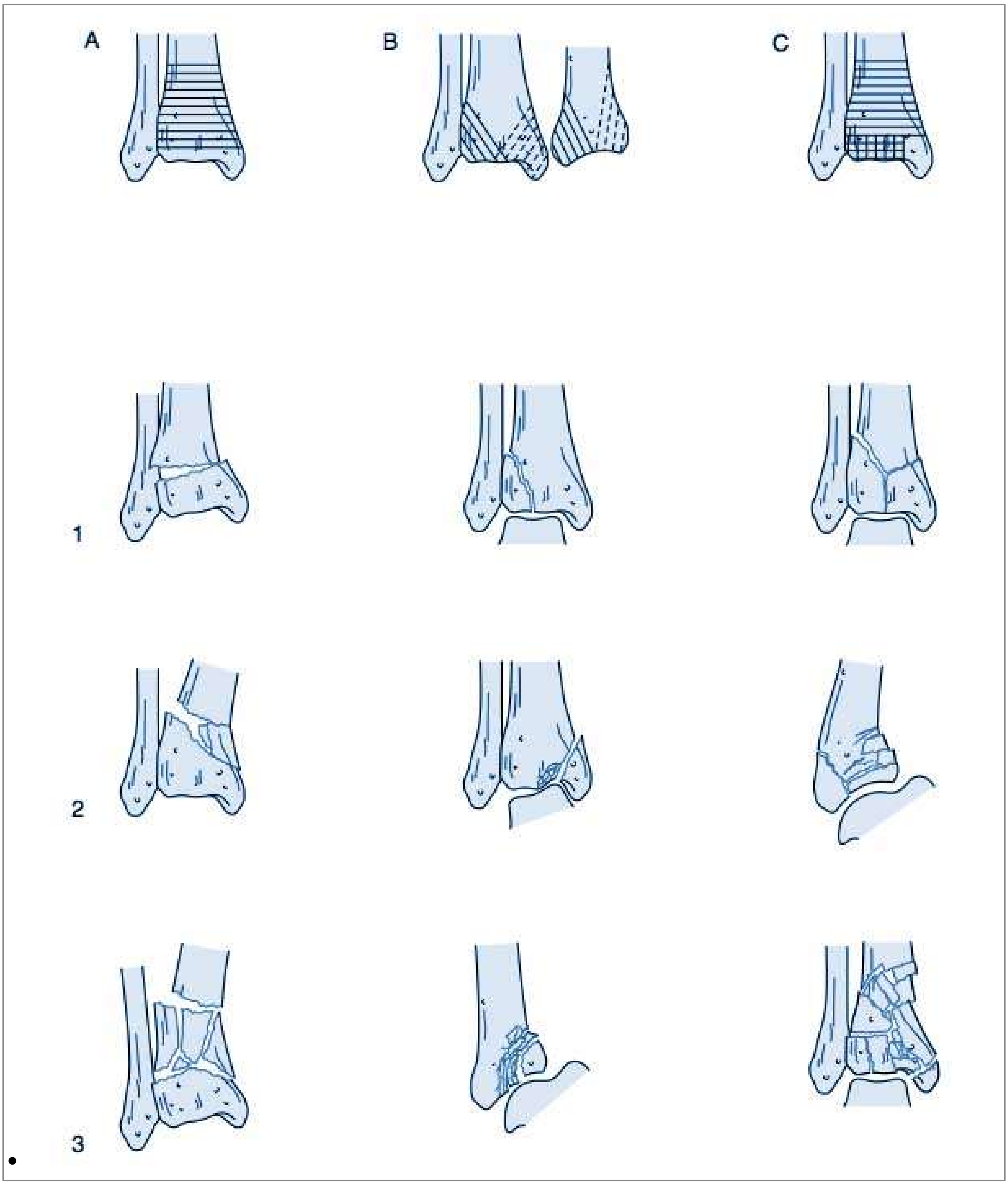
Ruedi and Allgower:

- **Type I** Intra-articular fracture of the distal tibia without significant displacement
- **Type II** Intra-articular fracture of the distal tibia with significant displacement but minimal comminution
- **Type III** Fracture of distal tibia with severe comminution and significant intra-articular displacement



AO – OTA:

• **43A/B/C**
• A1: Extra-articular fracture, metaphyseal simple • A2: Extra-articular fracture, metaphyseal wedge • A3: Extra-articular fracture, metaphyseal complex • B1: Partial articular fracture, pure split • B2: Partial articular fracture, split-depression • B3: Partial articular fracture, multifragmentary depression • C1: Complete articularfracture, articular simple, metaphyseal simple • C2: Complete articularfracture, articular simple, metaphyseal multifragmentary • C3: Complete articular fracture, multifragmentary


A
B
C
1
2
3

CASE NO. 13:

Pre op and post op x-ray.

Dorsiflexion.

Plantar flexion.

CASE NO. 21:

Pre op and post op x-ray.

Plantar Flexion

Dorsiflexion

Intra op insertion of the plate

Incision is made over the medial malleolus.

A tunnel is made for the passage of the locking plate.

Plate is inserted to check if it slides in easily.

A proximal incision is made and the length of the plate is measured.

Plate is inserted through the distal incision.

Insertion of the plate is done which can be adjusted through the proximal incision if required.

Results and Analysis

The results and objectives of the study are mentioned below under various headings.

Age distribution:

The percentage distribution of cases is shown in Table 1 and Fig.1

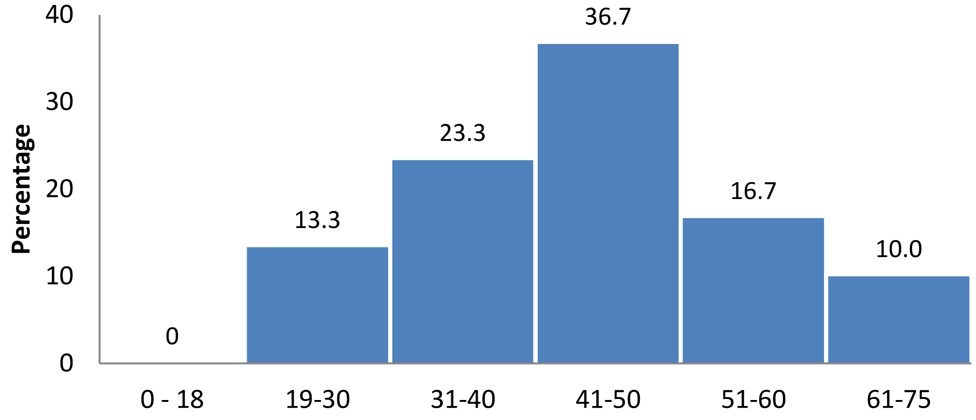
Table 1:

Age in years	**Number of Cases**	**Percentage**
0 – 18	-	-
19-30	4	13.3
31-40	7	23.3
41-50	11	36.7
51-60	5	16.7
61-75	3	10.0
Total Cases	**30**	**100**

Patients included in our study were aged above 18 years.

Maximum number of cases (36.7%) seen were in the age group of 41-50 years. Least number of cases seen were in the age group of 61-75 years.

Fig. 1: Percentage Distribution of cases according to their age group



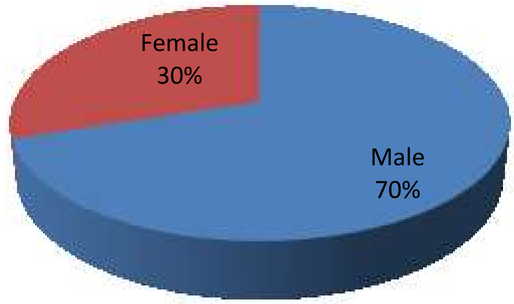
Sex distribution:

The distribution of cases according to sex is shown in Table 2 and Fig.2.

Table 2:

Sex	**Number of Cases**	**Percentage**
Male	21	70.0
Female	9	30.0
Total	**30**	**100.0**

Fig. 2: Distribution of cases according to their sex



70% of the cases treated were males and 30% were females.

The higher percentage of male cases seen could be due to reason that relatively males as compared to females have a more active lifestyle.

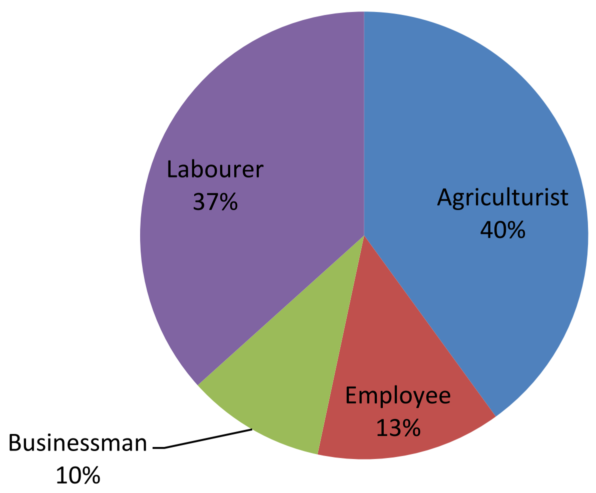
Occupational distribution:

The distribution of the cases according to their occupation is given in Table 3 and Fig.3

Table: 3

Occupation	Number of Cases	Percentage
Agriculturist	12	40.0
Employee	4	13.3
Businessman	3	10.0
Labourer	11	36.7
Total	**30**	**100.0**

Fig 3: Distribution of cases according to their Occupation



40% of the cases in our study were agriculturists probably due to the location of the hospital, to which people from nearby villages are brought for treatment.

Mode of injury:

Majority of the cases were due to road traffic accident (RTA) i.e 76.7%. Remaining were due to fall i.e 23.3%.

Table:4

Mode of Injury	Number of Cases	Percentage
RTA	23	76.7
Fall	7	23.3
Total	**30**	**100.0**

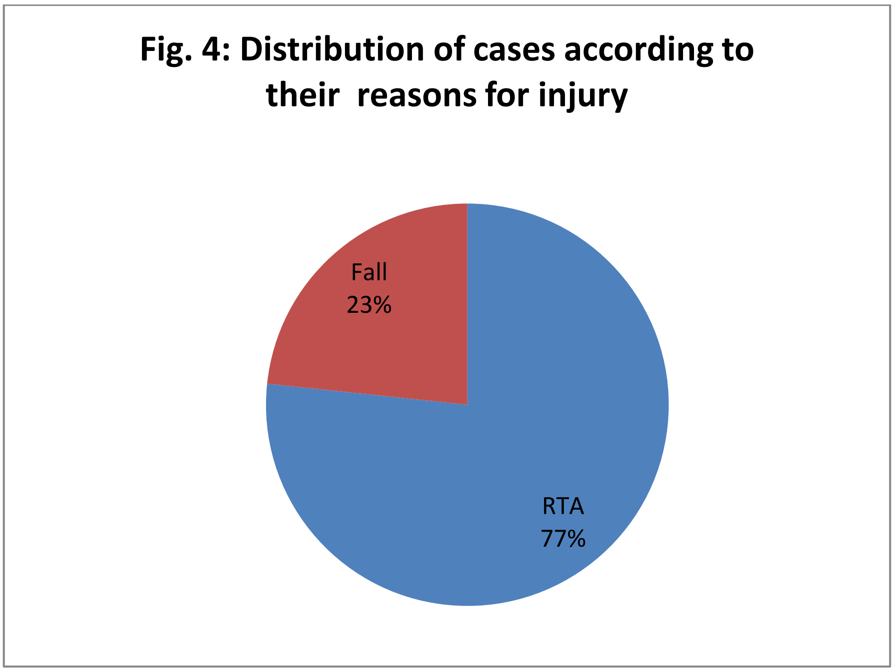


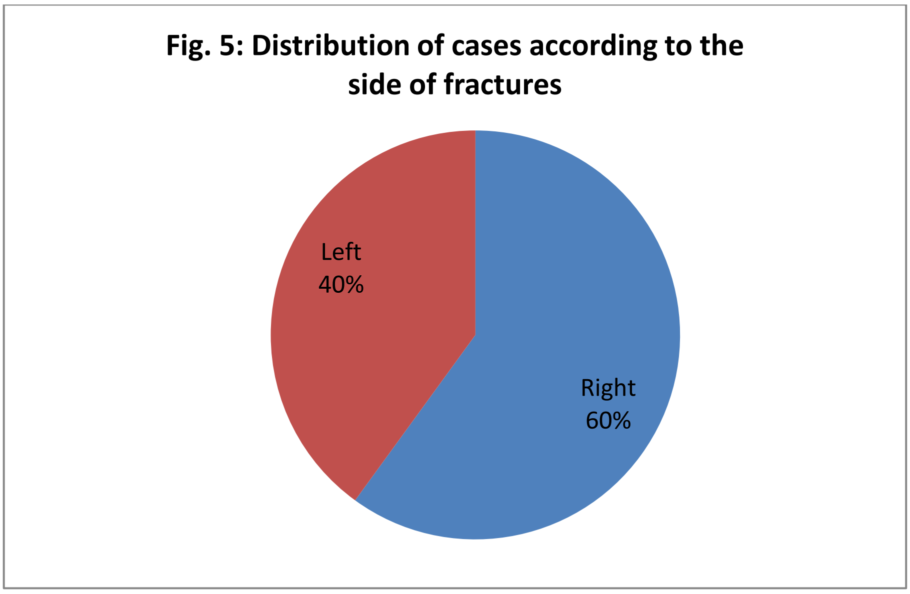
Fig. 4: Distribution of cases according to their reasons for injury
Fall
23%
RTA
77%

Side of fracture:

Distribution of cases according to side of fracture is given in Table 5 and Fig.5

Table-5

Side of fracture	**Number of Cases**	**Percentage**
Right	18	60.0
Left	12	40.0
Total	**30**	**100.0**



Fracture was more common in the right leg i.e 60% of the cases.

Complications:

Complications were seen in 14 cases.

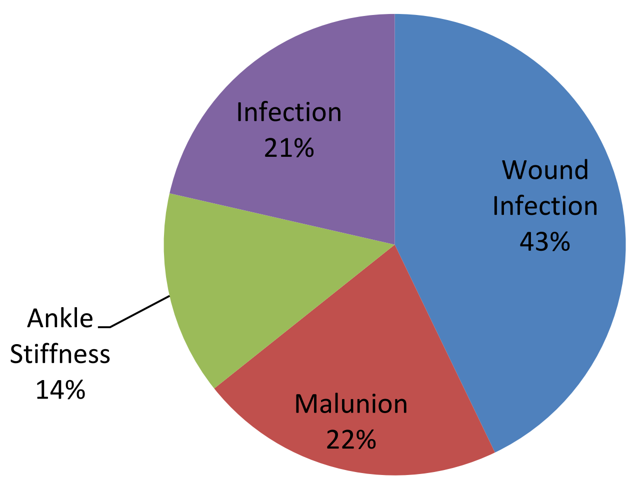
Most common was wound infection which was seen in 42.9% of the affected cases.

Mal union was seen in 21.4% and Ankle stiffness was seen in 14.3% of the affected cases.

Table-6

Complications	Number of Cases	Percentage
Superficial Wound Infection	6	42.9
Malunion	3	21.4
Ankle Stiffness	2	14.3
Deep Infection	3	21.4
Total cases	**14**	**100.0**

Fig. 6 : Distribution of cases according to their type of complications



Radiological union of fractures

Table 7

Sl. No.	Union time (Weeks)	No. of Cases	%
1	Up to 12	5	16.7
2	12 - 16	6	20.0
3	16 - 20	13	43.3
4	20 - 24	5	16.7
5	24 - 28	1	3.3
	Total	30	100.0

AO/OTA Type

Table 8

Sl. No.	Type	No. of Cases	%
1	43. A1	16	53.3
2	43. A2	6	20.0
3	43. A3	5	16.7
4	43. B1	3	10.0
	Total	30	100.0

Clinical results:

Excellent results were seen in 46.7% of the cases.

The percentage of cases which achieved poor result was 10%.

Table-9

Clinical results	**OAMS**	**Number of Cases**	**Percentage**
Excellent	>85	14	46.7
Good	70-80	9	30
Fair	55-65	4	13.3
Poor	<50	3	10
Total cases		**30**	**100.0**

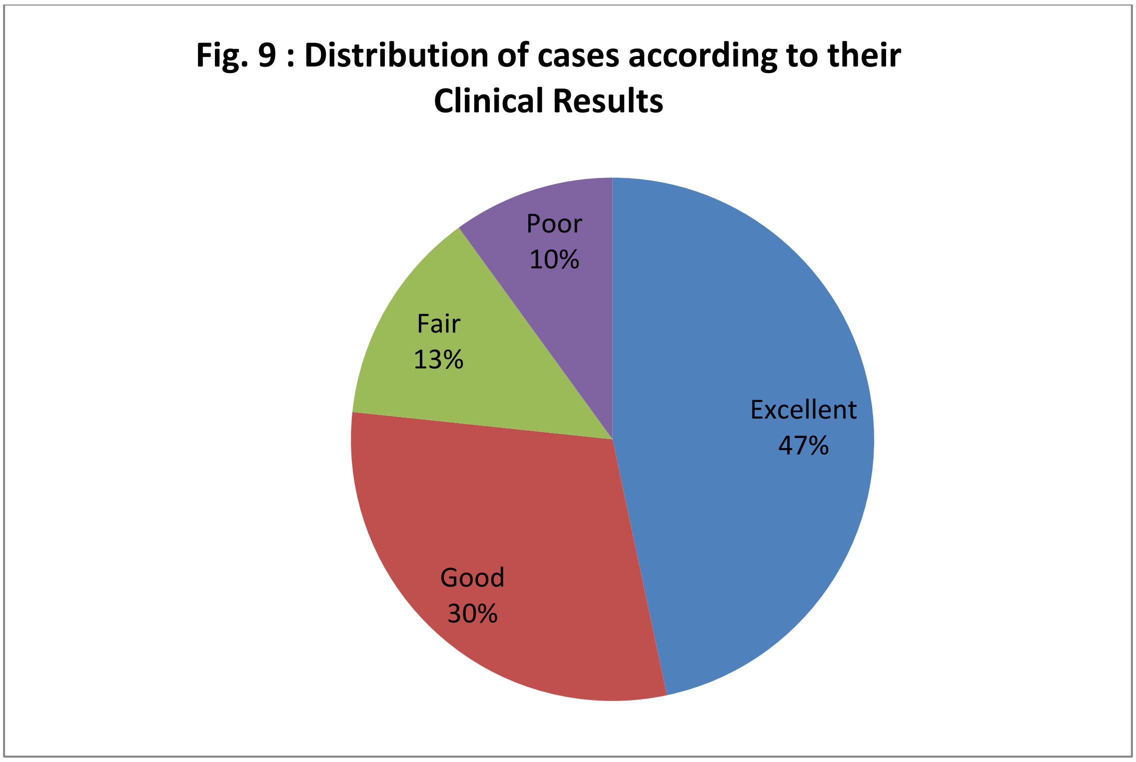


Fig. 9 : Distribution of cases according to their Clinical Results
Poor
10%
Fair
13%
Excellent
47%
Good
30%

DISCUSSION

Biological fixation is based on other minimally invasive methods of fixation such as intramedullary nailing. These techniques are newer and technically demanding. Indirect reduction techniques are developed to reduce soft tissue elevation at the fracture site and to improve the rate of fracture healing. These techniques in addition reduce the overall incidence of infection, refracture and the need for autogenous bone grafting. The perforators as well as nutrient arteries are well preserved by this method if plate is carefully inserted.

The bone healing is excellent with this type of fixation because the stresses are distributed over a longer segment of bone and the force per unit area on the plate is lower if the segment without screws is longer. Thus the good results in this method can be explained by a combination of rapid fracture consolidation due to preserved vascularity and a greatest resistance of the plate to fatigue, since the stress is distributed over a longer length of plate. Our study has focussed on the above treatment modality with use of locking compression plate.

Comparison of MIPPO technique with locking compression plate against conventional plating techniques.

- Patients included in our study were aged above 18 years.
- Maximum number of cases (36.7%) were seen in the age group of 41-50 years.
- Least number of cases were seen in the age group of 61-75 years.
- 70% of the cases treated were males and 30% were females. The probable reason for this could be that males have a more active lifestyle.

- Most of the injuries were caused by Road traffic accidents. This percentage came up to 77%.
- Fracture was more common in the right leg i.e. 60% of the cases.
- Complications were seen in 14 cases.
- Most common was superficial wound infection which was seen in 42.9% of the affected cases.
- Mal union was seen in 21.4% and Ankle stiffness was seen in 14.3% of the affected cases.
- Superficial wound infections were treated by anti-biotics for a period of 7-10 days and the infection subsided subsequently.
- The deep wound infections were treated rigorously with I.V antibiotics and wound became healthy after few weeks.
- Excellent results were seen in 46.7% of the cases.
- Good results were seen in 30% of the cases.
- The percentage of cases which achieved poor result was 10%.
- The results in our study were comparable to various other studies.

Leung et al(2009) treated 62 patients from august 2002 to august 2007. According to AO classification, there were 8 cases of Type A1, 15 cases of Type A2, 9 cases of Type A3, 7 cases of Type B3, 11 cases of Type C1 and 12 cases of Type C2. Of them 52 pts had closed fractures and 10 had open fractures. The x-ray films were taken after 3 months of operation. Near anatomical reduction was achieved in 56 fractures and acceptable reduction in 6 fractures. According to Teeny and Wiss ankle scoring system, 30 pts got excellent results, 25 good and 7 fair. The excellent and good rate was 88.7% at 12 month follow up.

The study carried out by us included 30 patients and the results achieved were comparable to the results of the study mentioned above.

CONCLUSION

On the basis of the findings in the study it can be concluded that:

- The application of locking compression plate using MIPPO technique does not compromise with the periosteal blood supply thereby causing less interference with the fracture haematoma and the fracture healing. There is rapid fracture consolidation and better union time.
- There are few incidences of delayed and non union.
- There is decreased need for bone grafting.
- Locking of screw into plate ensures angular as well as axial stability eliminating the possibility of screw to toggle, slide or be dislodged and thus reduces the chance of post operative loss of reduction.
- As the study of locking compression plate doesn't rely on the compression between the plate and the bone so pre contouring of the plate is not required.
- There is better fixation in osteoporotic bone as locking head screws have more resistance against bending and torsion forces with decreased pull out of the screws.
- Plate induced osteoporosis is less frequently seen with locking compression plate so there are less chances of refracture after plate removal.
- There is less incidence of infection due to limited exposure.
- There is no chance of vascular complication by carefully inserting the plate sub muscularly through limited incision.

- There is no need of any specialised instrumentation and the method is less time consuming and cost effective.

- Soft tissue complications knee and ankle stiffness are avoided.

- Few cases complained of palpable hardware which can be minimised by using low profile titanium plate.

- Few patients complained of pain and swelling at operation site on exertion which usually resolves on implant removal.

- The usefulness of MIPPO technique using locking compression plate has been established in present study.

- This technique can be used in fractures where locked nailing can’t be done like vertical slit and markedly comminuted fractures, narrow or very wide medullary canals, fractures with metaphyseal extension and osteoporotic fractures and bad skin condition at the entry portal of I/M nail.

In conclusion, MIPPO is an effective alternative treatment for tibial diaphysis and distal tibia fractures.

MIPPO aims to reduce surgical trauma and protect the vascular integrity and osteogenic hematoma of the fracture, and is an effective alternative treatment for tibial diaphysis and distal tibia fractures with low complication and high union rates.

SUMMARY

In our study, 30 cases of distal tibia fracture were treated with MIPPO using LCP. Follow up was done for 6 months.

- Male patients (70%) outnumbered females (30%) in incidence.
- More common in the age group of 41-50 years with the average being 44.9 years.
- Most common mode of injury was road traffic accident (76.7%).
- Right leg was affected in 60% of the cases.
- Complications were seen in 14 cases with the most common being superficial wound infection which was seen in 6 cases.
- Ankle stiffness was seen only in 2 cases.
- 13 cases achieved union in 16-20 weeks time.
- Maximum number of cases (53.3%) were AO Type A1.
- Overall excellent result was achieved in 46.7% of the cases.

BIBLIOGRAPHY

1. Hille GH. Titanium for surgical implants, Journal of materials. Vol.2, June 1966, p.373.
2. Lewing PG. Compatibility of bio-materials, CM Evarts edition. Orthopaedic clinics of North America 1973;249.
3. Zwicker V, Buhler K, Muller R, Beck H, Schmid HJ, Fertle J. Titanium 80 science and technology. AIME (1980);505.
4. Kempf I, Graf H, Lafforgue D, Francois JM, Anceau H, The Sarmiento method as a conservative treatment of tibial fractures. Rev Chir Orthop Reparatrice Appar Mot. 1980;66:373-81. French translated to English.
5. Williams DF. Biocompatibility of orthopaedic implant materials. Vol.1, DF Williams (Ed), CRC, Boca Raton 1983.
6. Brunnel N, Helsen JA. Journal of Biomedical Materials and Research, 22(1988), p.203.
7. Helfet DL, Shonnard PY, Levine D, et al.Minimally Invasive plate osteosynthesis of distal fractures of the tibia. *Injury*. 1999;28:S-A42-S-A48.
8. Collinge C, Sanders R.Minimally-invasive plating .*J AmerAcadOrthopSurg* .2000;8:211-217
9. Collinge C, Sanders R,DiPasquale T. Treatment of complex tibialperiarticular fractures using percutaneous techniques . *ClinOrthopRelat Res*.2000;375:69-77.
10. Dogra AS, Ruiz AL, Thompson NS, Nolan PC. Dia-metaphyseal distal tibial fractures treatment with a shortened intramedullary nail: a review of 15 cases. Injury. 2000;31:799-804
11. Egol KA, Kubiak EN, Fulkerson E, Kummer FJ, Koval KJ. Biomechanics of locked plates and screws. *J Orthop Trauma*. 2004;18:488–493.

12. Kaab MJ, Frenk A, Schmeling A, Schaser K, Schutz M, Haas NP. Locked internal fixator: sensitivity of screw/plate stability to the correct insertion angle of the screw. *J Orthop Trauma*. 2004;18:483–487.
13. Hasenboehler E, Rikli D, Babst R. Distal tibia fractures and analysis of treatment in 32 patients, Clin orthop 2006; 365:370.
14. Hazarika S, Chakravarthy J, Cooper J. Minimally invasive locking plate osteosynthesis for fracture distal tibia in 20 patients. Clin orthop 2006; 877:887.
15. Bedi A, Le TT, Karunakar MA. Surgical treatment of non articular distal tibia fractures. Am Acad Orthop Surg. 2006;14:406-16.
16. Namazi H, Mozaffarian K. Awful considerations with LCP instrumentation: a new pitfall. *Arch Orthop Trauma Surg.* 2007;127:573–575
17. Cory Collinge, MD, Mark Kuper , DO, Kirk Larson , RNFA, and Robert Protzman,MD.Minimally Invasive Plating of High-Energy Metaphyseal Distal Tibial Fractures . *J Orthop Trauma* 2007;21:355-361.
18. Bahari S, Lenehan B, Khan H, McElwain JP. Minimally invasive percutaneous plate fixation of distal tibia fractures. Acta Orthop Belg. 2007;73:635-40.
19. Vallier HA, Le TT, Bedi A. Radiographic ana clinical comparisons of distal tibia shaft fractures (4 to 11 cm proximal to the plafond) : plating versus intramedullary nailing. J Orthop Trauma. 2008;22:307-11.
20. Zha G, Chen Z, Qi X. Minimally invasive percutaneous locking compression plate internal fixation in the treatment of tibial fractures. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2008;22:1448-50. Chinese translated to English
21. Shahid R, Asif M, Maqsood M. Distal tibia fixation with locking compression plate using minimally invasive plate osteosynthesis. Eur jou of trauma 2009; 159:164.

22. Chezhiyan S, Ronga M, Umile G, Oliva F, Maffulli N. Minimally invasive osteosynthesis of distal tibia fractures using locking plates. Orthopaedic clinics of north america 2009; Vol 40, Issue 4.
23. Gupta R, Rohilla R, Sangwan K, Singh V, Walia S. Locking plate fixation in distal tibial fractures. Int orthop 2009; 863:869.8
24. Ronga M, Shanmugam C,Longo UG, Olivia F, Maffulli N. Minimally invasive osteosynthesis of distal tibial fractures using locking plates . *Ortho Clin North Am*.2009 Oct;40(4):499-504, ix.
25. Ronga M, Longo UG, Maffulli N. Minimally Invasive Locked Plating of Distal Tibia Fractures is safe and effective. Clin Orthop Relat Res. 2009;468:110-14.
26. Gupta RK, Rohilla RK, Sangwan K, Singh V, Walia S. Locking plate fixation in distal metaphyseal tibial fractures: series of 79 patients. Int Orthop. 2009;33:120-23.
27. Leung FK, Law TW. Application of minimally invasive locking compression plate in treatment of distal tibia fractures. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2009; 23:1323-5. Chinese translated to English.
28. Mario R, Umile G, Nicola M. Minimally invasive locked plating of distal tibia in 21 patients. clin orthop 2010; 975:982.
29. Mohamed S, Michael M, Cathy I. Minimally invasive plate osteosynthesis of distal tibia a multicentric view. Jor orthop 2010; 7(1)e7.
30. Feng Chen Kao, Yuan Kun Tu, Kuo Yao Hsu, Chin Hsien Wu, Cheng-Yo Yen, Ming Chih Chou. Treatment of distal tibial fractures by minimally invasive percutaneous plate osteosynthesis of 3 different plates: Results and cost effectiveness analysis. Formosan Journal of Musculoskeletal Disorders. 1(2010)35-40.

31. Shrestha D, Acharya BM, Shrestha PM. Minimally invasive plate osteosynthesis with locking compression plate for distal diametaphyseal tibia fracture. Kathmandu Univ Med J. 2011;34(2)62-8.
32. Mehmet AEA, Ismail C, Arslan KA, Tughan K, Mahmut U. The results of minimally invasive percutaneous plate osteosynthesis (MIPPO) in distal and diaphyseal tibial fractures. Acta Orthop Traumatol Turc 2012;46(3):161-167 doi:10.3944/AOTT.2012.2597.

ANNEXURE- II

PROFORMA FOR DISTAL TIBIA FRACTURES TREATED WITH LCP USING MIPPO.

1. NAME :

6. IP NO.:

2. AGE :

7. D.O.A :

3. SEX :

8. D.O.D :

4. ADDRESS :

5. MARITAL STATUS : 9.D.O.S :

COMPLAINTS

1. Mode of trauma :
2. Pain :
3. Inability to move the limb :
4. Associated complaints :

HISTORY OF PRESENT ILLNES

1. History of trauma

a. Forceful trauma

Fall from height/ fall while running

Road traffic accident

b. Miscellaneous injury:

2. Treatment received before reaching the hospital / method of first aid given-

PAST HISTORY

1. History of chronic illness – DM / HTN / BRONCHIAL ASTHMA / TB
2. Past medical history --
3. Personal history--

a. Nature of work :

b. Menstrual history:

c. Habits : smoker / non smoker

Alcoholic / non alcoholic

d. Bladder function : normal / altered

4. Family history

GENERAL PHYSICAL EXAMINATION

1. Built : well / moderate /poor
2. Nourishment : well / moderate / poor
3. Pallor : icterus :

Clubbing : lymphadenopathy :

Oedema: cyanosis:

4. Vital signs :

a. Pulse rate : c. Respiratory rate :

b. Blood pressure : d. Temperature :

OTHER SYSTEMS

1. CARDIOVASCULAR SYSTEM :

2. RESPIRATORY SYSTEM :

3. PER ABDOMEN :

4. CENTRAL NERVOUS SYSTEM:

LOCAL EXAMINATION

INSPECTION

- Attitude of limb :
- Swelling :
- Deformity:

PALPATION

- Local rise of temperature :
- Tenderness :
- Crepitus:
- Abnormal mobility:
- Peripheral neurovascular examination:

MOVEMENTS AT ANKLE

ASSOCIATED INJURIES

INVESTIGATIONS

1. X-RAY leg with ankle joint – AP & LATERAL VIEW
2. Screening chest x-ray.
3. ECG
4. Blood :

a. Hb% : e. Blood Urea :

b. Total count :

f. S. Creatinine :

c. Differential count :

g. RBS :

d. Blood grouping & typing :

i. Any other specific investigations :

FINAL DIAGNOSIS :

MANAGEMENT

PRE OPERATIVE TREATMENT

1. Analgesics :
2. Antibiotics :
3. Blood transfusion :
4. Others :

OPERATIVE TREATMENT

1. Date of operation :
2. Anaesthesia :
3. Approach :
4. Blood Transfusion :
5. Intra operative complications :

POST OPERATIVE TREATMENT

1. Antibiotics :
2. Analgesics :

3. Blood transfusion :
4. Suture removal on :
5. Follow up X-ray :
6. Post- operative rehabilitation:

POST OPERATIVE COMPLICATIONS

Immediate

1. Swelling of the limb.
2. Other complications

Early

Late

1. Wound infection
2. Deep vein thrombosis
3. Shortening/ lengthening
4. Pulmonary embolism
5. Deformity

Follow up:

	After 1 mth	After 3 mts	After 6mts
Range of movements (ANKLE)			
Tenderness at fracture site			
X-ray findings			
Any other complications			

OLERUD AND MOLANDER SCORE:

Final Result: Excellent/Good/Fair/Poor.

ANNEXURE- III

CONSENT FORM

STUDY OF MANAGEMENT OF DISTAL TIBIA FRACTURES BY MINIMALLY INVASIVE LOCKING PLATE OSTEOSYNTHESIS

DEPARTMENT OF ORTHOPAEDICS, RLJH,KOLAR

I ___________________________ _____________________ in my full senses.

Hereby give my complete consent for_____________________________or any other

Procedure deemed fit which is a diagnostic procedure / biopsy / transfusion / operation to be performed on me / my son / my daughter / my ward_____________________________

Age _________________________under any anesthesia deemed fit. The nature and risks

Involved in the procedure have been explained to me to my satisfaction. For academic and scientific purpose the operation/procedure may be televised or photographed.

Date:

Signature/Thumb Impression of Patient/Guardian

MASTER CHART

Sl. No.	Name	Hospital No.	Age	Sex	Occupation	Mode of injury	Side	Days before Surgery	Procedure	Complication	Result
1	Chowdamma	689855	61 yrs	F	Bussiness	Fall	Left	3 days	MIPPO with LCP	Ankle stiffness	Poor
2	Nagamani K	705358	42yrs	F	Agriculturist	Fall	Left	1 day	MIPPO with LCP	Wound infection	Good
3	Srinivas TR	708323	38 yrs	M	Bussiness	RTA	Left	1 day	MIPPO with LCP	None	Excellent
4	Anand	710842	35 yrs	M	Agriculturist	RTA	Right	2 days	MIPPO with LCP	None	Excellent
5	Kempamma	740724	58 yrs	F	Agriculturist	RTA	Right	1 day	MIPPO with LCP	None	Good
6	Chowda Reddy	740929	50 yrs	M	Employee	RTA	Right	2 days	MIPPO with LCP	Infection	Good
7	Akhil	741591	32 yrs	M	Labourer	RTA	Right	1 day	MIPPO with LCP	None	Excellent
8	Aakappa	741626	42 yrs	M	Labourer	RTA	Right	2 days	MIPPO with LCP	None	Excellent
9	Channappa	741643	43 yrs	M	Labourer	RTA	Right	3 days	MIPPO with LCP	None	Excellent
10	Narayanswamy	744580	53 yrs	M	Agriculturist	RTA	Right	3 days	MIPPO with LCP	Mal union	Poor
11	Harish	744773	29 yrs	M	Agriculturist	RTA	Right	1 day	MIPPO with LCP	None	Excellent
12	Lingaraja	755508	42 yrs	M	Agriculturist	RTA	Left	3 days	MIPPO with LCP	Wound infection	Excellent
13	Nagraju	755682	36 yrs	M	Employee	Fall	Right	2 days	MIPPO with LCP	None	Fair
14	Narayan Reddy	758762	60 yrs	M	Labourer	RTA	Left	4 days	MIPPO with LCP	Wound infection	Good
15	Yallappa	764412	49 yrs	M	Employee	RTA	Right	1 day	MIPPO with LCP	None	Excellent
16	Kondappa	764652	71 yrs	N	Agriculturist	RTA	Left	5 days	MIPPO with LCP	Infection	Good
17	Iqbal	779924	28 yrs	M	Labourer	RTA	Left	2 days	MIPPO with LCP	None	Excellent
18	Chandraprakash	779962	35 yrs	M	Agriculturist	RTA	Left	1 day	MIPPO with LCP	None	Good

19	Hemavathy	795457	68 yrs	F	Labourer	Fall	Right	1 day	MIPPO with LCP	Mal union	Fair
20	Shamalamma	799855	25 yrs	F	Labourer	RTA	Left	2 days	MIPPO with LCP	None	Fair
21	Kamlamma	817099	47 yrs	F	Agriculturist	Fall	Left	5 days	MIPPO with LCP	Ankle stiffness	Poor
22	Srinivasa	821505	28yrs	M	Employee	RTA	Right	4 days	MIPPO with LCP	None	Excellent
23	Muniyappa	827285	45 yrs	M	Labourer	Fall	Right	2 days	MIPPO with LCP	None	Good
24	Ramanna	827672	45 yrs	M	Agriculturist	RTA	Left	3 days	MIPPO with LCP	None	Excellent
25	Balaraja	829689	32 yrs	M	Labourer	RTA	Right	2 days	MIPPO with LCP	None	Good
26	Krishnamurthy	829756	55 yrs	M	Bussiness	RTA	Left	1 day	MIPPO with LCP	None	Excellent
27	Ananda	831062	43 yrs	F	Labourer	RTA	Right	1 day	MIPPO with LCP	Mal union	Good
28	Gopalrao	849679	54 yrs	M	Agriculturist	RTA	Right	7 days	MIPPO with LCP	Wound infection	Excellent
29	Lakshmamma	882371	45 yrs	F	Labourer	Fall	Right	2days	MIPPO with LCP	Wound infection	Fair
30	Rajamma	886292	39 yrs	F	Agriculturist	RTA	Right	1 day	MIPPO with LCP	None	Excellent