"STUDY OF OUTCOME OF SURGICAL MANAGEMENT OF BI-MALLEOLAR FRACTURES IN ADULTS"

By

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SDUAHER

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IN

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ABSTRACT

Background:

Malleolar injuries are the most common significant lower extremity fractures. These injuries gain importance, because the whole body weight is transmitted through the ankle, and locomotion depends on the stability of the ankle. Open reduction and internal fixation have become the mainstay of treatment for most of the unstable bimalleolar fractures, as these operative methods restores the anatomy, biomechanics and contact loading characteristics of the ankle.

Objectives:

To study the functional outcome of surgically managed bimalleolar fractures of ankle in adults.

Methods:

A prospective study of 30 cases of bimalleolar fractures of ankle in adults, managed surgically by various techniques in R L Jalappa Hospital attached to Sri Devraj Urs Medical College,Tamaka,Kolar. During the period from December 2012 to May 2014 were studied, satisfying the inclusion and exclusion criteria were studied. The functional outcome was evaluated using the Biard and Jackson’s ankle scoring system.

Results:

In our study we achieved 86.6% excellent to good results, 6.6% fair results, 6.6% poor results. The results were comparable to other studies.

Interpretation & Conclusion:

- The operative results were satisfactory in 86.6% cases, with good to excellent functional outcome.
- Excellent results are obtained with stable fixation of fracture. Cancellous screws or malleolar screws are far better in internal fixation of medial malleolus compared to Kirschner -wire fixation and lateral plating was the best for fibular fractures.
- Good functional results are obtained by surgical management of bimalleolar ankle fractures. Early weight bearing and mobilisation is achieved in these patients.
- Anatomical reduction with restoration of the articular congruence is essential in all intra articular fractures, more so, if a weight bearing joint like ankle is involved. Open reduction and internal fixation restores the articular congruity of the ankle joint.
- TBW done for many PER and PA injuries showed promising results comparable to that with screw fixation and also lesser reports of skin irritation at the wound site. It is the method preferred for small tranverse fragments and osteoporotic bones of both malleoli especially in the elderly.

Keywords: Malleolus ; plating ; Cancellous ; biomechanics ; medial ; TBW

LIST OF ABBREVIATIONS

#	Fracture
Anat type	Anatomical type
AO	Arbeistgemeinschaftfur Osteosynthese fargen
AP	Anteroposterior.
ASIF	Association of study of internal fixation
BM	Bimalleolar
DCP	3.5mm Dynamic compression plate
DW	Danis Weber
L H TYPE	Lauge-Hansen type.
LM#	Lateral malleolus fracture
MM#	Medial malleolus fracture
PA	Pronation-abduction
PER	Pronation-external rotation
PM#	Posterior malleolus fracture
SA	Supination-adduction
SER	Supination –external rotation
STP	Semi-tubular plate
TBW	Tension band wiring
TM	Trimalleolar

TABLE OF CONTENTS

LIST OF TABLES

LIST OF GRAPHS

LIST OF FIGURES

INTRODUCTION

Sir Robert Jones said, “Ankle is the most injured joint of the body but the least well treated”[1]. Ankle injuries gain importance because body weight is transmitted through the joint and locomotion depends upon the stability of it. They are usually mixed injuries, ligamentous and bony; and each injury is an end result of the sequence of ligamentous and bony failure due to deforming forces. Malleolar fracture have varied presentations which have given rise to a wide variety of classification systems, of which two are in vogue: Lauge-Hansens and Danis-Weber classification.

Malleolar fractures are one of the most common fractures in orthopaedictraumatology. As with all intra articular fractures, malleolar fractures necessitate accurate reduction and stable internal fixation. When malleolar fractures are not reduced accurately they may lead to post traumatic painful restriction of motion or osteoarthritis or both[2].

As for the treatment of malleolar fractures, many of them which are stable are reduced by conservative treatment andhave given good result. The other unstable displaced and open fractures require open reduction internal fixation. The superiority of ORIF over closed treatment have been thoroughly demonstrated in literature[3].

The operative method restores the anatomy and contact-loading characteristic of the ankle. Additional advantages include easier rehabilitation without a cast, early mobilization and earlier weight bearing[4].However all studies have not obtained good results in cases of bimalleolar fractures. The purpose of this study is to assess the functional outcome and results of surgical treatment of malleolar fractures.

OBJECTIVES

1. To study the functional outcome of surgically managed bimalleolar fractures of ankle in adults.
2. To restore the anatomy of malleoli and ankle perfectly by operative treatment with internal fixation.
3. To assess the union of fractures after surgical management.
4. To achieve stable fixation and early mobilization of the ankle.
5. To compare the results of the present study with those in literature.

REVIEW OF LITERATURE

HISTORICAL REVIEW

Evidence of healed ankle fractures have been described in the remains of mummies from ancient Egypt[4]. In the 5th century B. C., Hippocrates recommended that closed fractures be reduced by extension (traction) of the foot but that open fractures should not be reduced or the patient would die of “Inflammation and gangrene” within 7 days[4].

Except for the anatomical description of the ankle by Vesalius and a discussion of fractures of the fibula by Pare, there were few advances in the understanding and treatment of ankle injuries until the mid 18th century.

Petit wrote that the talus might luxate but always in connection with a fracture or diastasis of the malleoli. He recommended careful positioning of the foot to improve the outcome[5].

Percival Pott (1768) described a fracture of the fibula 2 to 3 inches above the distal tip, with an associated rupture of the medial ligaments and lateral subluxation of the talus. He recommended that the knee be flexed to relax the calf muscles, allowing reduction with minimal traction[5].

Jean Pierre David (1771) was the first to try to explain the mechanism of injury in fractures of the ankle. He wrote that the ligaments that held the fibula in combination with outward movement of the foot (external rotation) resulted in a fracture of the distal fibula[5].

Boyer (1814), the personal physician of Napoleon, described two different mechanisms of fractures of the fibula. He recognized that for subluxation of the joint to occur, there must be either a malleolus fracture or a ligamentous injury or both[4].

Dupuytren(1819) was the first to use experimental methods in the study of ankle injuries by producing fractures in cadavers. His writings include a combination of these experimental results and clinical observations and personal opinions. He emphasized on the role of abduction and the position of the foot in the mechanism of ankle injuries. He fixed the foot distal to the malleoli and moved the talus sideways and studied the forces acting on the ligaments on each side. He believed the genesis of the fracture could be due to forceful abduction of the foot[5].

Sir Astley Cooper (1822) presented his extensive work on fractures and dislocations, and categorized a wide range of ankle injuries, including fractures of the anterior and posterior tibial margins and diastasis of the tibia and fibula[7].

Maisonneuve(1840) recognized the importance of both external rotation forces and the syndesmotic ligaments in determining the pattern of the fracture. He noted that external rotation produced two different types of fractures of the fibula. When the syndesmotic ligaments remained intact, an oblique fracture occurred at the level of the joint and when the anterior tibiofibular ligament ruptured first, then a proximal fibula fracture occurred[5].

Malgaigne(1847) described the Volkmann's triangle, which is now known as the posterior lip[5]

Tillaux(1872) described fractures of the anterolateral margins of the tibia, implicating an avulsion injury of the anteroinferior tibiofibular ligament[7].

Von Volkmann (1875) described a fracture of the anterior lateral portion of the tibia but incorrectly described the mechanism of injury[4].

Wagstaffedescribed an avulsion fracture of the anterior margin of the fibula at the insertion site of the anterior tibiofibular ligament[33].

Lane (1894) was the first to recommend operative treatment to achieve an anatomical reduction of the ankle[4].

William Konrad Roentgen (1895) accidentally discovered X-ray and vastly contributed to the field of medicine.

Destot(1911), coined the term third malleolus to the posterior fragment. He correlated radiographic findings with anatomical experiments providing the basis for determining the mechanism of injury[33].

Cotton (1915) described trimalleolar fracture in the American literature[6].

Ashhurst and Bromer(1922), were the first to attempt to classify ankle fractures. They divided them into abduction, adduction, and external rotation groups. They emphasized on bony components, while ignoring the concomitant ligamentous injuries[5].

Danis, recommended the concept of internal fixation in which the original anatomy of the bone was restored and maintained with stable fixation which allowed immediate movement of the involved joint and adjacent muscles[34].

Bosworth (1947), described the fracture-dislocation of the ankle with entrapment of the fibula behind tibia due to severe external rotation of the foot[7].

Lauge-Hansen(1948), made important contribution to treatment of ankle injuries. He produced these fractures experimentally and termed it as Genetic classification[33].

Denham (1964), observed that the posterior fragment of the tibia moves with the lower end of fibula because of the strength of the inferior tibiofibular ligament in trimalleolar fracture.

Cedel CA and Wiberg G (1964) studied 387 cases of supination-external rotation injuries. They treated all the cases with open reduction and repair of ligaments and concluded that secondary osteoarthritis and instability was less common after surgery[7].

RECENT LITERATURE:

Purvis G D (1982) in a review of 157 displaced unstable ankle fractures has suggested that external rotation injuries causes most of the ankle fractures, with the pronation type injuries being six times more common than the supination type injuries. Accurate rigid fixation of displaced unstable ankle fracturestends to prevent talar tilt and reduces the tendency for arthrosis. If the fibula is not fixed, it tends toshorten and allows tilt or spread of the syndesmosis with resulting arthrosis. Minimal external fixation is desirable, and rapid restoration of motion is needed[8].

Pettrone FA et al.(1983), in a series of 146 displaced ankle fractures the effects of age, sex, side of injury, mechanism of injury, severity as determined by the Lauge-Hansen classification, type of injury (open or closed), open or closed treatment, and internal fixation of one or both malleoli were analyzedusing subjective, objective, and radiographic parameters. The significant parameters were age of the patient, the adequacy of the post-reduction positions of the medial and lateral malleoli, and completeness of the restoration of the deltoid ligament and distal tibiofibular syndesmosis. Open reduction proved superior to closed reduction, and in bimalleolar fractures, open reduction of bothmalleoli was better than fixing only the medial side. Using the data one the first 109 fractures, a multiple linear regression equation was formulated and used to predict the outcomes of the last thirtyseven fractures in the study. The accuracy of the predictions in them was 81 percent[9].

Lindsjo U.(1985), in a prospective study of 321 consecutive cases of ankle fracture dislocation, operatively treated according to the AO (ASIF) principles, followed 306 cases (95%) for up to two to six years after surgery. The infection rate was 1.8% with no septic arthritis. The clinical results were “excellent and good” in 82%, “acceptable” in 8%, and “poor” in 10%. Post-traumatic arthritis occurred in 14% and was significantly more common among middle aged women. There was strong correlation between the degree of arthritis and the clinical result. A computer analysis revealed that the most decisive factors influencing the clinical result were the type of fracture, the accuracy of the reduction, and the sex of the patient. Exact reduction, rigid internal fixation, early postoperative joint exercises, and subsequent full weight bearing in a below the knee walking plaster are essential for a good end result of fracture-dislocations of the ankle joint[10].

Bostman O et al.(1989), a report on a prospective study of 102 patients with displaced unimalleolar and bimalleolar fracture they used cylindrical biodegradable implants 3.2 and 4.5mm in diameter and reported 87% good results[11].

Bray TJ, Endicott M, Capra SE (1989), retrospectively reviewed thirty one open ankle fractures treated over a period of 11 years and with an average follow–up period of sixty one months. Fifteen were managed by closed immobilization and delayed internal fixation. Sixteen were treated with immediate open reduction and internal fixation. Functional scores at follow-up examination were the same for both the groups. The fractures treated with immediate open reduction and internal fixation showed less impairment of range of motion but had a greater incidence of chronic ankle swelling. The hospitalizationtime was significantly shorter for the patients treated by open reduction and internal fixation. Immediate open reduction and internal fixation of open ankle fractures sped the recovery with no greater incidence of infection than encountered with conservative treatment[12].

Georgiadis GM and White DB(1995) retrospectively reviewed twenty-two displaced medial malleolar ankle fractures that were treated surgically using the modified tension band method of Cleak and Dawson at an average follow-up of 25 months. The technique involved the use of a screw to anchor a figure-of-eight wire. There were no malreductions and all fractures healed well. Problems with the technique included technical errors with hardware placement, medial ankle pain, and asymptomatic wire migration. Despite this, modified tension band wiring remains an acceptable method for fixation of selected displaced medial malleolar fractures. It is especially suited for small fracture fragments and osteoporotic bone[13].

Van Laarhoven CJ, Meeuwis JD, Van der WerkenC(1996), in a prospective randomized trial of eighty one patients with fractures of the ankle of AO types A, B and C compared two regimes of postoperative management after internal fixation. The patients were mobilized either non-weight-bearing with crutches or weight-bearing in a below knee walking plaster. They found a temporary benefit in subjective evaluation only for those with a below-knee walking plaster. There were no significant differences between the groups in the loaded dorsal range of movement or in the overall clinical result. Both treatments were considered to be satisfactory and their choice depended on the ability to mobilizenon-weight-bearing, wound healing, the type of work and personal preference[14].

Beris AE et al.(1997), in a major review study of malleolar fractures during 10 year period, that wereclassified and treated according to A-O system. Assessment of the outcome was done using scoringsystems of Baird and Jackson which is based on subjective, objective and radiological criteria. Excellent and good results were achieved in majority who were treated surgically, overall excellent and good results obtained in all unimalleolar fractures. Posttraumatic arthritis was found to be associated significantly with poor clinical results and unsatisfactory surgical reduction. Presence of large bony fragment or dislocation also significantly affected final outcome[15].

R. G. McCormack, J. M. Leith in 1998 did a study on complications of surgical management of ankle fractures in diabetics. They compared the results of the management of displaced malleolar fractures in 26 patients with those of a matched group of non-diabetic patients, using a case-controlled study. The groups were matched for patient age, fracture type and treating surgeon. The incidence of significant complications in diabetic patients was 42.3%. By contrast, there were no complications in the matched group of non-diabetic patients. Of 19 diabetic patients treated surgically, six developed major complications including one case ofmalunion, one of necrosis of the wound edge requiring a flap, and two of deep sepsis. Two patients required amputation and both died. Diabetic patients with displaced ankle fractures treated non-operatively had a high incidence of loss of reduction and malunion but these caused few symptoms. In these patients, non-operative management may have been be preferable in viewof the high risks of major complications after surgeryand the acceptance of malunion by the older patient with lower demands.[16]

Rukavina A in 1998 did a study on role of fibular length and the width of the ankle mortise in post traumaticosteoarthosis after malleolar fractures of the ankle joint by comparison of radiographs of the affected and unaffected sides. They concluded thata shortened fibular malleolus ($p<0.01$), a wide ankle mortise ($p<0.01$) and weber type B facture ($p<0.01$) were significantly associated with the development of osteoarthritis but an elongated fibular ($p>0.05$) and a narrowing of the ankle mortise ($p>0.07$) were not.[17]

Makwana N K, Bhowal B, Harper WM, Hui AW in (2001) did a study on comparative versus operative treatment for displaced ankle fractures in patients over 55 years of age. Of the forty seven patients with displaced fracture of the ankle thirty six were reviewed after a mean of 27 months. The outcome was assessed clinically, radiologically and functionally using the Olerud score. The results showed that anatomical reduction was significantly less reliable and loss of reduction significantly more common in the group with closed treatment. Those managed by reduction and internal fixation had a significantly higher functional outcome score and a significantly range of motion of the ankle[18].

Lee YS et al.(2005),in a series of 168 patients with an isolated displaced lateral malleolar fractures which were surgically treated by Knowles pin between 1995-2000 and the functional results were evaluated byusing Baird and Jackson's ankle scoring system. There was a 100% union rate, and there was no instrumentation problem intra operatively. Three complications occurred but resolved non-operatively. Thus they concluded that Knowles pin fixation for displaced lateral malleolar fractures is effective method, which offers several advantages like, easy application, less soft tissue dissection, less palpable instrumentation, staple fixation and a short operating time[19].

Gerhard K et al. (2005), in a series of 54 patients with closed ankle fracture which were treated surgically, 26 patients were operated on by using a thigh tourniquet and 28 patients had surgery without the use of tourniquet. The objective of this prospective random study was to quantify the effect of tourniquet on postoperative swelling, pain and range of motion after open reduction and internalfixation of ankle fractures .They concluded that using a tourniquet, did increase post-operative pain and swelling. They found a trend that there was a better range of motion until 6 weeks follow up in the non-tourniquet group compared with tourniquet group .Thus use of tourniquet for osteosynthesis of ankle fractures is not recommended[20].

Nirmal C. Tejwani, M.D, Toni M, et. al., in (2007) studied 456 patients in whom an unstable fractures of ankle where treated surgically. At one year after surgical stabilization of an unstable ankle fracture, most patients, experienced little or mild pain and had few restrictions in functional activities. However, the functional outcome for those with a bimalleolar fracture wasworse than that for those with a lateral malleolar fracture and destruction of the deltoid ligament, possibly because of the injury pattern and the energy expended[21].

Paul B et al, in (2007) has shown that when a patient has suffered a simple oblique or spiral fracture of the lateral malleolus and has good bone quality, lag screw only fixation is preferable to plate osteosynthesis. The lag screw method has several advantageous characteristics over that of plate osteosynthesis including, in particular, less soft tissue dissection, less prominent, symptomatic and palpable hardware and areduced requirement for secondary surgical removal.[22]

DolfiHerscovici et al, in (2008) concludedthat , pronation external rotation ankle fractures, syndesmotic injuries and talar neck fractures are common problems seen by most orthopaedic surgeons. Adequatepreoperative evaluations, sufficient visualization of the pathological characteristics and use of good surgical techniques should decrease the rates of complications associated with the management of these injuries[23].

Nelson E, SooHoo M.D., et al, in (2009) by analyzing a large, diverse patient population, it clarified the risks associated with open reduction and internal fixation of ankle fractures. Open injury, diabetes, and peripheral vascular disease were strong risk factors in predicting a complicated short term postoperative course. Fracture type was a strong predictor of reoperation for ankle fusion or replacement. Hospital volume did not play a significant role in the rates of short term or intermediate term complications[24].

R. Mohammed. S Syed, S. Metikala S.A. Ali in (2011) evaluated syndesmotic only fixation for Weber-C ankle fractures with syndesmotic injury and concluded thatsyndesmosis-only fixation as an effective treatment option for a combination of syndesmosis disruption and Weber type C lateral malleolar fractures[25].

Szczesny G, Janowicz J in (2012) concluded that minimally invasive technique is an alternative to the traditional method. It allows for proper stabilization with minimal soft tissue traumatization, and thus could be recommended for patients with coexisting massive injuries affecting soft tissues and for those who do not agree to open reductions for cosmetic reasons. It allows for reduction in operation time and hospital stay. Nevertheless, it involves higher exposition to fluoroscopy and, in some cases, widening of surgical approach.[26]

Kim GD et al in (2013) after studying medial malleolar insufficiency fractures of the ankle in an elderly patient with osteoporosis concluded thatpostmenopausal osteoporosis is the most common cause of insufficiency fractures. An early diagnosis is best made with a bone scan or magnetic resonance imaging, as radiographs may initially appear normal[27]

Song KS et al in (2013) after doing a study on false negative rate of syndesmotic injury in pronation external rotation stage 4 ankle fractures concluded that it is important to understand the fracture pattern characteristic of PER stage IV ankle fractures even though it appears normal on anteroposterior radiographs. It is to be confirmed for the concealed syndesmotic injury by the use of routine intraoperative external rotational stress radiograph.[28]

Isk C et al in (2013) after studying plate-screw and tension band techniques in the osteosynthesis ofDanis-Weber type A and B lateral malleolar fractures it was concluded thatboth surgical techniques used in thetreatment of Danis-Weber Type A and B fractures give excellent results. The tension band technique in the treatment of lateral malleolar fractures is a cheap and clinically acceptable treatment alternative. For reasons such as less impairment of periosteal circulation, less mechanical irritation where there are skin problems in the surgical area, the need for a shorter incision, no problems such as screw loosening and no need to remove an implant, the tension band technique had conspicuous superiority. Plate and screw should be the choice in comminuted fractures, oblique fractures or osteoporotic fractures, where they provide better control of the fibular length and a more rigid fixation.[29]

SURGICAL ANATOMY[30,31]

The ankle is a composite joint (hinge). It consists of two dissimilar articulations: syndesmosis connecting the distal end of crural bones and diarthrosis between their ends and talus. The ankle is a mortise in which the talus is constrained by the fibula laterally and tibia both superiorly and medially, this configuration as also been referred to as the malleolar fork.

<u>TALOCRURAL JOINT (ANKLE JOINT)</u>:

The talocrural or ankle joint consists of tibial plafond including the posterior malleolus, articulating with the body of the talus, and the medial malleolus and the lateral malleolus. The ankle is complex hinge in which both bones & ligaments play important and inseparable roles.

The ankle often is divided into medial, lateral, and syndesmotic complexes to help the physician to understand the mechanism of injury better and to devise a treatment plan. The medial complex consists of the medial malleolus, the medial facet of the talus, and the superficial and deep components of the deltoid ligament, the lateral complex consists of the distal part of the fibula, the lateral facet of the talus, and the lateral collateral ligaments of the ankle and subtalar, and the syndesmotic complex the articulation between the tibia and the fibula as well as the interconnecting ligaments of the syndesmosis and the interosseous membrane.

<u>SKELETAL COMPONENTS OF ANKLE JOINT</u> (Fig. 1)

<u>TIBIA</u>: The tibial shaft flares distally and the bone changes from tubulocortical to metaphyseal and cancellous. It is quadrilateral in cross section, terminating in an articulating surface. The anteromedial aspect of the distal tibia is notable for prominent medial malleolus, which carries the medial articular surface of the ankle mortise. It is smaller than the lateral malleolus and can be divided into an anterior colliculus, covered laterally with articular cartilage, and posterior colliculus. The inferior surface is articular, concave antero-posteriorly, and slightly convex transversely, dividing the surface into a wider lateral and narrower medial segment. Laterally the distal tibia is indented by a shallow groove or incisura for the fibula. This is joined by a larger anterior tubercle (Chaput’s or Tillaux-Chaput’s) andsignificantly smaller posterior tubercle also known as the third malleolus or the Volkmann’s process. The posterior border of the ankle joint is lower than the anterior border. The posterior border is in continuity with the posterior surface of the medial malleolus.

FIBULA: The distal fibula becomes triangular in cross section and is known as the lateral malleolus.There is a triangular facet that has its facet inferiorly, located on the medial surface, which articulateswith lateral surface of the talus. Posterior to this facet is the fibular fossa. The lateral malleolus extends about 1 cm lower than the medial malleolus and is located more posteriorly.

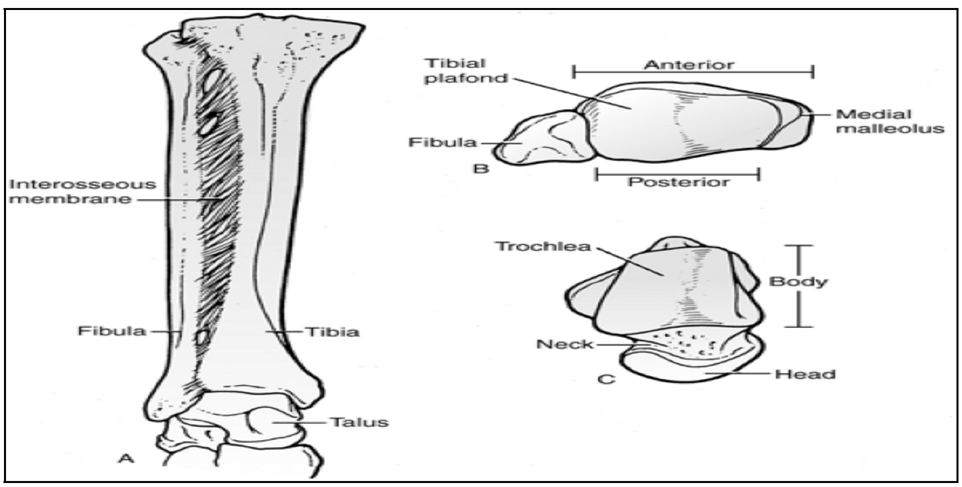


Fig. 1 SKELETAL COMPONENTS OF ANKLE JOINT

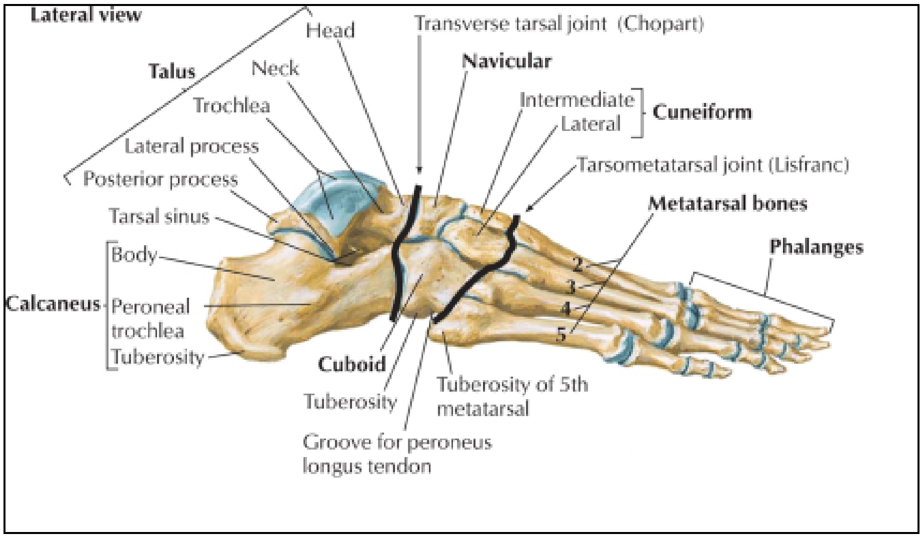


Fig. 2 ANKLE (ONLY TALAR HALF) WITH FOOT

TALUS: The body of the talus, superiorly is formed by the trochlear articular surface, which carries the body weight to the joint. The dome of the talus is trapezoidal, with the anterior surface wider than the posterior surface. The superior surface is convex from front to back and it is slightly concave from side to side. The medial and the lateral facets of the talus are continuous with the superior articular surface. The talus is almost entirely covered by articular cartilage, with no musculotendinous attachments.

LIGAMENTS:[Fig.3]

The ligaments supporting the ankle joint are considered to be made up of three distinct groups:

A) The lateral collateral ligaments and

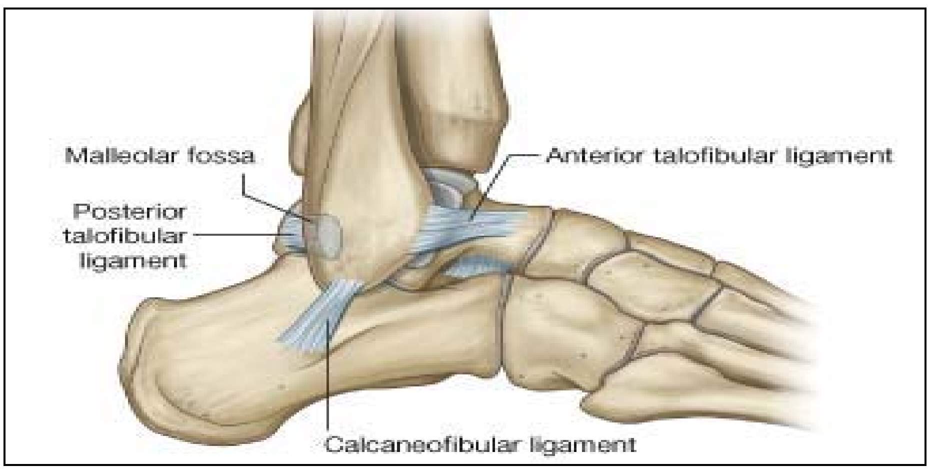
B) The medial collateral ligaments

C) The syndesmotic ligaments

<u>THE LATERAL COLLATERAL LIGAMENTS</u>:

It is made up of three portions:

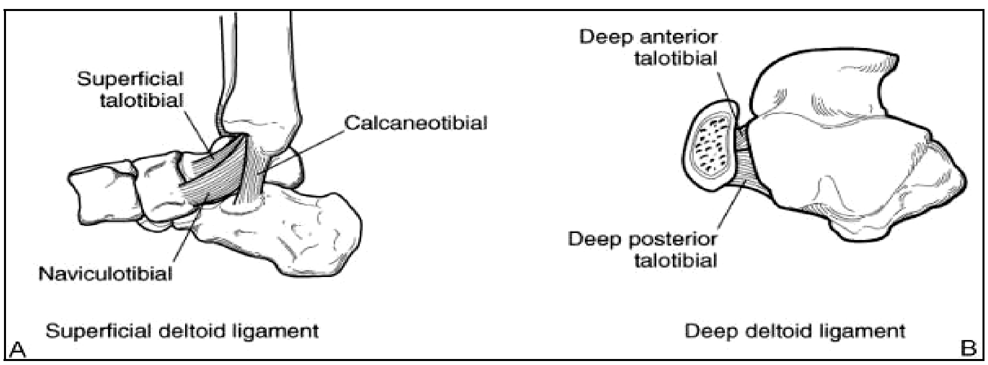
- Anterior Talofibular Ligament : Directed anteromedially, it originates from the inferior oblique segment of the anterior border of the lateral malleolus inserting on to the talar body, prevents the anterior subluxation of the talus when the ankle is plantar flexed.
- Posterior Talofibular Ligament : Nearly horizontal, it originates from the medial surface of the lateral malleolus and inserts on the posterior surface of the talus. It resists posterior and rotator subluxation of the talus. The posterior talofibular ligament is the stronger of the two.
- Calcaneofibular ligament : A short flat oval ligament originating from the lower segment of the anterior border of the lateral malleolus, running deep to the peroneal tendons, and inserting on the posterior aspect of the lateral calcaneus. This ligament resists inversion with ankle in dorsiflexion and stabilizes both ankle and subtalar joint.



THE MEDIAL COLLATERAL LIGAMENTS:

The medial collateral ligament (Deltoid ligament) is a large strong triangular ligament spreading fan shaped over medial aspect of ankle joint. It consists of two parts namely, the superficial part and the deep part.

- The Superficial Deltoid ligament: It arises at the anterior colliculus and distally goes to the talus, the calcaneus and the navicular. It is responsible for resisting eversion of the calcaneus.
- The Deep Deltoid ligament: Short thick ligament that originates from the wider area between the anterior and the posterior colliculi, inserting on the medial surface of the talus. It is the primary medial stabilizer of the ankle joint. It restrains external rotation of the talus in the mortise.

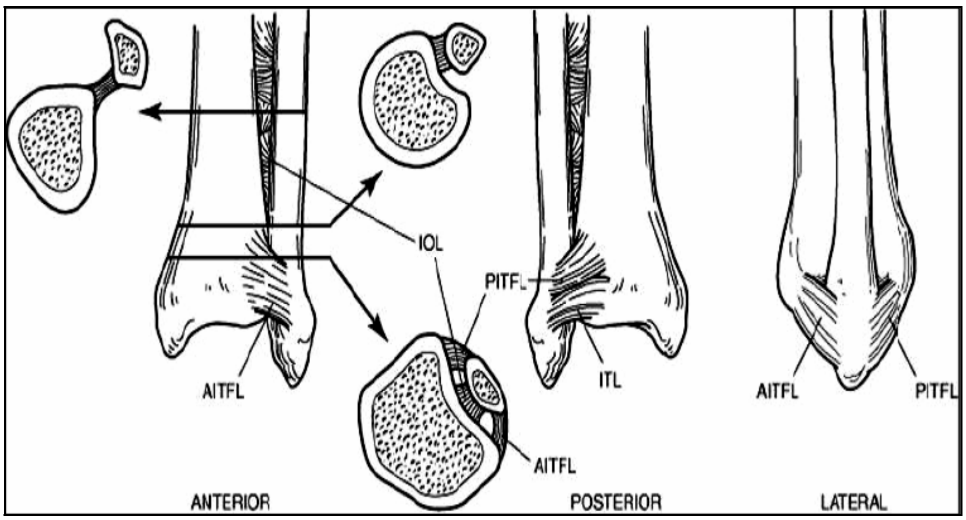


THE SYNDESMOTIC LIGAMENTS:

The syndesmosis is the most significant ligamentous complex, which unites the distal tibia and the fibula and is largely responsible for the structural integrity of the ankle mortise. It consists of three portions, namely AITFL, PITFL and Interosseous ligament. The anterior inferior tibiofibular ligament (AITFL) runs obliquely slightly distally from the antero-lateral tubercle of the tibia to the anterior portion of the lateral malleolus.

The postero-inferior tibiofibular ligament (PITFL) runs obliquely proximally from the posterior tubercle of the lateral malleolus to the posterior border of the tibial articular surface.

The posterior tibiofibular ligament is longer than the anterior tibiofibular ligament. The interosseous ligament, a thickening in the tibiofibular interosseous membrane, a short and variable distance above the ankle. It is the key transverse stabilizer of the ankle.



Syndesmosis relationship

AITFL = anterior inferior tibiofibular ligament IOL = interosseous ligament

PITFL = posterior inferior tibiofibular ligament ITL = inferior transverse ligament

Fig 3 Syndesmotic ligaments of ankle

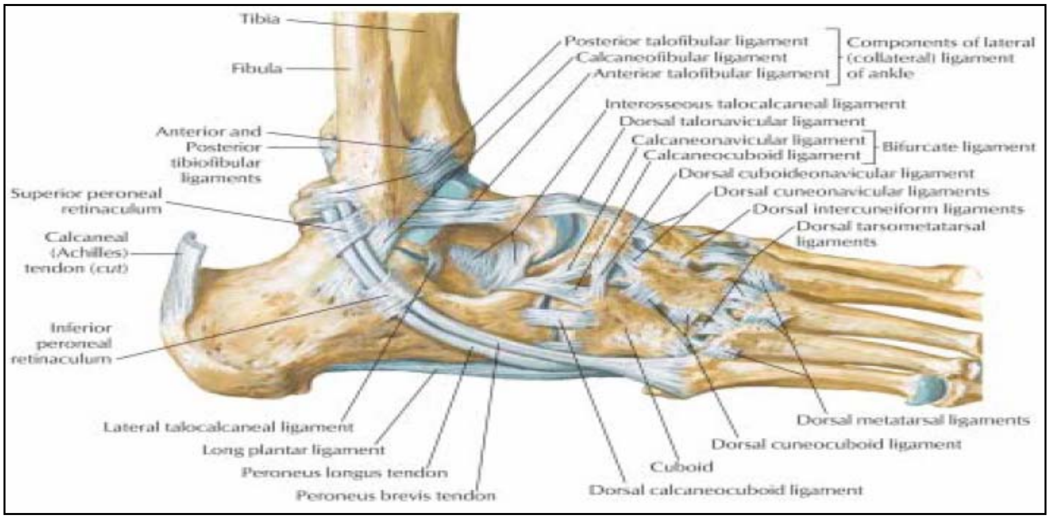


Fig 4. Lateral Collateral Ligaments of Ankle

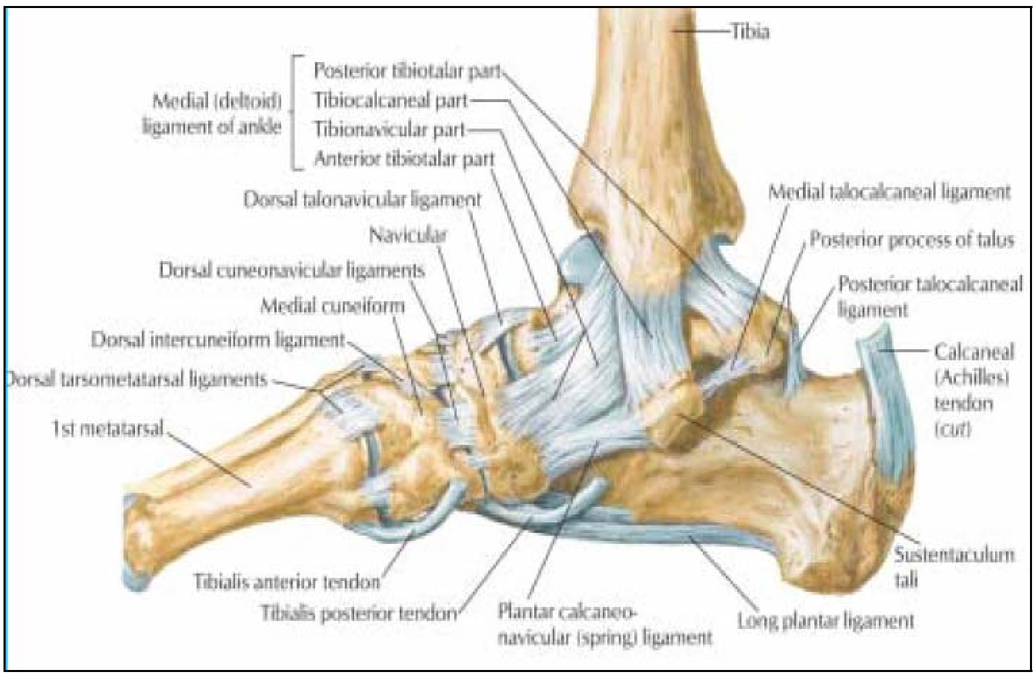


Fig 5. Deltoid Ligament of the Ankle

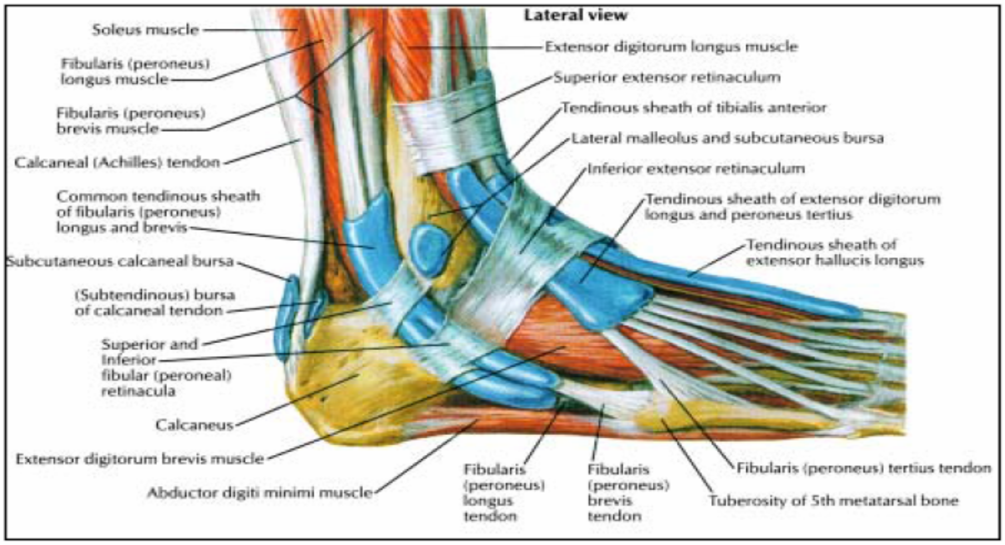
<u>TENDONS AND NEUROVASCULAR STRUCTURES</u>: [Fig .6, 7 & 8]

Five nerves, two major arteries and veins, and 13 tendons cross the ankle. Superficially and posteriorly, the powerful plantar flexor of the ankle, the tendocalcaneus tendon is prominent. The plantaris tendon runs along the medial border of the Achilles tendon and attaches to calcaneus just medial to it. Immediately lateral to the Achilles tendon is the sural nerve, which innervates the skin on the lateral heel and lateral border of the foot.

On the lateral side of the ankle, the peroneal tendons are transmitted under the superior peroneal retinaculum, posterior to the fibula. As they reach the lateral border of the foot, the peroneus longus crosses plantarwards under the peroneus brevis to insert on the proximal first metatarsal and first cuneiform. The peroneus brevis inserts on the base of fifth metatarsal.

On the medial side of the ankle, the flexor tendons are transmitted under cover of the retinaculum. Immediately posterior to the medial malleolus, the posterior tibial tendon, with the flexor digitorumlongus, the posterior tibial artery and associated vein with the tibial nerve, flexor hallucislongus, in that order, posterior.

Anterior to medial malleolus courses the saphenous vein and accompanying nerves. On the anterior aspect of the ankle, the extensor retinaculum restrains the external tendons, anterior tibial vessels and the deep peroneal nerve. They are from medial to lateral – Tibialis anterior tendon, Extensor hallucislongus tendon, Anterior tibial artery, Deep peroneal nerve, Extensor digitorumlongus tendon and Peroneus tertius.



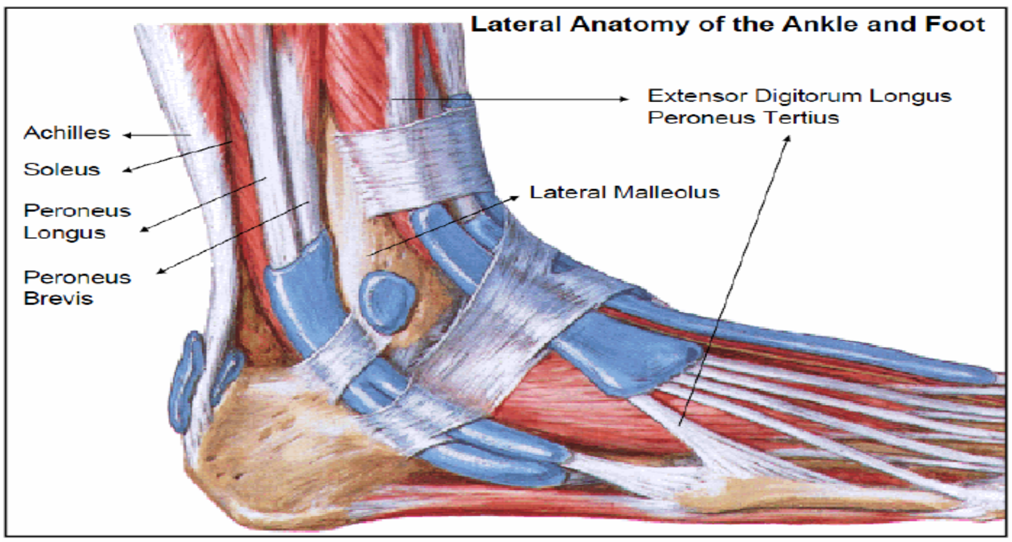
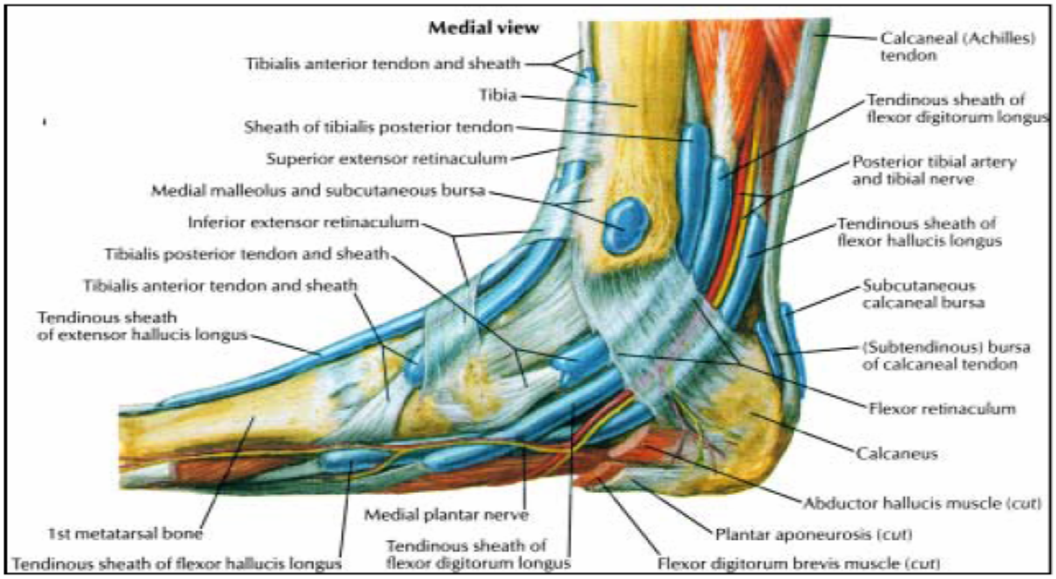


Fig 6 : Tendon Sheaths of Ankle (Lateral View)



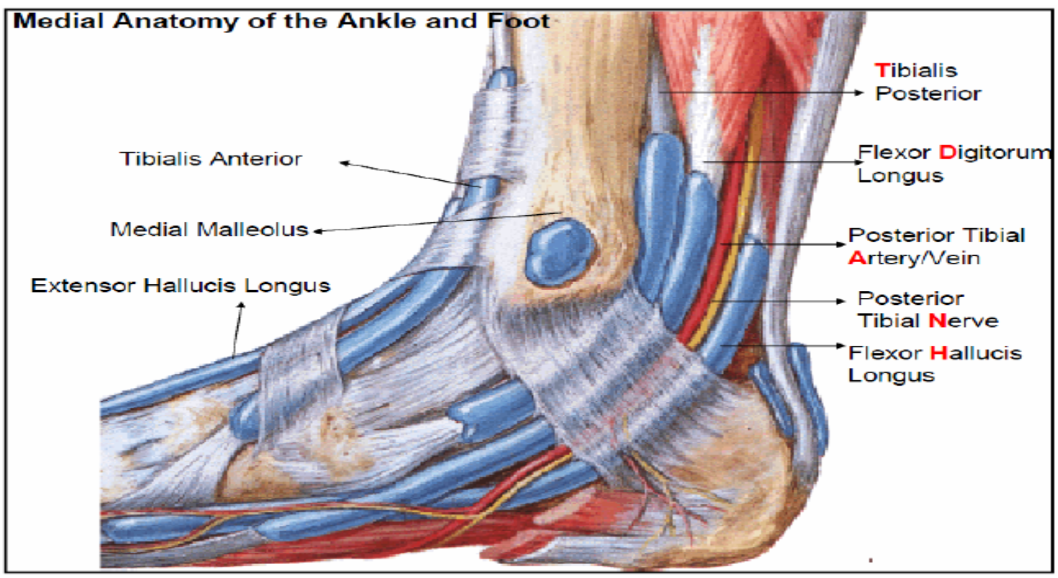


Fig 7 : Tendon Sheath of Ankle (Medial View)

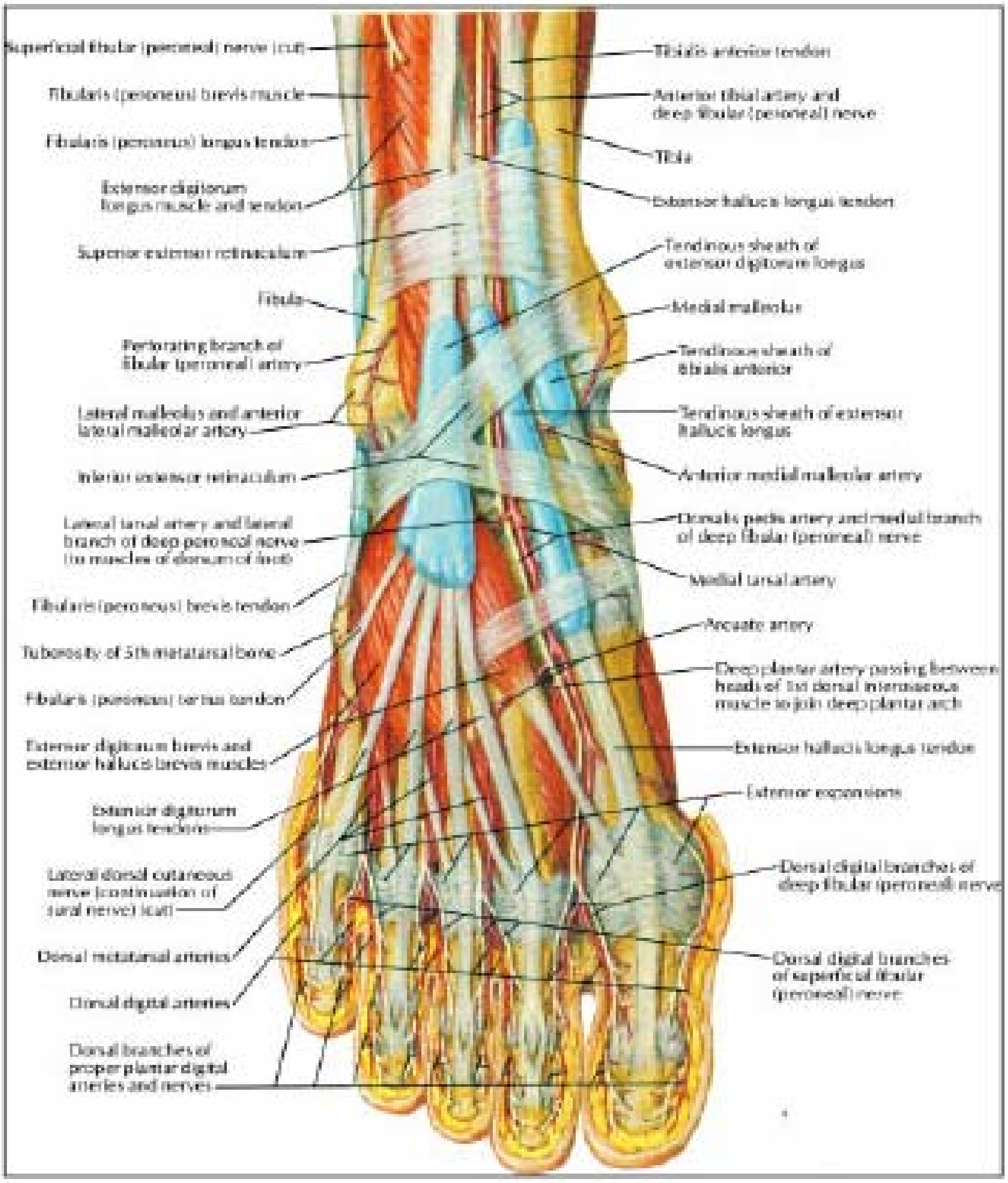


Fig 8 : Tendons And Neurovascular Structures Over The Anterior Aspect Of Ankle

MOVEMENTS OF THE ANKLE :

The movements of the ankle joint are hinge in nature which occur about an axis through the body of talus. They are - Dorsiflexion - about 20- 25°, Plantar flexion – about - 35-50°.

Muscles assisting in dorsiflexion are tibialis anterior, extensor digitorumlongus, extensor hallucislongus and peroneus tertius muscle. Those limiting dorsiflexion are tendoachillis, deltoid ligament and talocalcaneal ligament. Calcaneofibular ligament is the prime stabilizer in dorsiflexion of ankle joint. With dorsiflexion there is external rotation and posterior gliding of the talus.

Muscles assisting plantar flexion are tibialis posterior, flexor hallucislongus and flexor digitorumlongus and those limiting plantar flexion are anterior talofibular ligament, anterior fibres of deltoid ligament, soleus and gastrocnemius.

The anterior talofibular ligament is taut in plantar flexion thereby providing stability during inversion. This motion occurs around an axis which passes in the frontal plane below and infront of tip of lateral malleolus. This axis makes an angle of 30 degree with bimalleolaraxis. This arrangement accounts for the greater excursion between lateral surface of talus to lateral malleolus. This is also the reason for occurrence of little inversion with plantar flexion and eversion with dorsiflexion. Whatever movement occurs at anteroposterior axis is called adduction and abduction and is resisted by collateral ligaments. Other movements which are associated with ankle movements are inversion and eversion. These movements occurs at subtalar joints, calcaneocuboid and calcaneonavicular joints. Muscles assisting inversion are tibialis anterior, tibialis posterior, and those assisting eversion are peroneus longus and peroneus brevis.

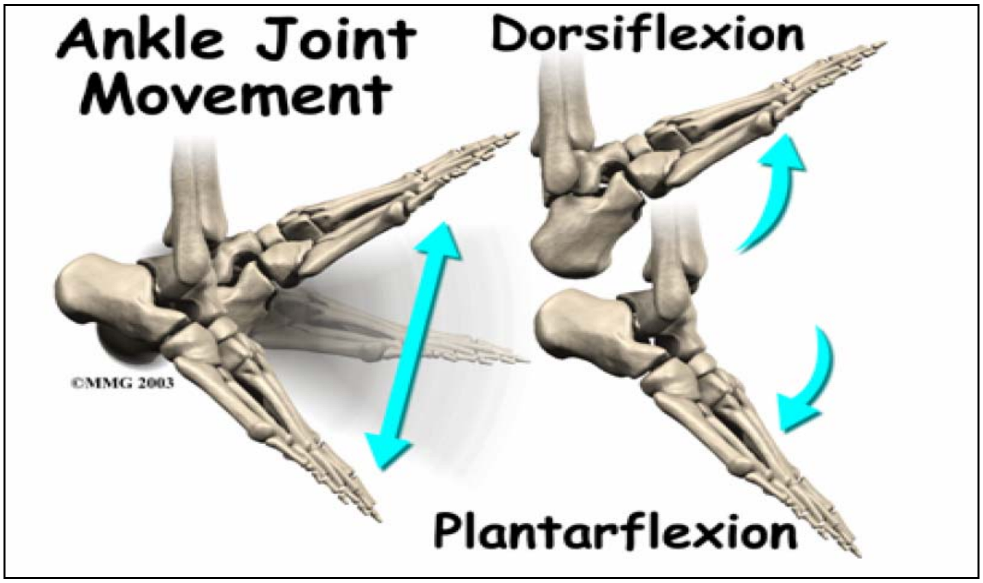


Fig 9: Ankle Joint Movements

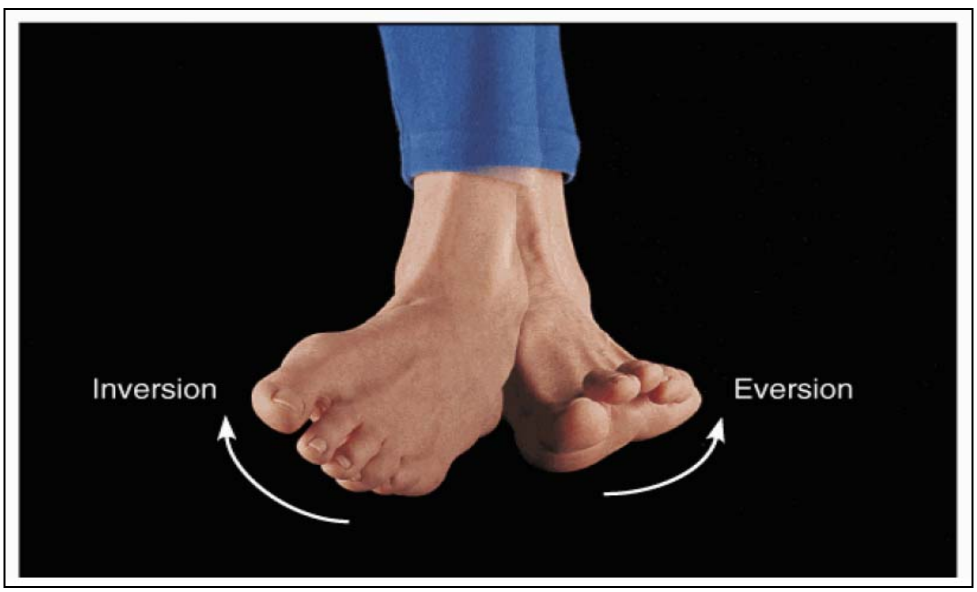


Fig 10 : Inversion and Eversion at subtalar joint

Normal Movements of Ankle Joint

Sl. No.	Movements	Range of Movements in degree	Muscle Acting	Nerve Supply
1	Dorsiflexion	20-25	Tibilias anterior External digtorium longus External hallucis longus Peroneus tertius	Deep peroneal nerve
2	Plantarflexion	35-50	Tibialis posterior Flexor hallucis longus Flexor digitorum longus	Tibial nerve
3	Inversion	0-35	Tibialis anterior Tibialis posterior	Deep peroneal nerve Tibial nerve
4	Eversion	0-35	Peroneus longus Peroneus brevis	Superficial peroneal nerve

BIOMECHANICS[32]

Normal motion of the ankle joint is predominantly in the sagittal plane, but it involves variable degrees of rotation around the vertical and longitudinal axis.

Inman described the empiric axis of the ankle joint as passing approximately 5 mm distal to the tip of the medial malleolus and 3 mm distal and 8 mm anterior to the lateral malleolus. Although the concept of a single axis may be helpful for optimizing placement of a single-axis external fixator, in reality, the ankle joint has a continuously changing axis of rotation. In dorsiflexion, the axis is inclined downward and laterally, whereas in plantar flexion, the axis is inclined downward and medially. The changing axes of rotation can be explained on the basis of the variable contours of the medial and lateral talar dome trochlea. During dorsiflexion of the ankle, the intermalleolar distance increases approximately 1.5 mm as the fibula rotates externally and displaces laterally. This motion is coupled with the lateral rotation of the talus and is controlled by the matching wedge contour of the talus in the mortise.

The syndesmosis firmly binds the tibia to the fibula. With the deltoid ligament, it contributes to the rotational stability of the talus in the ankle mortise, and it allows the talus to assume a close-packed configuration with dorsiflexion during the stance phase of gait. Stability of the ankle joint in stance appears to be conferred mostly by articular congruity.

MECHANISM OF INJURY

The ankle fractures occur as a result of strong rotational or predominantly axial Loading forces.[32]

The malleolar fractures are caused predominantly by rotational forces whereas axial loading causes tibial plafond fractures, predominantly.

The malleolar fractures primarily involve lateral or medial malleolus and often other parts of the ankle as well. Shearing and tensile forces apposed through the talus produce them indirectly. Most malleolar fractures occur when the part, including the talus, is fixed on the ground by the body's weight[32].

The type of malleolar fracture that occur depends on two factors: the position of the foot at the time of injury, either supination or pronation, and the deforming force,which are external rotation, abduction or adduction[33,32]. A relative bending moment is created with rotation either in the coronal plane, producing talar adduction or abduction relative to tibia or transverse plane causing relative internal rotation of the tibia on the talus. These injuries are referred to as external rotation injuries[33].

The initial position of the foot is important because it determines which structures are tought and therefore are most likely to be injured first. When the foot is pronated and the deltoid ligament is tense, the initial injury is medial- either a medial malleolar fracture or a deltoid ligament disruption will occur .The two most common injury patterns are the supination external rotation (SER) and the pronation external rotation (PER) types[33].

The supination-external rotation injury begins at the anterolateral corner of the ankle. The structures that are damaged are, in order, the anterior tibiofibular ligament (stage 1), the lateral malleolus (stage 2), the posterolateral aspect of the capsule or the posterior malleolus (stage 3), and the medial malleolus or the deltoid ligament (stage 4)[32].

The pronation-external rotation injury begins on the medial side of the ankle with an injury of the deltoid ligament or the medial malleolus (stage 1) and then progresses around the ankle to the anterolateral ligaments (stage 2), the lateral malleolus or the proximal part of the fibula (stage 3), and the posterolateral ligaments or the posterior malleolus (stage 4)[32].

In supination adductionas the foot supinates the lateral structures tighten, continued supination andadduction force may rupture portion of lateral collateral ligaments or avulse these ligaments from their bony attachment sites on distal fibula, resulting in a transversefracture below the level of syndesmosis. Further adduction drives the talus against themedial side of the joint, resulting in vertical fracture of the medial malleolus and sometimes an impaction fracture of the medial articular surface of the tibia.In pronation abduction the medial structures tighten and are injured first, there is either anavulsion fracture of the medial malleolus or rupture of the deltoid ligament. Theabduction force then either ruptures the syndesmotic ligaments or avulse their bonyattachment sites. Continued lateral force from the talus fractures the fibula at or below the level of the syndesmosis and ruptures the interosseous membrane upto the level of this fracture. This fracture is either transverse or oblique with lateral comminution or abutterfly fragment.

Injuries of the syndesmotic ligaments occur as a result of abduction or externalrotation of the talus within the ankle mortise. This mechanism most commonly occurs inassociation with pronation-externalrotation, pronation-abduction, and occasionallysupination-external rotation injuries (type-C and some type – B injuries)[32].

For a given foot position and the direction of the deforming force, the sequence of injured structure as the force increases is similar and reproducible. But it is important to recognize that in abduction and adduction fractures the direction of deforming force is translational rather than rotational. The supinated feet sustain adduction fractures and pronated feet sustain abduction fractures[32].

Exceptions do occur and that a given injury pattern may have an atypical mechanism or more than one probable cause. It is also likely that more than a single force vector acts during the injury. This may result in variable impaction of the weight bearing plafond, if the joint was loaded axially when the injury occurred. This seems to be a major element in production of large posterior lip fracture, anterior lip fracture and those transitionalmalleolar injuries that have significant associated metaphyseal components[32].

CLASSIFICATION

Several different classification systems of ankle injuries exists, but those in current use are Anatomical types, Lauge – Hansen's system, Danis-Weber system and the AO/Orthopaedic Trauma Association (AO/OTA) system.

ANATOMICAL CLASSIFICATION:

Rotational ankle fractures are typically described by the location of malleolar fracture lines involving the medial, lateral, or posterior malleoli, or more than one of these[32]. Ankle fractures can be classified purely along anatomical lines as monomalleolar, bimalleolar, trimalleolar fractures. This is a simple descriptive system that is commonly used[34].

LAUGE-HANSEN SYSTEM[32]:

Lauge – Hansen's system, reported in 1950, was the first modern classification for fractures about the ankle. It was based on the reproduction of fracture patterns in the cadaver. The classification is a two part nomenclature in which the first word denotes the "position of the foot at the time of the injury" and the second word indicates the "direction of the deforming force". The initial position of the foot is either supination or pronation, and the deforming force is either rotational (internal or external) or translation (abduction or adduction).

Four major fracture types were described: supination-adduction, supinationexternal rotation (SER), pronation-abduction, and pronation-external rotation (PER) fractures. In all these types, the initial injury may be isolated or may be followed in a predictable sequence of further injury to other structures around the ankle. These sequential injuries were described by Lauge-Hansen and account for the subgroups of the classification. The most common injury mechanism is SER, which accounts for the majority of all patterns. The Lauge-Hansen classification is useful because it characterize the mechanism and sequence of injury and in particular, emphasizes the associated ligamentous injuries.

LAUGE – HANSEN CLASSIFICATION

SUPINATION – ADDUCTION (SA):

1. Transverse avulsion–type fracture of the fibula below the level of the joint or tear of the lateral collateral ligaments.
2. Vertical fracture of the medial malleolus.

SUPINATION – EVERSON (EXTERNAL ROTATION) (SER):

1. Disruption of the anterior tibiofibular ligament.
2. Spiral oblique fracture of the distal fibula.
3. Disruption of the posterior tibiofibular ligament or fracture of the posterior malleolus.
4. Fracture of the medial malleolus or rupture of the deltoid ligament.

PRONATION – ABDUCTION (PA):

1. Transverse fracture of the medial malleolus or rupture of the deltoid ligament.
2. Rupture of the syndesmotic ligaments or avulsion fracture of their insertions.
3. Short, horizontal, oblique fracture of the fibula above the level of the joint.

PRONATION-EVERSION (EXTERNAL ROTATION) (PER):

1. Transverse fracture of the medial malleolus or disruption of the deltoid ligament.
2. Disruption of the anterior tibiofibular ligament.
3. Short oblique fracture of the fibula above the level of the joint.
4. Rupture of posterior tibiofibular ligament or avulsion fracture of the posterolateral tibia.

PRONATION – DORSIFLEXION (PD):

1. Fracture of the medial malleolus.
2. Fracture of the anterior margin of tibia.
3. Supramalleolar fracture of the fibula.
4. Transverse fracture of the posterior tibial surface.

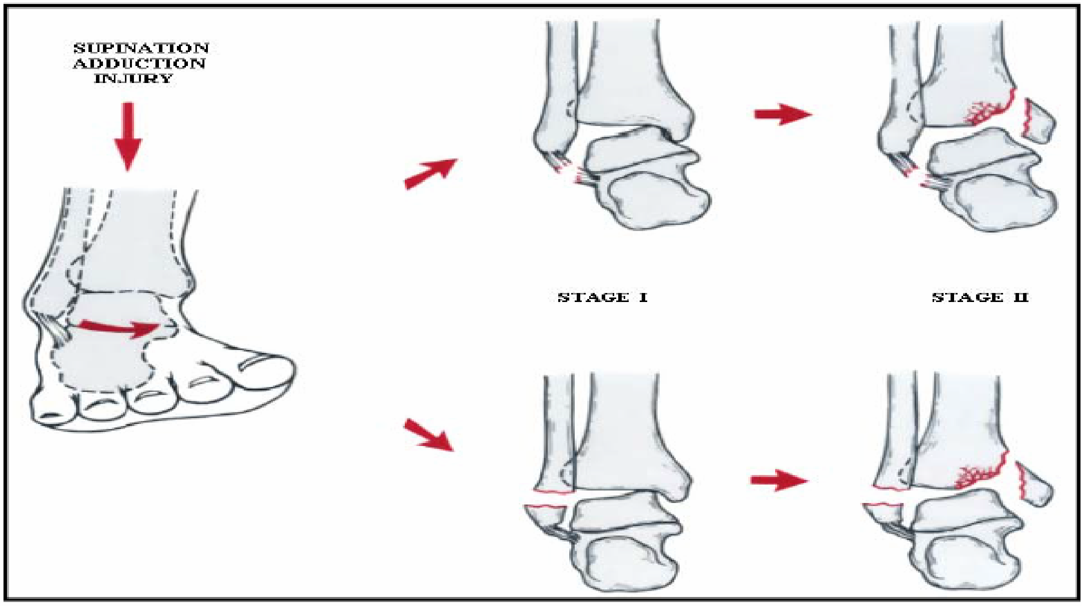


Fig.11 : Supination Adduction Injury

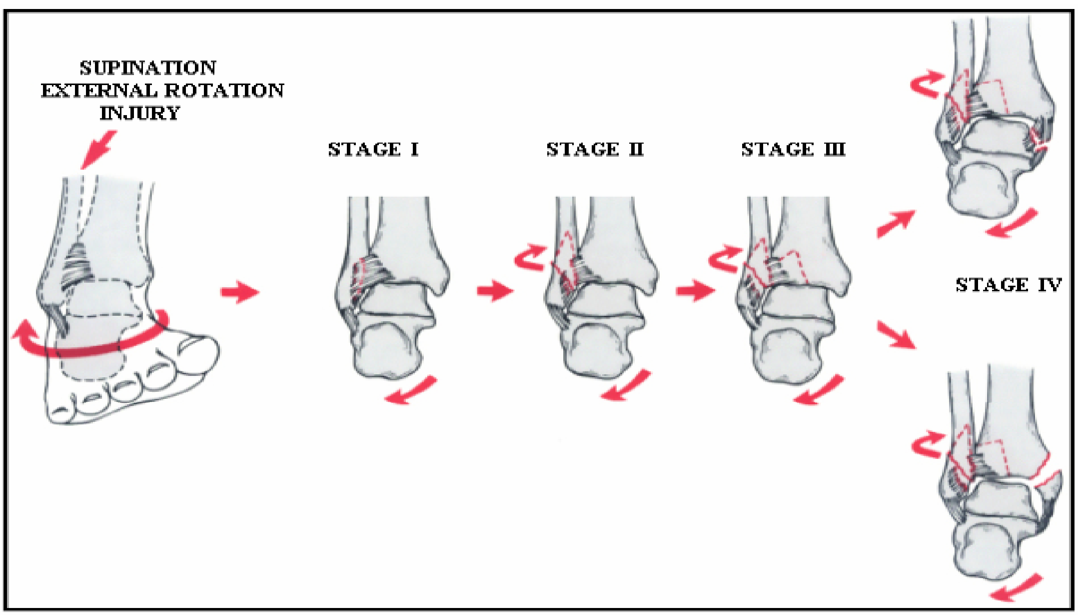


Fig. 12 Supination External Rotation Injury

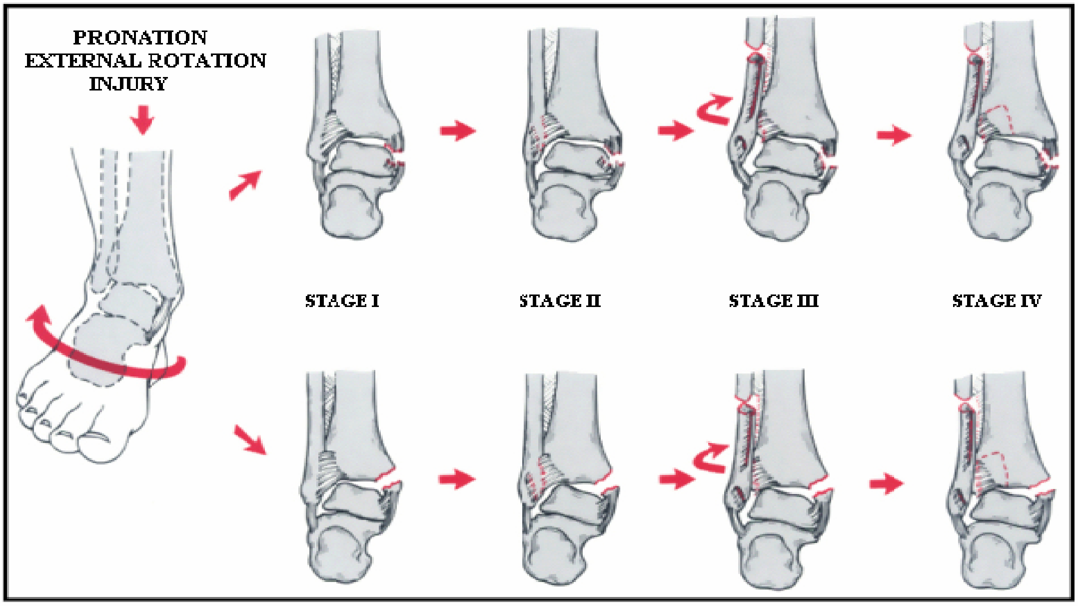


Fig. 13 Pronation External Rotation Injury

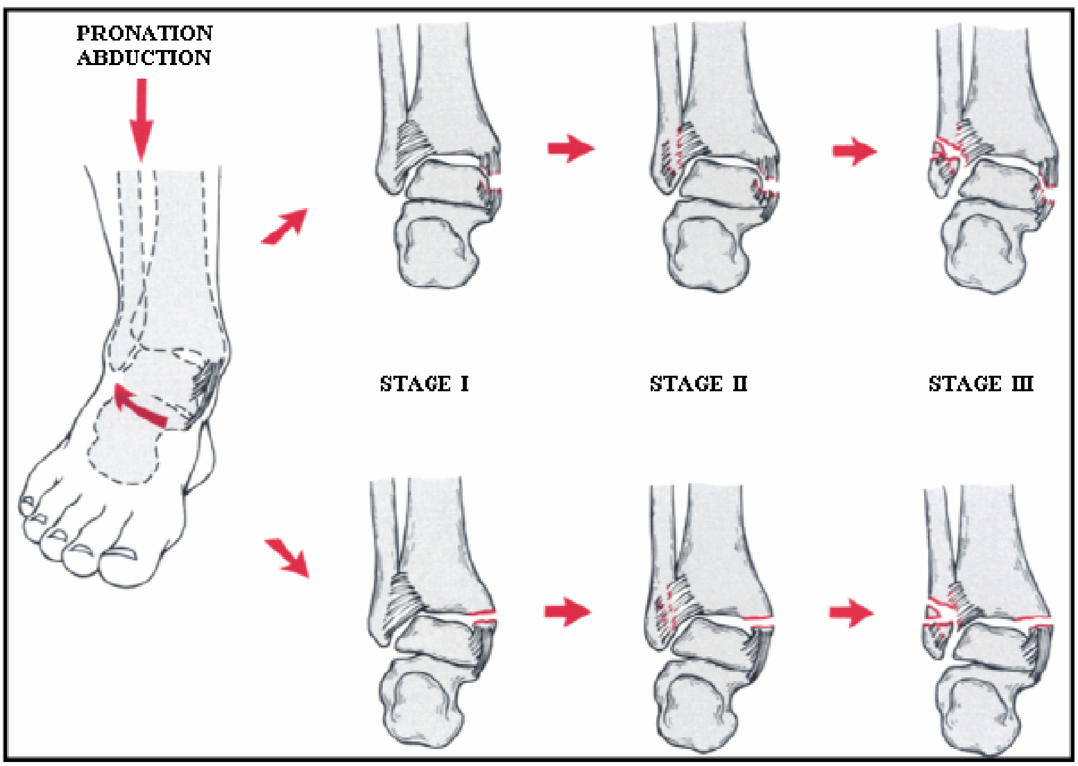


Fig. 14 Pronation Abduction Injury

Summary of Lauge – Hansen's classification

Lauge – Hansen's Type	**Position of foot**	**Direction of talar movement**	**Common terminology**
Supination – external rotation (SER)	Inversion	Lateral rotation	External rotation injury without diastasis
Pronation – Abduction	Eversion	Abduction	Abduction
Pronation –external rotation (PER)	Eversion	Lateral rotation	External rotation with diastasis
Supination – Adduction	Inversion	Adduction	Adduction
Pronation – Dorsiflexion	Eversion	Dorsiflexion	Vertical compression injuries

The Lauge – Hansen's classification uses radiographic features to determine the mechanism of injury, but then it classifies the fractures based on the mechanism rather than directly on the radiographic appearance.

The rationale for the development of the Lauge – Hansen's classification was to guide the closed treatment of fractures about the ankle. It was thought that an understanding of the mechanism of injury would facilitate the manipulative reduction, thus reversing the mechanism of injury and resulting in an optimum reduction. While this system can certainly help to guide closed treatment of unstable injuries, it is fairly complicated and can be difficult to apply.

DANIS –WEBER SYSTEM:

With the advent of modern operative techniques that emphasize an anatomical, rigid fixation, Weber introduced a second classification scheme.

The Danis – Weber system is based on the level of the fracture of the fibula. The risk of injury is greater to the syndesmosis, with more proximal fracture of the fibula,and the more likely that the joint will be unstable[34].

There are three types of fractures in this classification system. The fractures are categorized into types A, B and C, based on the level of the fibular fracture.Type "A" fractures are below the level of distal tibiofibular syndesmosis, "B" fractures at the level of the syndesmosis and "C" fractures above the syndesmosis[34].

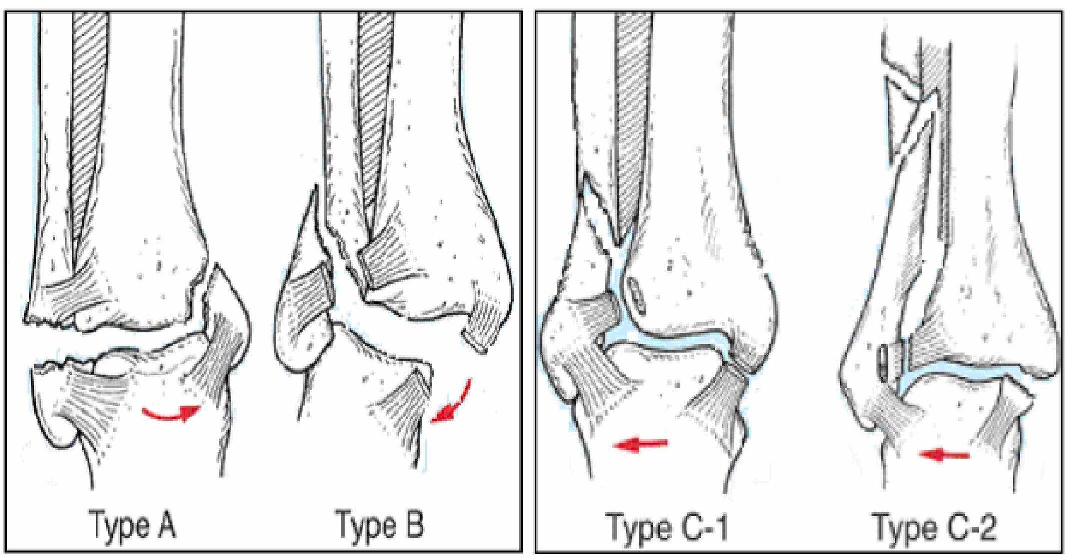


Fig. 15 Danis –Weber's Classification

Summary of Danis Weber Classification

Fracture site in relation to key point	A	B	C
Fibula(in relation to syndesmosis)	Below	At	Above
Deltoid Ligament	Not injured	Injured	Injured
Medial malleolus	High vertical fracture	May present transverse	Transverse
Tibiofibular Syndesmosis	Not damaged	Unlikely to be damaged	Likely to be damaged
Causative force	SA, PA, PER	SE, PA, PER	PA, PER

This classification was attractive for its simplicity and because it guides the treatment. This classification ignored the medial side that is now considered to be an important determinant of the most appropriate treatment. The level of the fibula fracture does not always accurately predict the degree of syndesmosis injury and the level of the fibula fracture may not provide a good guide to prognosis after treatment of lateral malleolar fractures[32].

<u>AO/OTA CLASSIFICATION</u> :

This classification is essentially a detailed, numerically based expansion of the Danis-Weber classification. It is an important research and publication tool. However, as with other detailed classifications, it probably suffers from interobserver and intraobserver variability and it is cumbersome for day-to-day usage.

It uses an alphanumeric code to provide a detailed morphologic description of rotational ankle fractures. It has three types, nine groups and 27 subgroups. The three types, A, B and C have remained the same as those described in the Danis-Weber classification. They are based on the level of the fibular fracture, in relation to the jointline or syndesmosis. Further, details about ligament injuries and medial side injuries have been added to expand the classification into nine groups, 1, 2, and 3 each for types A, B and C. For types A and B, the distinction is made on the presence or absence of characteristics of medial lesion and for type C it is based on the characteristics of the fibular fracture.

The 27 subgroups are based on the factors such as ligament injuries versus bony avulsion and the presence of Chaput's tubercle fracture (anterolateral corner of the tibia), Le Fort's avulsion (Fibular insertion of anterior tibial ligament), and Volkmann's fragment (posterior margin the tibia). These additions address some of the concerns about the incompleteness of the Weber system[32].

AO/OTA CLASSIFICATION:

Type A – Fibula fracture below syndesmosis (Infrasyndesmotic)

A1 – Isolated

A2 - With fracture of medial malleolus

A3 - With a postero – medial fracture

Type B- Fibula fracture at the level of syndesmosis (Trans-syndesmotic)

B1 – Isolated

B2 - With medial lesion (malleolus or ligament)

B3 - With medial lesion and fracture of posterolateral tibia

Type C – Fibula fracture above syndesmosis (Suprasyndesmotic)

C1 – Diaphyseal fracture of fibula, Simple

C2 – Diaphyseal fracture of fibula, Complex

C3 – Proximal fracture of fibula.

Both the Lauge – Hansen and the AO/OTA system are comprehensive classifications that allow the majority of the ankle fractures to be classified. Unfortunately, using the complete versions of these classifications, it is currently not possible to consistently classify fractures with a high degree of reliability and reproducibility[32].

Currently, no classification systems can substitute for complete and accurate description of the fracture. The history, aspects of the physical examination and x-ray appearance all should be used to characterize a given injury completely, to provide optimal treatment, and to determine prognosis[32].

ATYPICAL MALLEOLAR FRACTURES:

A certain number of malleolar fractures are not classifiable according to the schemes presented. Those caused by direct crushing or angulating forces, as seen often in open injuries, frequently fall into this category[33].

- Lefort–Wagstaffe fracture – Avulsion fracture of anterior cortex of lateral malleolus.
- Wagstaffe fracture – Isolated fracture of posterior lip of tibial plafond caused by supination external rotation injury. This is caused directly after inferior tibiofibular ligament tear.
- Volkmann’s Fracture – Fracture involving anterior margin associated with distal shaft of tibia, with fracture of medial malleolus, fibular shift with diastasis of inferior tibiofibular syndesmosis.

- Kerbstone fracture – avulsion fracture of posterior tibial margin by forced plantar flexion.
- Coonrad fracture – Important fracture of lateral weight bearing surface of tibia, a shearing injury in which the talus is impacted laterally against the tibial plafond compress the subchondral bone and impacts displaces the lateral articular portion superiorly.

Any classification system that attempts to categorize all possible combinations will become complex and difficult to use or remember. There is some advantage in understanding these different systems because each emphasizes features of the anatomy and biomechanics important in evaluation and treatment planning. All of these systems require a thorough evaluation of the patient, and treatment decisions should not be made only on the basis of radiographic appearance or classification categories.

MANAGEMENT

DIAGNOSIS:

History: The major points to be gained from the history of a patient with an injured ankle are as follows:

1. How, when and where the injury happened,
2. The pre-existing status of the injured part and
3. The overall medical condition of the individual.

The ankle fractures usually result from low-energy rotational forces sustained during sports or a misstep during routine activities of daily living.

The mechanism of injury is only occasionally presented in a way that provides definitive understanding of the direction and magnitude of applied force and a good clue to the diagnosis. But despite the use of mechanistic classifications, the patient is rarely accurately aware of the position of the foot or the direction of the deforming force, and this information is better derived from the x-rays[35]

The status of the leg before the present injury is also important. Evidence of neurological difficulty (diabetes mellitus), vascular disease, venous stasis ulcers, claudication, or chronic infectionshould be sought[35].

Systemic illness clearly has an impact on overall management and often on local treatment choice as well. Smokers have a higher risk of problems with wound and fracture healing. An alcoholic person may not be able to cooperate with limited weight bearing. A patient with cardio-respiratory disease may not be able to handle the energy cost of walking with crutches or a cast[35].

PHYSICAL EXAMINATION:

A careful examination is needed to determine the status of the skin, soft tissues and neurovascular structures, as well as the bones and ligaments. The entire lower leg, including the full length fibula should be examined.

The ankle should be inspected circumferentially for open or impending wounds, crushed, abraded, or swollen areas, and bony deformity. The vascular examination must include palpation of the posterior tibial and dorsalis pedis pulses, any swelling or deformity may interfere with this.

Testing light touch and pain sensation in each of their sensory areas, assesses the nerves that cross the ankle. The medial border of the foot is innervated by the saphenous nerve. The dorsal webspace between the great and second toe is the territory of the deep peroneal nerve. The superficial peroneal nerve provides sensation for the majority of the dorsum of the foot. The sural nerve supplies the lateral heel and lateral border of the foot. The sole is innervated by the medial and lateral plantar nerves, branches of the tibial nerve. Initial motor examination is confined to dorsiflexion and plantar flexion of the toes, but this should be accurately described and graded.

Function of the tendons crossing the ankle may be difficult to assess but must be checked initially and then reviewed as a more thorough examination becomes possible. The Achilles tendon is checked by palpation for tenderness or a defect and by means of Thompson's test.

Examinations for range of motion and stability should be deferred if an obvious injury is present on the basis of either physical examination or radiographs. The average nge of motion is about 30° dorsiflexion and about 30° to 45° plantar flexion. In assessing the ankle's range of motion, it is important to recognize that a surprising amount of dorsiflexion and plantar flexion occurs in the tarsal and tarsometatarsal joints. A better estimate of true ankle motion is obtained, as Segal suggested, by measuring the angle between the tibia and the weight-bearing surface of the foot, while the patient dorsiflexes maximally. The angle between the plantar surface of the heel only and the tibia is the measure of plantar flexion. By measuring the angle between the leg and the surface on which the foot rests, tibiotalar motion can be better distinguished from that of more distal joints. Inversion and eversion are intimately associated with ankle motion and should be assessed as well[32].

Stress testing is often difficult in the acute setting, and analgesic premedication and local or regional anaesthesia may be needed.

Various stress tests include:

- The anterior drawer maneuver evaluates the anterior talofibular ligament. With the ankle in neutral position, a forward force is applied to the heel while a backward force is applied to the tibia. A different of more than 8 mm compared with the opposite side suggests an injury.
- An inversion (supination) stress test is performed with the ankle in plantar flexion to test the anterior talofibular ligament and in neutral or slight dorsiflexion to test the calconeo fibular ligament. The ankle is inverted and comparison made to the opposite side.
- An eversion stress test is performed with the ankle in neutral and tests primarily the superficial deltoid ligament complex.
- An external rotation stress test evaluates the syndesmotic ligaments. The tibia is stabilized, the ankle placed in a neutral position, and the foot externally rotated.

Sideways movement of the talus within the mortise suggests instability of the mortise, with laxity or rupture of the syndesmotic ligaments. This may produce pain and may also be associated with a sensation of the talus moving laterally or clicking back against the medial malleolus after having been subtly displaced away from it[32].

RADIOLOGICAL EXAMINATION :

The standard radiographic evaluation of the ankle includes anteroposterior, lateral and mortise views. Localized malleolar tenderness or inability to bear weight is the best indication to obtain ankle radiographs[32, 36.]

Anteroposterior x-ray is taken in line with the second ray of the foot. The entire fibula should be included on this radiograph if there is any tenderness in the proximal fibula. The lateral view is obtained with the tibia perpendicular to the long axis of the foot and the beam is centered on the talus. The mortise view (true AP view) is obtained with the patient's leg internally rotated approximately 150, so that the x-ray beam is perpendicular to the intermalleolar line[32]. An external rotation lateral view may be helpful in assessing fractures of the posterior malleolus.

RADIOGRAPHIC MEASUREMENTS OF ALIGNMENT AND STABILITY :

After an injury or reduction, x-ray studies are used to determine the adequacy of alignment and to infer the degree of stability. Standard x-ray measurements can be used to help determine whether this has been achieved. These parameters can provide the objective measurements of instability and are useful not only in the diagnosis but also in planning the treatment and in assessing the accuracy of reduction and final results.

The parameters that typically can be obtained are as follows :

<u>Talocrural angle</u> :

The talocrural angle is the angle subtended by a line drawn parallel to the articular surface of the distal tibia and one connecting the tips of both malleoli. Normally, the angle ranges from 4 to 11 degrees. Another method of measurement is to use the angle formed by a line perpendicular to the distal tibia articular surface and the intermalleolar line. This angle is normally 83+4 degrees. By either method, this angle should be within 2 degrees to 3degrees of the opposite side. A difference of greater than this is abnormal and indicates fibular shortening[32]**.**

<u>Medial clear space</u> :

On the mortise view, the distance between the lateral border of the medial malleolus and the medial border of the talus (the medial clear space) should be equal to the superior clear space between the talus and the distal tibia. A space greater than 4 mm is considered abnormal and indicates a lateral shift of the talus[32].

<u>Syndesmotic integrity</u>:

Evaluating syndesmotic widening is perhaps the most difficult task when interpreting ankle x-rays for alignment and stability.

- The simplest approach is to measure the distance between the medial wall of the fibula and the incisural surface of the tibia. This *tibiofibular clear space* should be less than 6 mm on both AP and mortise views (28).A wider space indicates syndesmotic injury.
- Another method is by measuring the *tibiofibular overlap*. On the AP view, this tibiofibular overlap is measured between the lateral border of the anterior

tibial prominence and the medial border of the fibula. An overlap of less than 10mm is abnormal and indicates a syndesmotic injury, resulting in separation of the tibia and fibula. On the mortise view, this tibiofibular overlap should be 1mm or less. It should be apparent that plain x-rays of good technical quality are essential to evaluate the ankle. They define the bony anatomy and provide direct or indirect evidence of joint instability. Abnormal talar tilt (especially into valgus), increased width of the mortise, subluxation of the talus, shortening or displacement of the fibula, and fracture of the posterior malleolus are all radiographic signs that suggest instability. Persistent radiographic abnormality after treatment may indicate inadequate reduction, unrecognized instability, interposed soft tissue or technical errors of fixation[32].

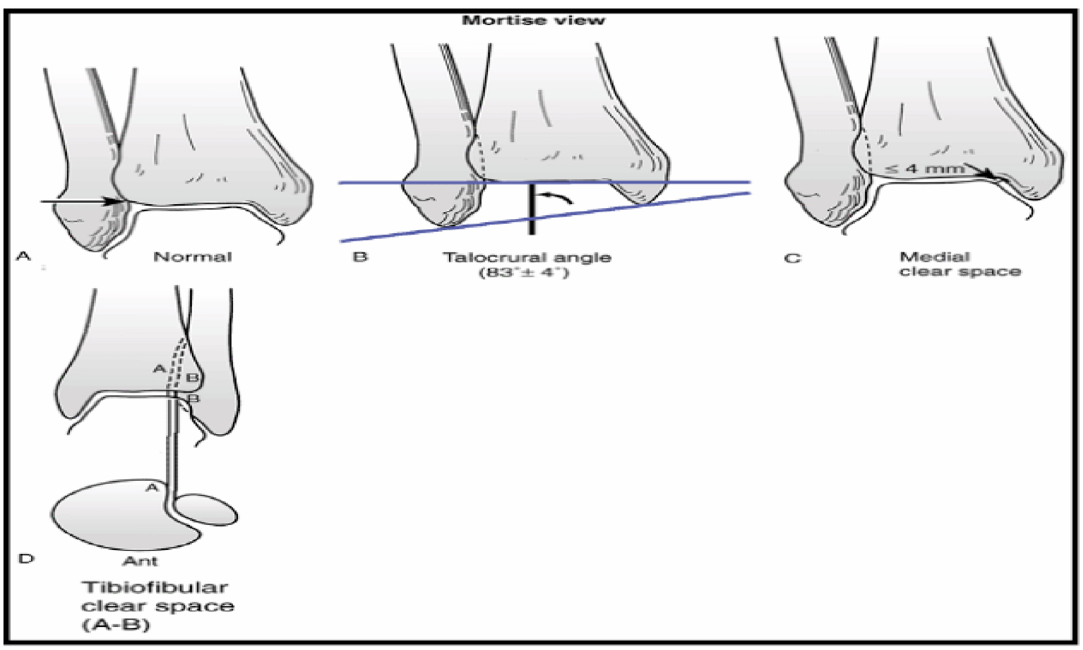


Fig 16 . Radiological Parameters

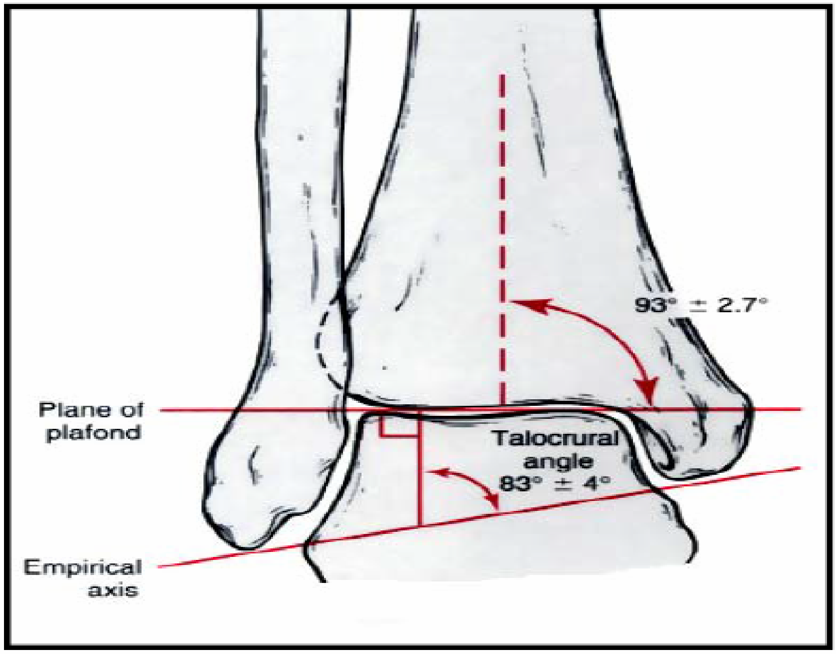


Fig 17 Talocrural Angle

TREATMENT

The goals of treatment are to obtain an anatomical reduction, maintain this reduction until the fracture heals, and return the patient to his or her pre-injury level of function with a painless, mobile ankle[32].

The outcome correlates directly with how well the anatomy of the ankle has been restored. The indications for operative treatment and consequently, non-operative treatment have changed over the past few years[32].

Non-operative treatment:

Non-operative treatment is indicated for un-displaced or stable fractures. For displaced fractures, when an anatomical reduction is obtained and maintained, and in patients who are not fit for surgery[33]

Closed reduction is done for stable fractures and open reduction and internal fixation for the unstable fractures. If stability is defined as the ability of the injured ankle to withstand stress without displacement, then a stable fracture is one that will not become displaced on the application of physiological stress, and an unstable fracture is one that will.

Successful closed reduction requires an understanding of the mechanism of injury and an assessment of the inherent stability of the injury. Closed reduction is usually best achieved by reversing the mechanism of injury that produced the displacement and fracture pattern evident on initial radiographs. Reduction of the talus, rather than direct pressure on the malleoli, brings the malleoli back into position maintains alignment.

- Supination adduction fracture is reduced by abducting (everting) the hind foot.
- External rotation fractures at that level of the syndesmosis are reduced by gentle distraction, internal rotation and varus stress.
- Pronation-abduction fractures are reduced by distraction and adduction.

In unstable fractures, the talus is displaced medially or laterally 2mm or more from its anatomical position. Fractures associated with syndesmotic disruption, Pronation – external rotation, Abduction-external rotation, are usually unstable and often require operative stabilization.

Correct casing technique and moulding is essential to maintain reduction. Three point fixation and careful moulding is essential. Stable or undisplaced ankle injuries may be managed in a short-leg cast or functional fracture brace for 4 to 6 weeks.

In some fracture patterns, a closed manipulation may be difficult to achieve or maintain. Although a closed manipulation will usually restore the talotibial relationship, it rarely reduces the lateral malleolus anatomically. Because some shortening or malrotation is likely to remain, the lateral malleolus will not be able to maintain the precise alignment of the talus after a cast is removed and normal weight bearing is resumed. Loss of reduction and repeated manipulations has been associated with unsatisfactory results. Prolonged immobilization may also lead to osteoporosis and joint stiffness. Thus, open reduction and internal fixation is generally preferred.

Operative treatment:

The goals of operative treatment are to obtain an anatomical reduction that is maintained by stable fixation, resulting in a healed fracture and recovery of normal function. This goal is more relevant in the young, active, healthy individual, for slight deviations from an anatomic alignment are acceptable in elderly patient[32].

Operative method has now become the method of choice in all unstable and complex ankle fractures. It offers the best outlook for optimal results. Other indications are[32]:

- Failure of closed reduction,
- For displaced or unstable fractures that result in displacement of the talus or widening of the mortise greater than 1 to 2 mm, and
- In open fractures.

Surgery is carried out as early as possible to avoid subsequent swelling and skin problems. Ankle swelling may peak in 1 to 7 days, and operative treatment is best done before the period of maximal swelling or after the initial swelling has resolved. If significant soft tissue injury with marked swelling and blisters is evident, surgery should be delayed until the skin has healed as it is associated with a reduced likelihood of anatomic reduction, with poorer results.

The reconstruction of the fibula takes priority and therefore the lateral side is dealt with before the medial side. It may sometimes be necessary to fix the medial side first, as in complex fractures with comminution and discontinuity of the fibula[32].

General Principles:[32]

1. Longitudinal incisions are used and should be long enough to provide adequate exposure and allow gentle retraction without undue tension on the skin.
2. The incisions should extend directly to the periosteum of the bone, resulting in full-thickness skin flaps. Flaps should be kept as thick as possible.
3. The fracture site can be opened by gentle distraction, re-creating the mechanism of injury, and organized hematoma and interposed soft tissue are removed from the fracture site. A direct or indirect reduction is done carefully without forceful twisting of the ankle to minimize further soft-tissue injury.
4. Each of the fractures that require fixation should be exposed, reduced, and provisionally stabilized before proceeding with definitive fixation, because fixation of one malleolus may occasionally make reduction of the remaining fracture or fractures difficult. After internal fixation, the ankle is moved through a full range of motion with the fracture sites visible to check the stability of the fixation. Radiographic confirmation, especially with a good mortise view, of both the reduction and implant placement is obtained before wound closure.

SURGICAL APPROACHES & FRACTURE FIXATION:

I. Lateral malleolus:

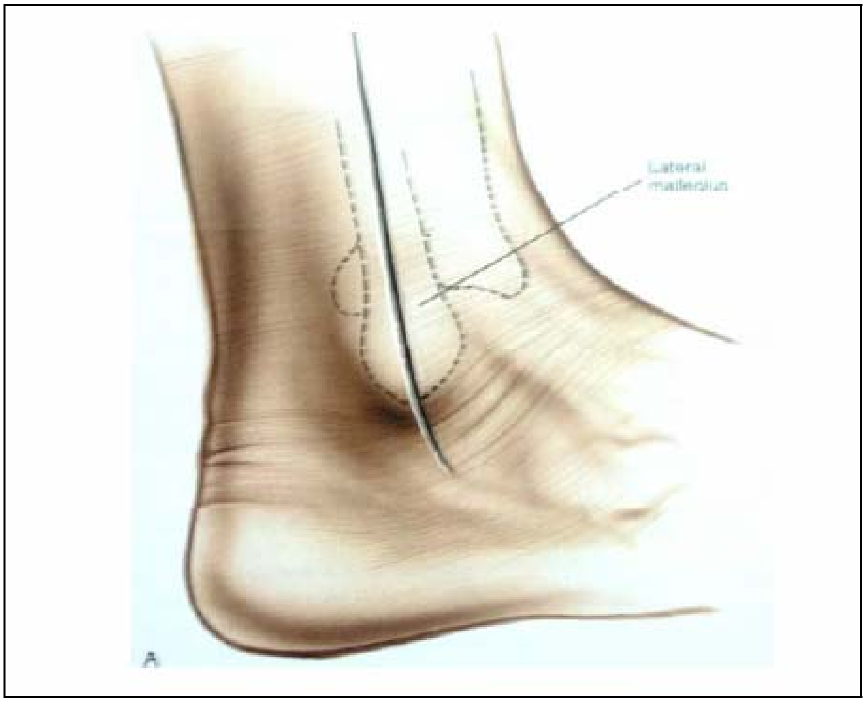
A secure anatomic repair of a displaced lateral malleolus fracture is one of the most important steps in operative management of a malleolar fracture because of the role this structure plays in maintaining tibiotalar alignment.

Approach: A direct lateral approach over the fibula was standard for reducing and internally fixing distal fibula fractures. The dissection plane was between the peroneus tertius anteriorly and the peroneus longus and brevis posteriorly. The standard lateral incision is moved slightly anterior when the need to fix the anterior syndesmosis or a Chaput's tubercle fragment from the anterolateral corner of the tibia[32,37.]

Reduction and fracture fixation[32,38]

1. Avulsion fractures of the distal fibula are reduced, held with a reduction forceps, and stabilized by either a tension band technique or a lag screw. A larger avulsed fragment of the distal lateral malleolus, typical of AO type A injuries, is best fixed with either a tension band wire or a small oblique screw.
2. AO/OTA type B fractures are fixed with one or two lag screws placed perpendicular to the line of the fracture. An oblique fracture was fixed with lag screws alone.
3. More secure fixation was achieved with one third tubular plate contoured to fit the concave, slightly spiral, lateral surface of the fibula. Compressing the fracture site with an anterior proximal to posterior distal interfragmentary lag screw was used augment the strength of the fixation.

4. Fractures above the syndesmosis were reduced and fixed with a one-third tubular plate. The position of the plate was dependent on the level of the fracture. The condition of the overlying soft tissues, and the extent of the communition.



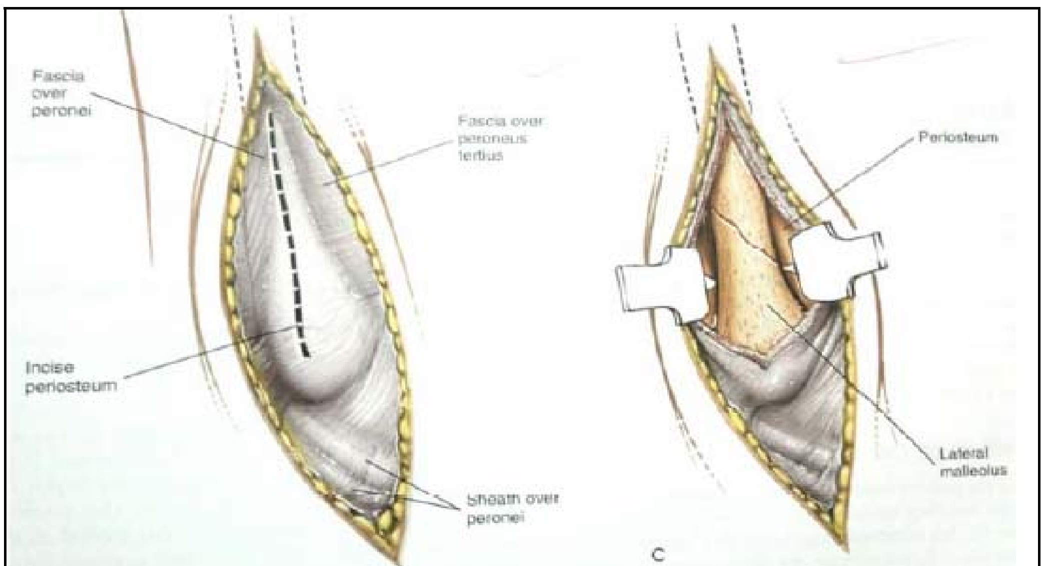
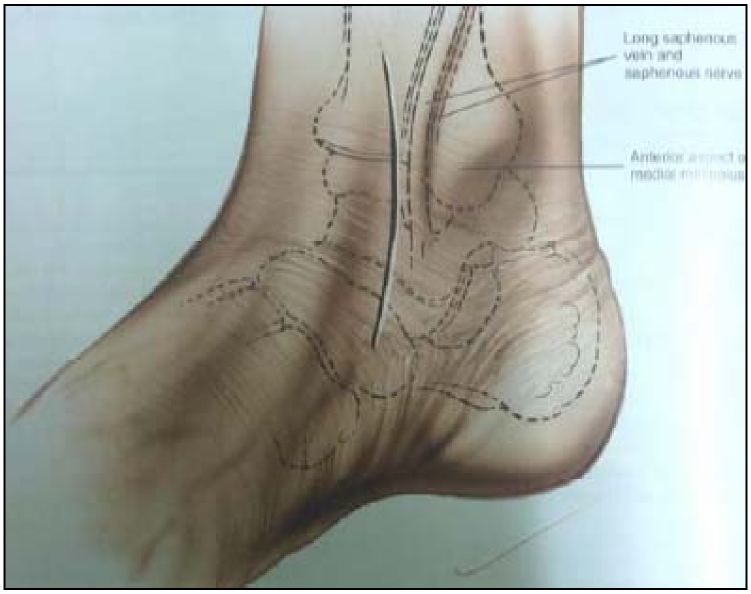


Fig 17 : Incision of Periosteum and Exposure of the bone

Fig 18: Approach to Lateral Malleolus

II. Medial Malleolar Fixation:

Approach: The medial approach to the ankle is centered on the medial malleolus itself and is shifted either anteriorly for better access to the joint or posteriorly to expose the back of the tibia. The incision used was longitudinal or curvilinear, depending on the exposure needed.[32,37]



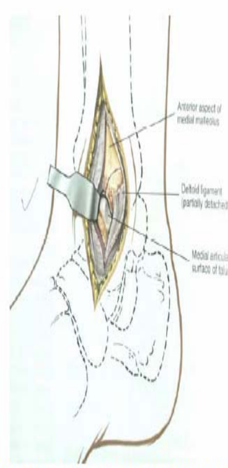


Fig 19 : split fibers of the deltoid ligement to allow for internal fixation of fractured Medial Malleolus

Fig 19: Approach to Medial Malleolus

Fracture fixation[32]

1. Avulsion fractures of the medial malleolus were best reduced after exposing both the anterior and the medial aspects of the fracture by sharply turning back the periosteum and attached fascia.
2. For intermediate-sized fragments, one wire and 2.0 or 2.5 mm drill bit was used to prepare a hole for a 4.0 mm partially threaded cancellous screw or malleolar screw.
3. For larger fragments, two such drills are used for provisional fixation and replaced one at a time with the 4.0 –mm partially threaded screws. To obtain a lag effect, their threads must not cross the fracture and they should be oriented perpendicular to plane of the fracture.
4. When the medial malleolar fragment was too small for screws or if comminuted, K-Wires with a figure-of-eight tension band was used for fixation.

III. <u>Syndesmosis Transfixation</u>:[32,34,38]

Obvious distal tibiofibular diastasis on initial or subsequent radiographs or gross mechanical instability of the syndesmosis signals the possible need for syndesmosis transfixation. The greater the degree of syndesmotic injury and the more unstable the ankle injury, the greater will be the need to fix the syndesmosis. The purpose of transfixing the syndesmosis with a screw is to maintain the distal tibiofibular relationship until the syndesmotic ligaments have healed

Anatomical reduction of the syndesmosis is necessary and the talus must be reduced in the mortise. If the fibula is fractured, its length, rotation, and alignment are restored first, and then the bone is reduced in the tibial notch. If the medial malleolus is fractured, it should be reduced and fixed as well. The reduction of the tibiofibular joint must be maintained during placement of any type of tran-syndesmotic fixation. Although many methods of fixation, including suture and use of synthetic grafts, have been reported, fixation with screws is the most common technique.

The fixation screw is a position screw its function is to hold the syndesmosis in the reduced position. The screw is used independently or in conjunction with a plate, depending on the type and location of the fibular injury. The screw is inserted at the top of the fibular sulcus in the tibia, usually about three to four centimeters proximal and parallel to the ankle joint, and was angled approximately 30 degrees anteriorly so that it is perpendicular to the tibiofibular joint and will not miss the tibia. Fixation is usually obtained by placing one or two screws from posterolaterally in the fibula to anteromedially in the tibia about 1.5 to 3.0 cm above the plafond.Fixation of the syndesmosis was done with the ankle in full dorsiflexion to avoid over tightening of the mortise and loss of dorsiflexion postoperatively.

The AO group advocated use of a fully threaded screw, a "position screw," with threads tapped in a pilot hole in both the fibula and the tibia. This procedure allows essentially no motion between the two bones unless the screw loosens, as it often does. It avoids the risk of overtightening inherent with a lag screw but permits no adjustment of the relationship between the fibula and the tibia from that existing when the screw is placed between the bones. There is a small incidence of screw fracture, and removal of a retained fragment in the tibia is traumatic. Use of a stronger screw, limited weight bearing, early screw removal, provision for some motion around the screw, and use of other devices are various ways to avoid screw failure.Removal of the screw was done at least 4 to 8 weeks.

Choice of Fixation:

1. The mainstay of internal fixation of malleolar fractures is the use of small fragment plates and screws, most often one-third semi-tubular plates and 3.5-mm and 4-mm partially and fully threaded screws. Rarely, for severely comminuted cases or for repair of fibular malunion, heavier 3.5-mm reconstruction or dynamic compression plates are required. The 4.5-mm fully threaded cortical screws are used for transfixing the syndesmosis. Kirschner wires (K-wires) are used in conjunction with wire for a tension band or along with screw for definitively fixing the medial malleolus.
2. The use of intramedullary implants has been limited because of poorer rotational control of the fibula and the inability to use adjunctive screw fixation for the syndesmosis.
3. Bioabsorbable implantsfor fixing ankle fractures are being extensively investigated. They have the potential advantages of eliminating the need for hardware removal, decreasing irritation over prominent screws and plates, and allowing for gradual stress transfer from the implant to the bone.

Complications:

Most complications of ankle injuries relate to one of three basic areas infection, soft tissue problems, or malunion and arthrosis (osteoarthritis).

Malunion:

Malunion of an ankle fracture may be caused by an inadequate closed reduction or by loss of such a reduction. Malalignment may follow ORIF if reduction is inadequate and not recognized or if is lost because of failure of fixation. Rotation can occur when only a single point of fixation is used. Unrecognized communication can result in shortening or rotation of the medial malleolus and in failure to restore the articular surface. The most common malunion of the ankle has been reported to be shortening and malrotation of the fibula. This may result from an uncooperative or bone quality. The risk of inadequate reduction of an ankle fracture is significantly increased in severe injuries with comminution, impaction, bone loss, and obscured land marks for reduction.

Incongruity of the articular surface and instability of the mortise due to bone or ligament malunion can alter the mechanics of the joint and lead to persistent symptoms, degenerative changes, and loss of function of the joint[32].

Nonunion:

Most non unions involve the medial malleolus. These are often avulsion injuries that were initially treated closed and fail to unite because of residual displacement of the fracture, interposed soft tissue, or associated lateral instability resulting in shearing forces on the fracture from the pull of the deltoid ligament. Nonunion of the lateral or posterior malleolus is uncommon. Nonunion after operative treatment can occur if the bone is extensively comminuted or devitalized, the reduction is incomplete or the fixation is inadequate[.32]

Wound Problems and Infection:

Marginal necrosis of skin edges after surgery occurs in about 3% of patients. The open ankle fracture is at highest risk for developing an infection after internal fixation. The risk of infection can be decreased with careful attention to the handling of soft tissues and the technical aspects of internal fixation[32].

Arthritis:

A painful arthrosis after ankle fracture may result from (1) severe cartilage damage at the time of injury, (2) a malaligned and shortened lateral malleolus allowing the talus to shift laterally, or (3) a combination of these factors. Anatomical reduction does not totally prevent the development of development of degenerative changes because blunt injury to the articular surfaces is not correctable. The incidence of arthritis increases with the severity of the injury. An increased incidence was also found in older patients, especially in women with osteoporosis. Considering the frequency of ligament and bony injuries involving the ankle, the incidence of degenerative of the ankle is surprisingly low[32].

Tibiofibular Synostosis:

After disruption of the tibiofibular sysndesmosis, heterotopic bone occasionally forms in the soft tissues between the tibia and the fibula and many unite to both to produce a synostosis. It occurs with and without syndesmosistransfixation screws and is probably dependent primarily on the severity of the original injury. A synostosis may interfere with the normal motion and mechanics of the fibula, patients may sometimes complain of stiffness even if they have good ankle motion[32].

METHODOLOGY

Patients admitted from December 2012 to May 2014 to the department of orthopaedics with bimalleolar fractures satisfying the inclusion criteria will be included in the study and with follow up from the time of admission to a minimum of 6 months of postoperative period will be done(minimum of 30 cases will be studied).

<u>CRITERIA FOR SELECTION OF THE CASES</u>:

Inclusion Criteria :

- All closed fractures.
- Open type 1 , 2 , 3a (Gustilo-Anderson).
- Above 18 years.

Exclusion Criteria:

- With associated Pilon fracture.
- Patients unfit for surgery.
- Patients with minimally displaced mono-malleolar fractures, avulsion fractures and stable fractures

All the patients were explained about the aims of the study, the methods involved and an informed written consent was obtained before being included in study. On admission of the patient, a careful history was elicited from the patient and/or attendants to reveal the mechanism of injury and the severity of trauma. The patients were then assessed clinically to evaluate their general condition and a complete survey was done to rule out significant injuries. Careful examination was done to rule out fractures at other sites. Local examination of injured ankle and following clinical signs were looked for.

Inspection:

Swelling of the ankle, any deformity, skin condition.

Palpation:

Skeletal components of the ankle i.e., lower ends of tibia/fibula and the malleolar parts were palpated and looked for bony tenderness, displacements, any abnormal painful mobility and crepitus. The inter-relation of the malleoli was also noted. Dorsalis pedis artery and posterior tibial artery pulsations were checked and noted. Distal neural status was also examined and noted.

Instability of the syndesmosis was identified on the basis of the mechanism of injury and the fracture pattern. Pain elicited with the squeeze test (manual medial-lateral compression across the syndesmosis) and the external rotation stress test was considered as indicative of clinical syndesmotic instability. Radiologically, tibiofibular clear space of more than six millimeters and widening of the medial clear space of more than four millimeters were considered as indications of syndesmotic instability. Intraoperatively, the stability was checked by laterally displacing the distal fibula from the tibia, if >3 or 4mm of lateral shift of talus occurs, it suggests instability (Cotton test).

Fractures of the ankle were evaluated using plain radiographs in anteroposterior, lateral and mortise views. The fractures were classified using the Lauge–Hansen, AO/OTA classification systems and anatomical types. Closed reduction and a below knee posterior POP slab was applied.

Patients with minimally displaced mono-malleolar fractures, avulsion fractures and stable fractures were excluded from the study. Also patients who were medically unfit for surgery were managed by closed reduction and were not included in the study.

Routine investigations were done. The patients were taken for surgery as early as possible once the general condition is stable and fit for surgery. The routine investigations were as follows: Hb%, Urine for sugar, RBS, Blood urea, Serum creatinine, HIV, HbSAg and ECG.

Preoperative Preparation of Patients:

Patients were prepared as per the anesthetist orders, tetanus toxoid injection, lignocaine test dose were given the day before surgery, adequate amount of blood was arranged according to requirements. A written and informed consent for surgery was taken.

Operative Technique:

Under spinal and /epidural anaesthesia, the patient was placed in supine position. The ipsilateral buttock was raised on a sandbag to improve the exposure of the lateral side. Pneumatic tourniquet was applied in all cases. The procedure was performed in a bloodless field, which facilitates good visibility to describe the fracture pattern and thus facilitating anatomical reduction.

Surgical Approaches & Fracture Fixation:

Lateral malleolus:

A secure anatomic repair of a displaced lateral malleolus fracture is one of the most important steps in operative management of a malleolar fracture because of the role this structure plays in maintaining tibiotalar alignment.

Approach: A direct lateral approach over the fibula was standard for reducing and internally fixing distal fibula fractures. The dissection plane was between the peroneus tertius anteriorly and the peroneus longus and brevis posteriorly. The incision was moved slightly anterior when the need to fix the anterior syndesmosis.

Fracture Fixation:

1. Avulsion fractures of the distal fibula were reduced, held with a reduction forceps, and stabilized by either a tension band technique or a lag screw. A larger avulsed fragment of the distal lateral malleolus, typical of AO type A injuries, is best fixed with either a tension band wire or a small oblique screw.
2. AO type B fracture was fixed with one or two lag screws placed perpendicular to the line of the fracture.
3. More secure fixation was achieved with one third semi-tubular plate contoured to fit the concave, slightly spiral, lateral surface of the fibula. Compressing the fracture site with an anterio-posterior interfragmentary lag screw was used to augment the strength of the fixation.
4. AO type C fractures were reduced and fixed with a one-third tubular plate. The position of the plate was dependent on the level of the fracture, the condition of the overlying soft tissues, and the extent of the communition.

Medial malleolar:

Approach: The medial approach to the ankle was centered on the medial malleolus itself and was shifted either anteriorly for better access to the joint or posteriorly to expose the back of the tibia. The incision used was longitudinal or curvilinear, depending on the exposure needed.

Fracture fixation:

1. Avulsion fractures of the medial malleolus were best reduced after exposing both the anterior and the medial aspects of the fracture by sharply turning back the periosteum and attached fascia.
2. For intermediate-sized fragments, one wire and 2.0 or 2.5 mm drill bit was used to prepare a hole for a 4.0 mm partially threaded cancellous screw or malleolar screw.
3. For larger fragments, two such drills are used for provisional fixation and replaced one at a time with the 4 -mm partially threaded screws. To obtain a lag effect, their threads must cross the fracture and they should be oriented perpendicular to plane of the fracture.
4. When the medial malleolar fragment was too small for screws or if comminuted, K-Wires with a figure-of-eight tension band was used for fixation.

Syndesmosis Transfixation:

Talus must be reduced in the mortise. Any associated medial or lateral malleolar fractures were fixed. The reduction of the tibiofibular joint must be maintained during placement trans syndesmotic fixation. The fixation screw or position screw (fully threaded) was used independently or in conjunction with a plate, depending on the type and location of the fibular injury.

The screw was inserted at the top of the fibular sulcus in the tibia, fixation is usually obtained by placing one or two screws from posterolaterally in the fibula to antero-medially in the tibia about 1.5 to 3.0 cm above the plafond. Fixation of the syndesmosis was done with the ankle in full dorsiflexion to avoid over tightening of the mortise and loss of dorsiflexion postoperatively.

Removal of the screw was done after at least 4 to 8 weeks, weight-bearing was delayed till screw removal.

Post – Operative Protocol:

Parenteral antibiotics were given in the post-op period for 3-5 days according to the wound condition. After 10 to 12 days, the sutures were removed and a below knee cast was applied for 4 weeks. Non-weight bearing gait was started from first or the second postoperative day. Partial weight bearing was started after the removal of the cast (after clinical and radiological signs of union become evident).Active exercises of the ankle was advised.

In patients with syndesmotic screw fixation, weight bearing was delayed till screw removal.

Follow up of cases was done at regular intervals of 6 weeks for minimum of 6 months. At each assessment, all patients were questioned with regard to pain, use of analgesics, stiffness, swelling, activities of daily living, use of walking aids, and return to work and participation in sports. At examination, the gait, any thickening, swelling, tenderness of the ankle and the range of motion of the ankle were evaluated. Anteroposterior, lateral and mortise radiographs of ankle were made at the time of examination. Baird and Jackson's ankle scoring system of subjective, objective and radiographic criteria was used for the study. All the patients were evaluated and scores were given.

<u>Baird and Jackson's Scoring System</u>[39]:

Scoring system for subjective, objective and radiographic criteria :

<u>Criteria Points</u>

I. Pain:

A. No Pain 15

B. Mild pain with strenuous activity 12

C. Mild pain with activities of daily living 8

D. Pain on weight bearing 4

E. Pain at rest 0

II. Stability of ankle:

A. No clinical instability 15

B. Instability with sports activities 5

C. Instability with activities of daily living 0

III. Ability to walk:

A. Able to walk desired distances without limp or pain 15

B. Able to walk desired distances with mild limp or pain 12

C. Moderately restricted in ability to walk 8

D. Able to walk short distances only 4

E. Unable to walk 0

IV. Ability to run:

A. Able to run desired distances without pain 10

B. Able to run desired distances with slight pain 8

C. Moderate restriction in ability to run, with mild pain 6

D. Able to run short distances only 3

E. Unable to run 0

V. Ability to work:

A. Able to perform usual occupation without restrictions 10

B. Able to perform usual occupation with restrictions in some strenuous activities 8.

C. Able to perform usual occupation with substantial restrictions 6.

D. Partially disabled; selected jobs only 3

E. Unable to work 0

VI. Motion of the ankle:

A. Within 10^0 of uninjured ankle 10

B. Within $15^0$of uninjured ankle 7

C. Within 20^0 of uninjured ankle 4

D. < 50% of uninjured ankle, or dorsiflexion < 5 degrees 0

VII. Radiographic result:

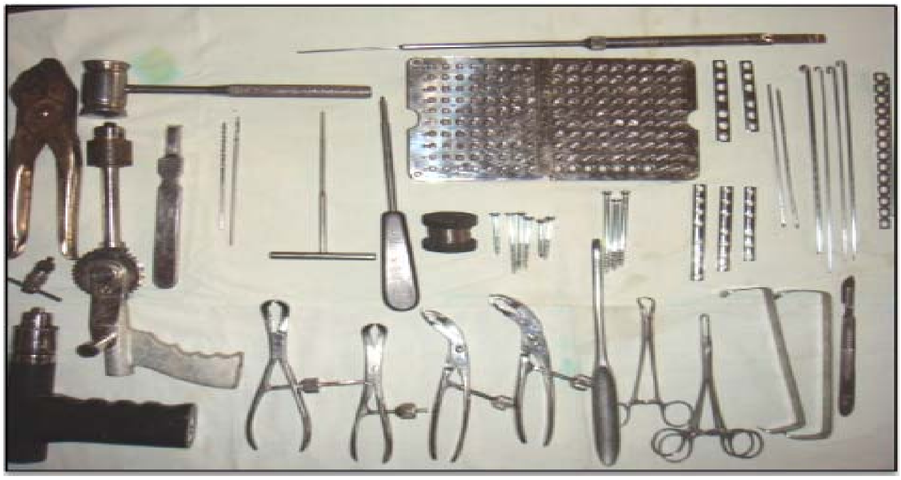
A. Anatomic with intact mortise (normal medial clear space, normal superior joint space, no talar tilt) 25

B. Same as A with mild reactive changes at the joint margins 15

C. Measurable narrowing of superior joint space, with superior joint space>2mm, or talar tilt >2mm 10

OPERATIVE PHOTOGRAPHS

INSTRUMENTS



- Universal bone drill
- 2.5 mm drill bit
- Bone tap with fixed T-handle
- Lawmans retractor
- Periosteum elevator
- Reduction forceps
- Reduction clamps
- Hexagonal screw driver

- AO tensioners
- Pliers
- Cutter
- Wire introducer

Pneumatic torniquet

Power drill

SURGICAL PROCEDURE

MEDIAL MALLEOLUS FRACTURE FIXATION

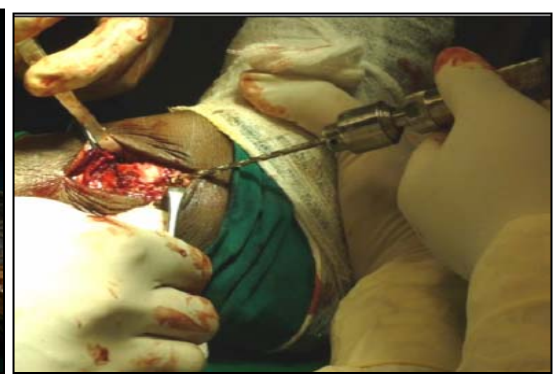
Foot and ankle prepared

Incision

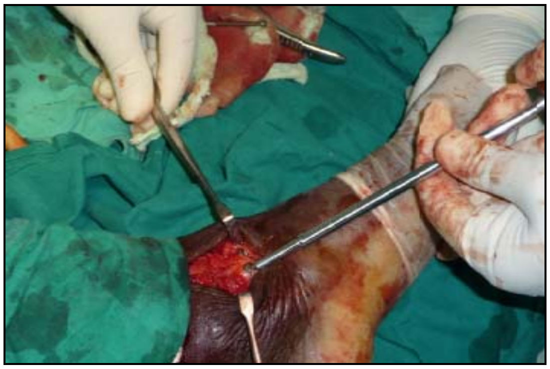
Exposure of medial malleolus fracture site

Reduced medial malleolus fracture

Fixation with tension band wiring



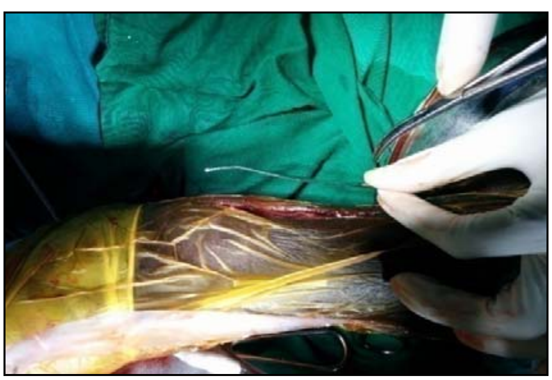
Drilling for insertion of 3.5mm malleolar screw



Fracture fixed with malleolar screw **Wound closure**

LATERAL MALLEOLUS FRACTURE FIXATION

Skin incision **Exposure of the fracture site**



Contouring the plate **Reduction of the fracture and application of the plate**

Drilling the bone

Fixation of the plae to bone

Skin closure

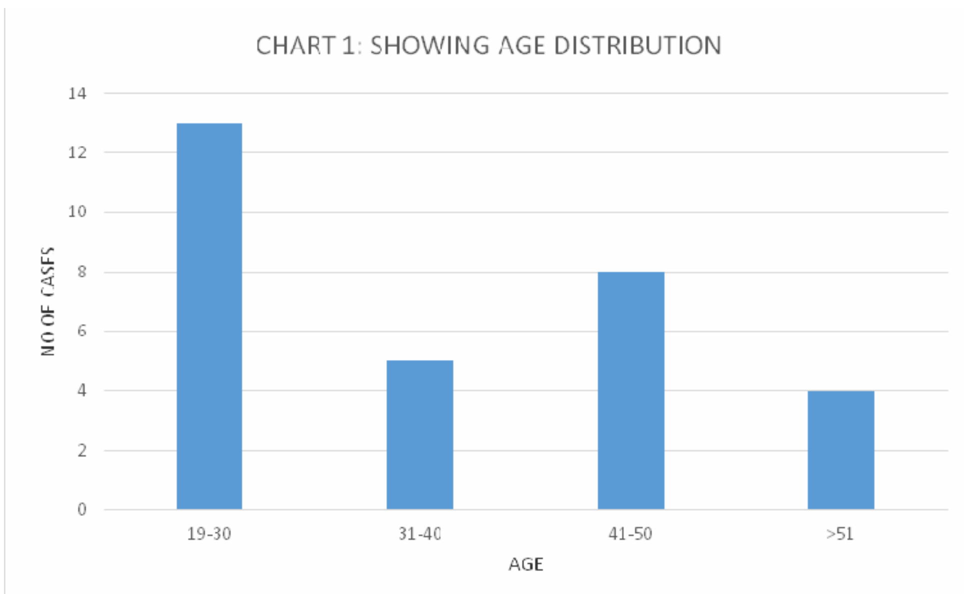
Below knee cast application after suture removal

OBSERVATION AND RESULTS

In our series 30 bimalleolar fractures of ankle, treated by surgical methods at R. L.Jalappa Hospital attached to Sri Devraj Urs Medical College, Tamaka, Kolar during the period of December 2012 to May 2014 were studied. The following were the observations made and the available date analyzed as follows.

1) **AGE INCIDENCE** :

Age (in years)	**19-30**	**31-40**	**41-50**	**>51**
No of cases	13	5	8	4
percentage	43.3	16.6	26.6	13.3

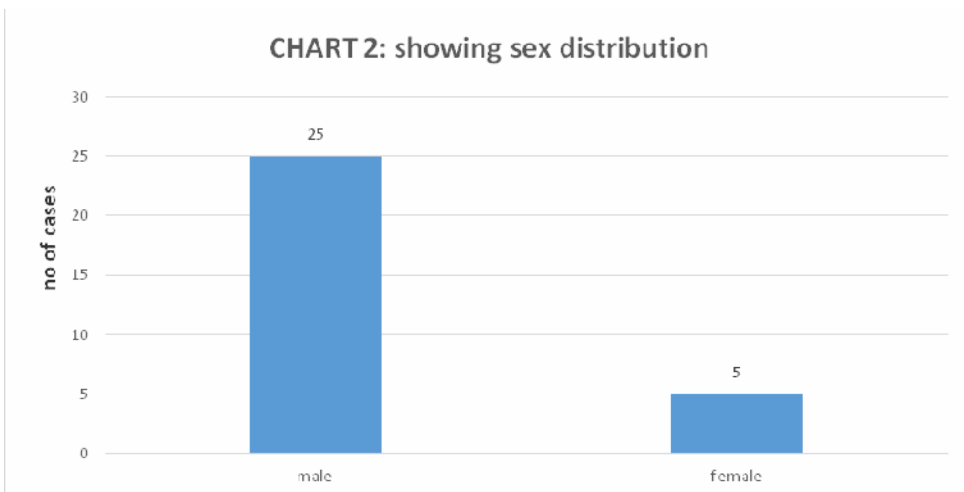


In our series majority of the cases i.e. 13 (43.3 %) were in the age group of 19-30 yrs, followed by 8 (26.6 %) were in the age group of 41-50. The youngest patient was 19 yr old and oldest being 80 year. The mean age was 37.3 yrs.

2) **SEX INCIDENCE**:

In the present series males were more commonly involved. Majority of the patients were males 25 (83.3 %) and 5 (16.6 %) were females.

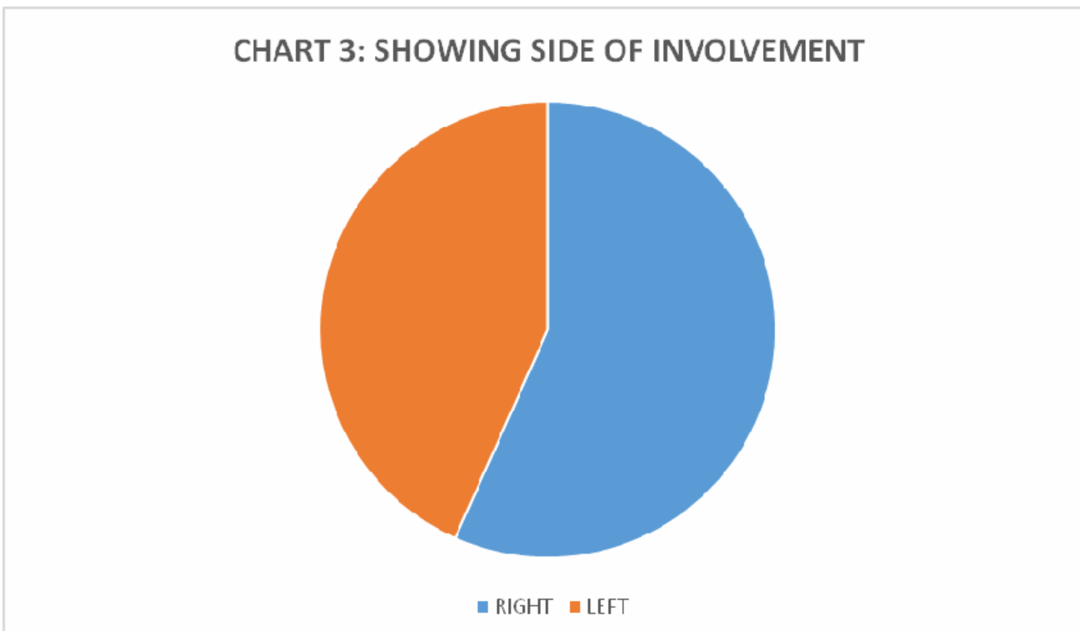
SEX	**No of cases**	**Percentage**
Male	25	83.3
Female	5	16.6



3) **<u>SIDE INVOLVEMENT</u>**:

Right ankle was more commonly involved than left. Patients with right leg involvement being 17 (56.6 %) and left being 13 (43.3 %)

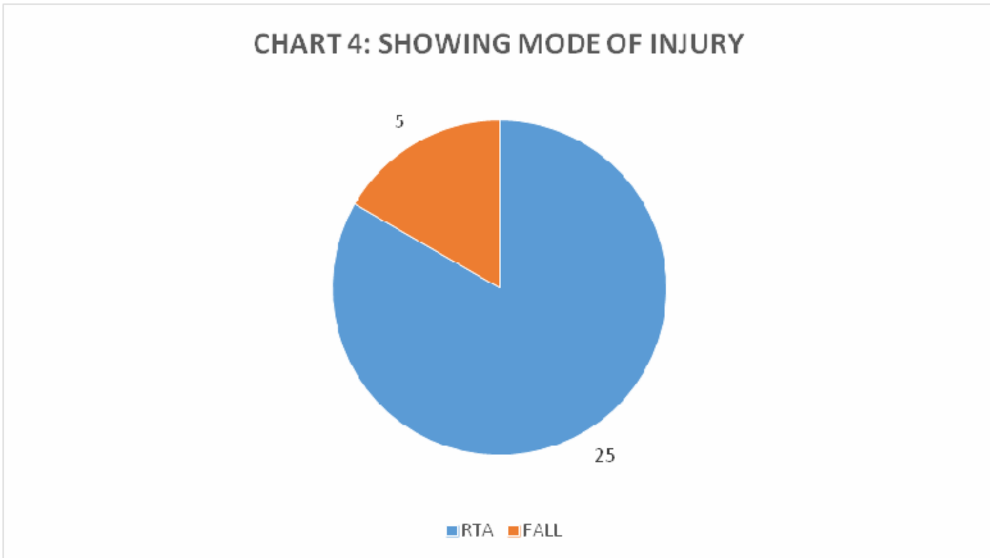
SIDE	**NO OF CASES**	**PERCENTAGE**
RIGHT	17	56.6
LEFT	13	43.3



4) **MODE OF INJURY**:

25 (83.3 %) cases were due to road traffic accidents, 5 (16.6 %) cases were due to fall. Road traffic accidents were the most common mode of injury in this study.

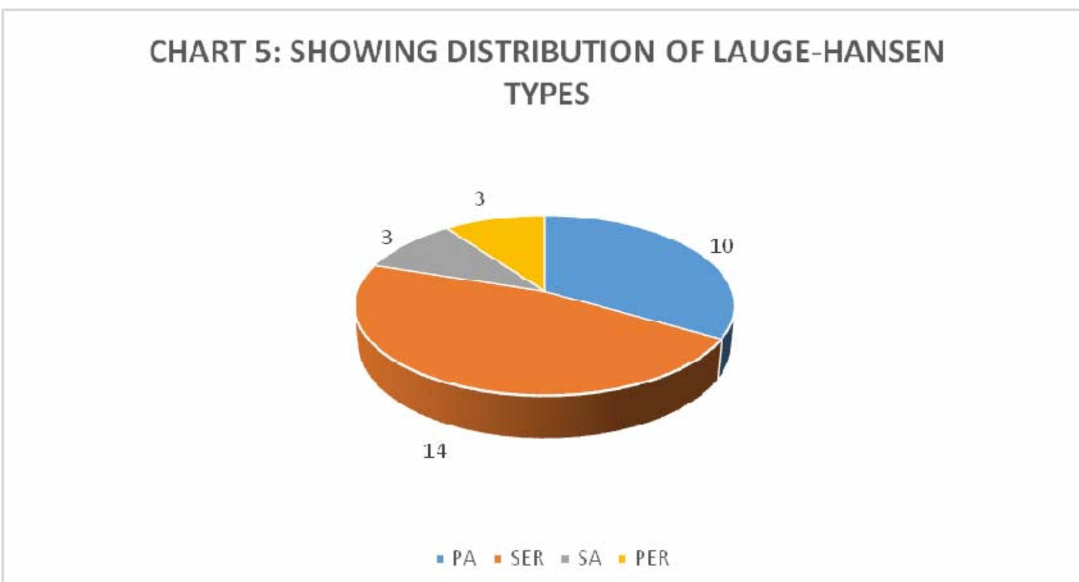
MODE OF INJURY	NO OF CASES	PERCENTAGE
RTA	25	83.3
FALL	5	16.6



5) **FRACTURE TYPE (LAUGE-HANSEN TYPE)** :

In the present study majority of the cases i.e. 14 (46.6 %) are supination external rotation injuries followed by pronation abduction injuries 10 (33.3%) cases.

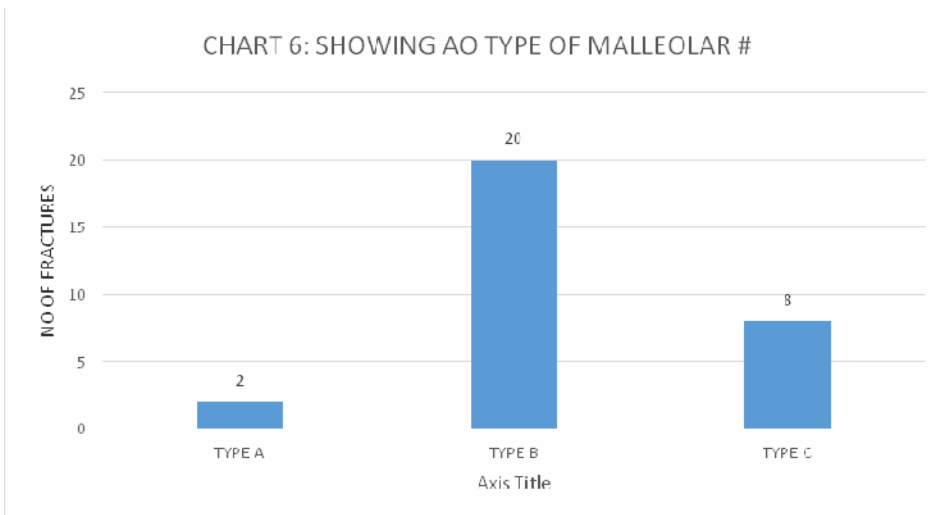
LAUGE-HANSEN TYPES	NO OF CASES	PERCENTAGE
SER	14	46.6
SA	3	10
PA	10	33.3
PER	3	10



6) **<u>AO TYPE</u>**:

The AO type B was the most common, involving 20 (66.6 %) followed by type C in 8 (26.6%) patients and least in type A.

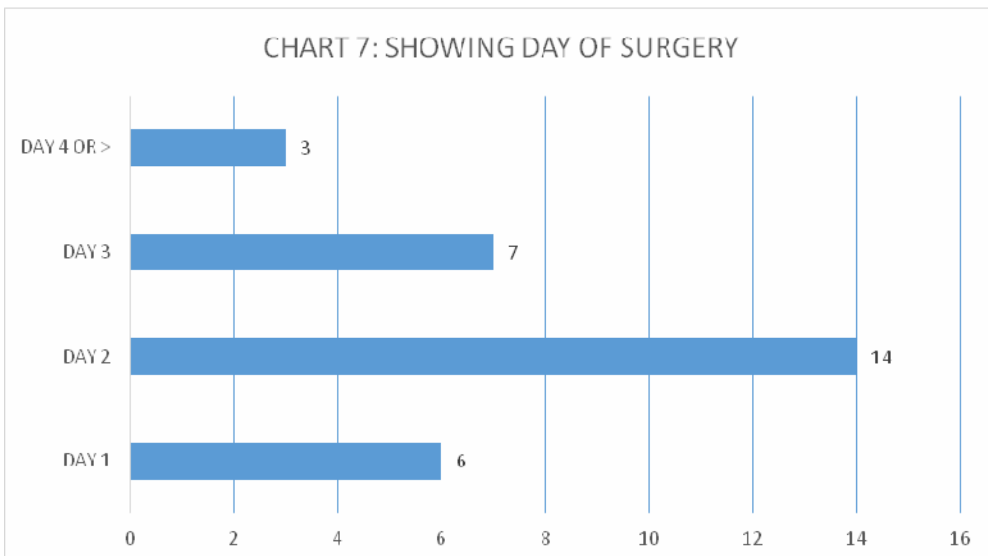
AO TYPE	NO OF CASES	PERCENTAGE
TYPE A	2	6.6
TYPE B	20	66.6
TYPE C	8	26.6



7) **TIME INTERVAL BETWEEN INJURY AND INTERVENTION**:

In this series most cases were operated between day 1 and day 3 (90%).

DAY	**DAY1**	**DAY2**	**DAY3**	**DAY4 OR >**
NO OF CASES	6	14	7	3
PERCENTAGE	20	46.6	23.3	10

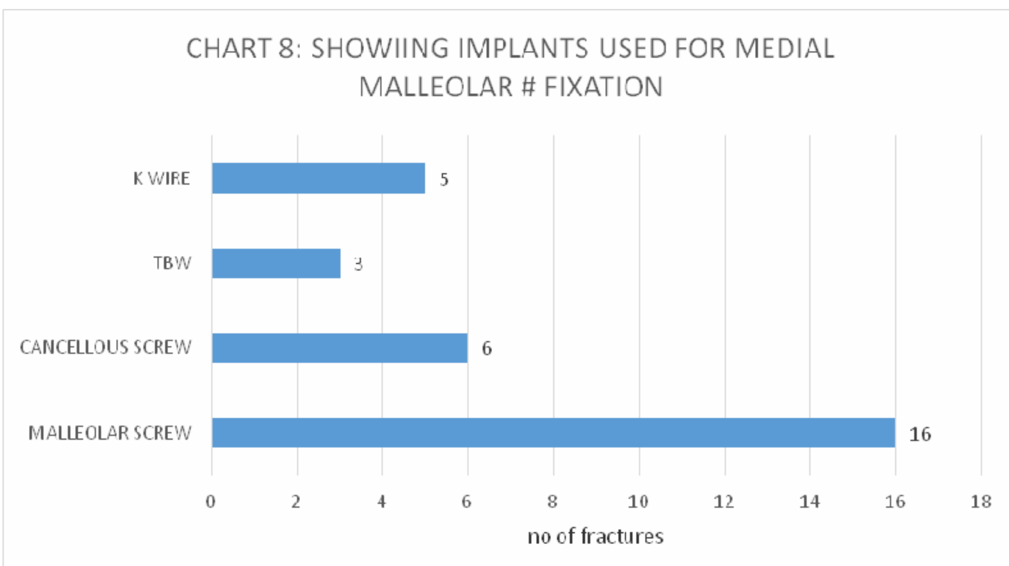


8) **TREATMENT OF INDIVIDUAL FRACTURES**:

A) **MEDIAL MALLEOLUS FRACTURE**:

Majority of the medial malleolus fractures were fixed with malleolar screws 16 (53.3 %). In the rest of the cases cancellous screws, tension band wiring and K wires were used.

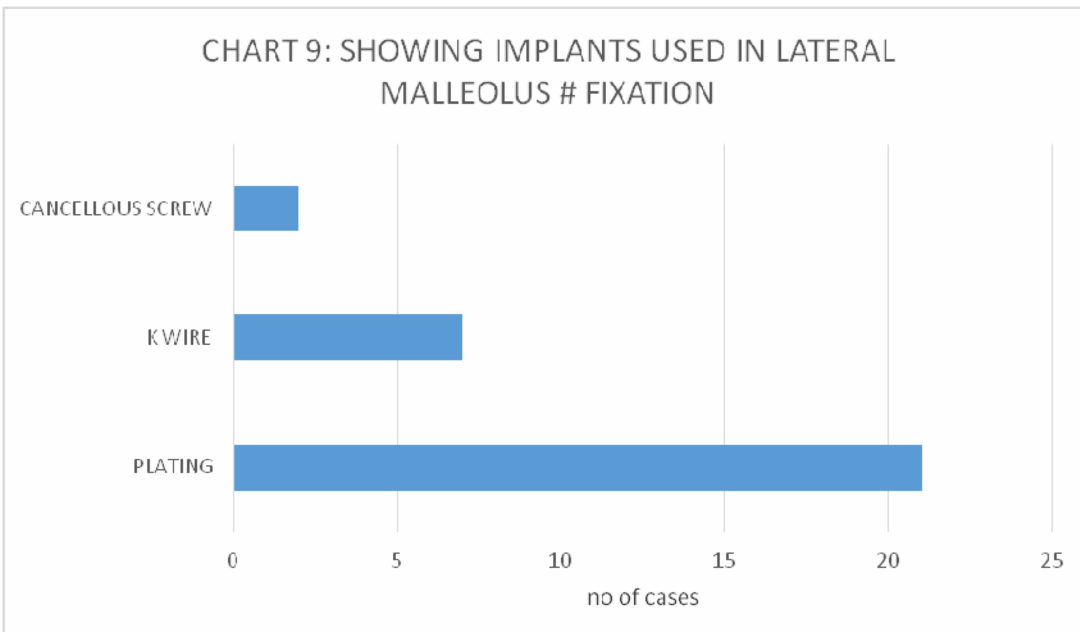
IMPLANTS	**MALLEOLAR SCREW**	**CANCELLOUS SCREW**	**TBW**	**K WIRE**
NO OF CASES	16	6	3	5
PERCENTAGE	53.3	20	10	16.6



B) **LATERAL MALLEOLUS FRACTURE**:

Majority of the lateral malleolar fractures were fixed with one third tubular plate 21 (70 %). Rest of the fractures were fixed with K wires and cancellous screws.

IMPLANT	**PLATING**	**K WIRE**	**CANCELLOUS SCREW**
NO OF CASES	21	7	2
PERCENTAGE	70	23.3	6.6



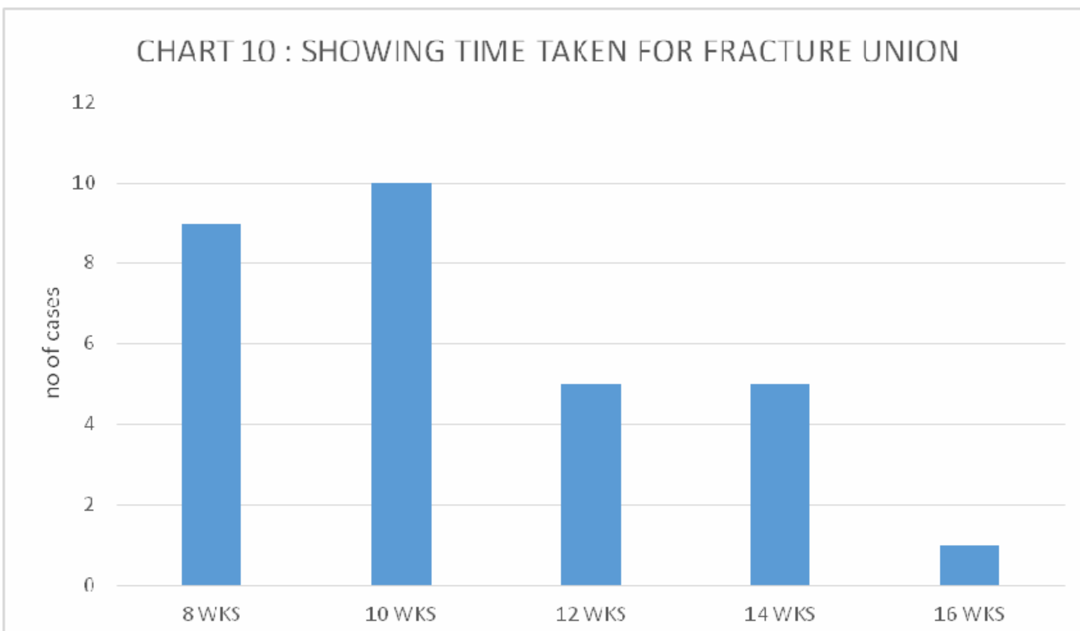
C) **SYNDESMOTIC FIXATION**:

In 3 cases (10 %) syndesmotic injury was noted and in these cases it was fixed with a fully threaded screw. Weight bearing was delayed till screw removal which was done at 6-8 weeks.

9) **UNION**:

In our study average time taken for union was 10.6 wks. Most of the cases showed union between 8- 14 wks.

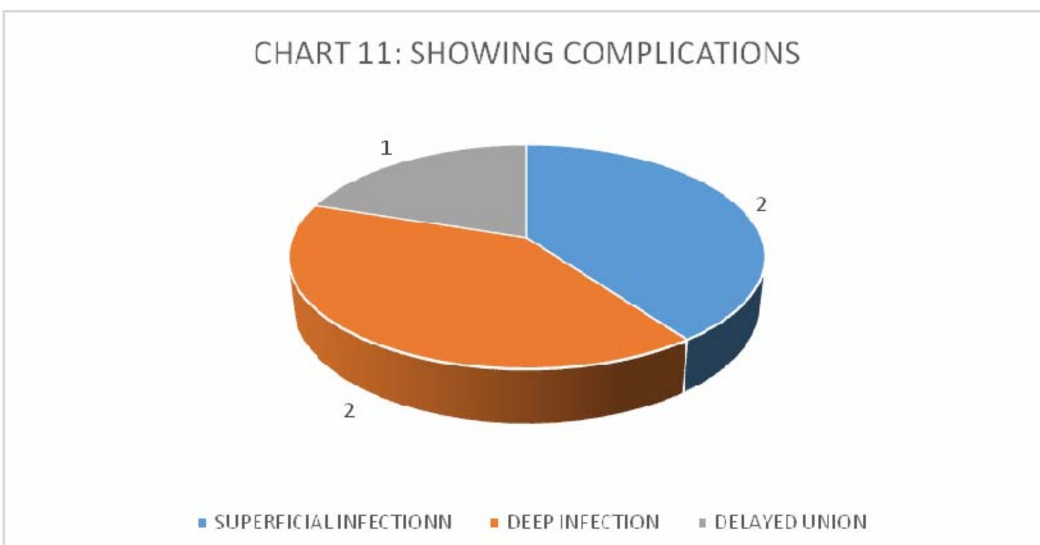
UNION (WKS)	**8 WKS**	**10 WKS**	**12 WKS**	**14WKS**	**16 WKS**
No of cases	9	10	5	5	1



10) <u>**COMPLICATIONS**</u>:

In our series 5 cases (16.6%) had complications. 2 patients had superficial infection, 2 patients had deep infection and 1 patient had delayed union. Infections were managed with debridements and antibiotics. Delayed union fracture medial malleolus is treated with continued immobilization, which eventually united without surgical intervention.

COMPLICATIONS	NO OF CASES	PERCENTAGE
SUPERFICIAL INFECTION	2	6.6
DEEPP INFECTION	2	6.6
DELAYED UNION OF MEDIAL MALLEOLUS #	1	3.3



11) <u>FINAL SCORE ACCORDING TO SUBJECTIVE, OBJECTIVE AND RADIOLOGICAL CRITERIA</u>:

Ankle pain:

In this series, 13 patients had no pain and 15 patients had grade B i.e; pain with strenuous activities and 2 patients had mild pain with activities of daily living.

Stability of the ankle:

None of the patients had clinical instability.

Ability to walk:

Majority of the patients, 25 could walk desired distances without limp or pain and 3 patients were able to walk desired distances with slight pain and 2 patients had moderate restriction in daily activity.

Ability to run:

17 patients were able to run desired distances without pain, 11 patients were able to run desired distances with slight pain and 2 patients had moderate restriction in ability to run with mild pain.

Ability to work:

12 patients were able to perform usual occupation without restriction and the rest 18 were able to perform usual occupation with restriction in some strenuous work.

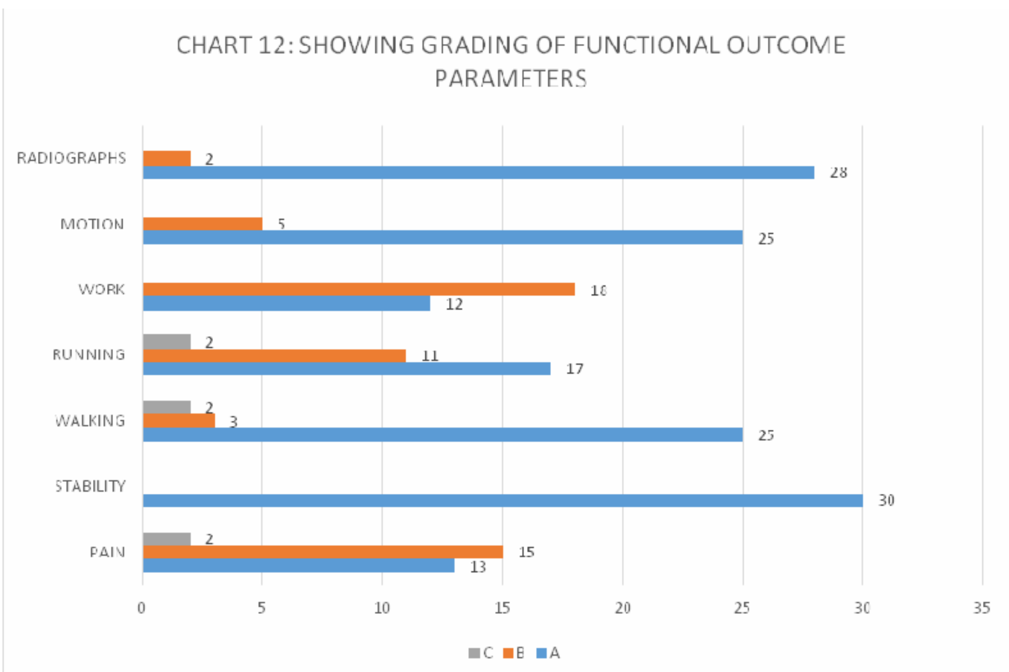
Motion of the ankle:

In this series, 25 patients had range of motion within 10^o of uninjured ankle, 5patients had range of motion within 15^o of uninjured ankle.

Radiographs:

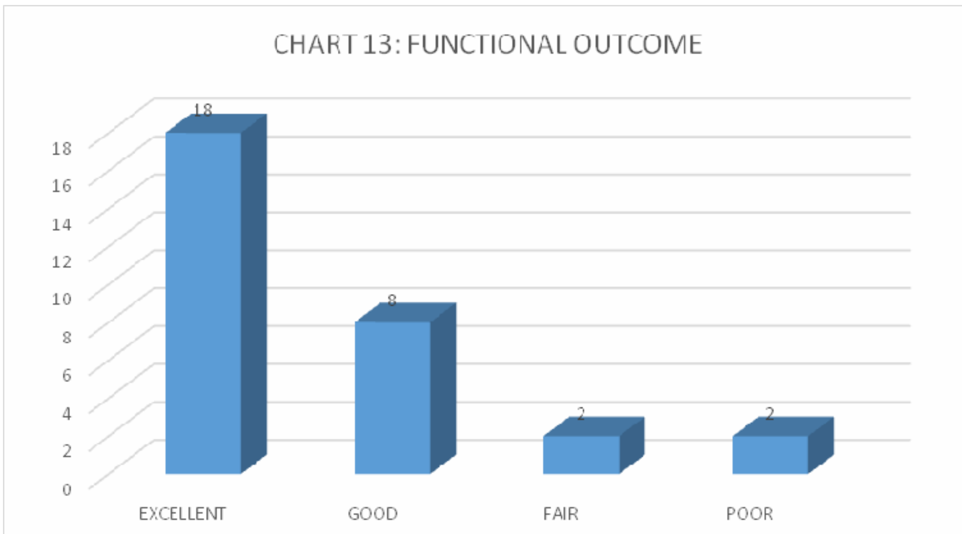
In this series 25 patients had anatomical reduction with normal medial clear space and superior joint space and 2 patients had reactive changes.

CATEGORY	A	B	C	D	E	TOTAL
PAIN	13	15	2			30
STABILITY	30					30
WALKING	25	3	2			30
RUNNING	17	11	2			30
WORK	12	18				30
MOTION	25	5				30
RADIOGRAPHS	28	2				30



12) **FUNCTIONAL RESULTS**:

FUNCTIONAL SCORE	NO OF CASES	PERCENTAGE
EXCELLENT	18	60
GOOD	8	26.6
FAIR	2	6.6
POOR	2	6.6



In this present study 30 patients with bi malleolar fractures were treated surgically. Excellent results were achieved in 18 cases (60 %), good in 8 cases (26.6%), fair in 2 cases (6.6 %), poor in 2 cases (6.6 %). Excellent results were seen in most of the bi malleolar fractures, 4 patients who had fair to poor results were seen in cases with delayed union of medial malleolus , superficial and deep infection. The patients who had poor results had mild pain during their activities of daily living, diminution in their ability to run and do work, reduced motion of ankle and narrowing of joint space.

X RAY AND CLINICAL PHOTOGRAPHS

CASE 2:

Pre op

post op

Union at 10 wks

6 months follow up

Dorsiflexion of ankle

Plantar flexion of ankle

Standing on one leg

CASE 5:

Pre op

Post op

Union at 10 wks

Ankle dorsiflexion **Ankle plantar flexion**

Standing on one leg

CASE 11:

Pre op

Post op

Union at 8 wks

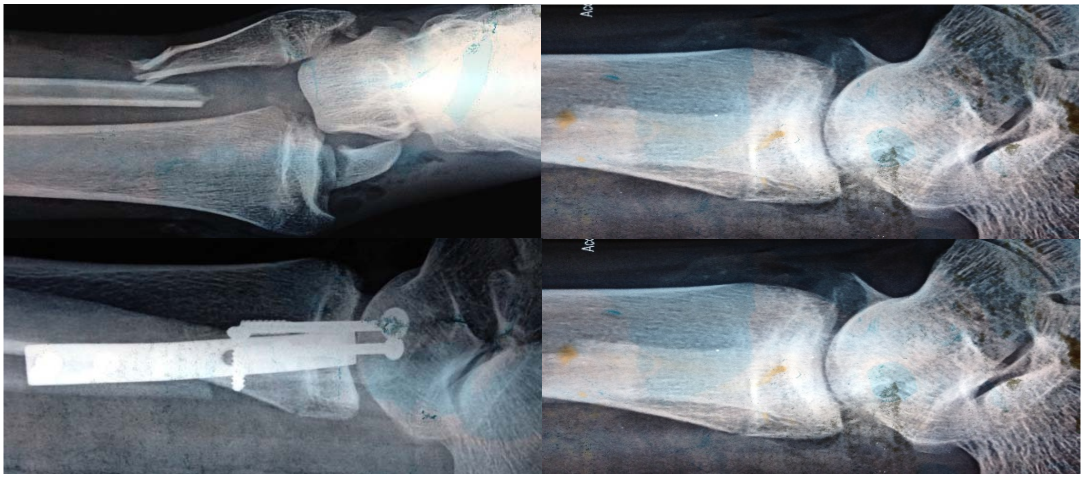
6months follow up

Ankle dorsiflexion

Ankle plantar flexion

Standing on one leg

CASE 15:



Pre op **Post op**

Union at 10 wks

Ankle dorsiflexion **Ankle plantar flexion**

Standing on toes **Squating**

CASE 19:

Pre op

Post op

Union at 12 wks

Ankle dorsi flexion **Ankle plantar flexion**

Standing on one leg

CASE 30:

Pre op

Post op

Union at 8 wks

6 months follow up

Ankle dorsi flexion

Ankle plantar flexion

Standing on toes

Squating

DISCUSSION

There has been an increase in the prevalence of bi malleolar fractures over the last two decades both in the young, active patients and in the elderly[40]. Methods to restore function and to prevent arthritis are either closed treatment, which includes manipulative reduction and immobilization in plaster cast or open reduction with internal fixation. Burwell and Charnley showed that anatomical reduction and rigid fixation led to early return to function[41].

There has been gradual evolution in management of ankle fractures due to improved analysis of biomechanics, improvement in fixation techniques and analysis of results of recent studies. The goal of treatment is to provide fracture union with painless full motion of ankle and with anatomical restoration of the injured ankle.

Closed method of treatment is often inadequate in restoring the anatomy and biomechanics of ankle in unstable malleolar ankle fractures. Conversely, open reduction with internal fixation is an excellent method for restoration of normal anatomy of joint.

Several studies indicated that, internal fixation of displaced malleolar fractures of ankle provides better results[41, 42,43]

The treatment of malleolar fractures with accurate open reduction and stable internal fixation using AO method and principles was found to give a higher percentage of excellent and good results[15]. This study supports these conclusions.

In the current study, we have 30 patients with bimalleolar ankle fractures, who were operated upon. All patients were followed up with minimum period of 6 months.

1. **<u>AGE DISTRIBUTION</u>:**

In our study, fractures were commoner in the 19-30 yrs age group, with mean age being 37.3 yrs. Our findings are comparable to the studies made by, Beris et al[15], Roberts RS[44], Baird and Jackson[39] and Lee et al[45].

STUDY	**NO OF CASES**	**MEAN AGE (in years)**
Roberts RS[44]	25	40
Beris et al [15]	144	43.8
Lee et al[45]	168	44
Present study	30	37.3

2. **<u>SEX DISTRIBUTION</u>:**

Our series had a male predominance with 83.3% and male: female ratio of 5:1,which is comparable to the study by Baird & Jackson[39] .

STUDY	**NO OF CASES**	**MALE:FEMALE**	**% OF MALE PATIENTS**
Roberts RS[44]	25	11:14	44
Beris et al[15]	144	56:88	38.88
Lee et al[45]	168	89:79	42.9
Braid and Jakson[39]	24	17:7	70
Present study	30	5:1	83.3

3) <u>MODE OF INJURY</u>:

In the current study, road traffic accidents constituted majority of cases, which was in accordance with study by Lee et al[45]

STUDY	**NO OF CASES**	**COMMONEST MODE**
Braid and Jackson[39]	24	Fall from height
Lee et al[45]	168	Road traffic accident
Present study	30	Road traffic accident

4) <u>LATERALITY OF FRACTURE</u>:

In the present study, right ankle was more commonly affected, in accordance with Roberts RS[44], Beris et al.[15]

STUDY	**NO OF CASES**	**RIGHT**	**LEFT**
Roberts RS[44]	25	14(56%)	11 (44%)
Beris et al[15]	144	73 (51%)	71 (49%)
Braid and Jackson[39]	24	11 (45%)	13 (55%)
Present study	30	17 (56.6%)	13 (43.3%)

5) <u>TYPE OF INJURY</u>:

In this present study, Lauge-Hansen classification system was used for operative evaluation. The most common type of injury was supination-external rotation (46.6%), followed by pronation-abduction injury (33.3%), in accordance with by Roberts RS[44], Beris et al[15], Baird and Jackson[39]

STUDY	NO OF CASES	L-H TYPE	PERCENTAGE
Roberts RS	25	SER	34
Braid and Jackson	24	SER	44
Present study	30	SER	46.6

6) <u>FUNCTIONAL RESULTS</u>:

The results in current study were compared with that of Burnwell & Charnley[41],Colton[46], De souza et al**Error! Bookmark not defined.**, Beris et al[15] .

In Colton**Error! Bookmark not defined.** series, 70% of the patients had a good to excellent results. Burnwell &Charnley[41] in their series of 132 patients, 102 (77.3%) had good results, 16% had fair results and 6% were found to poor score.

In De souza[42] series, 150 cases of ankle fractures treated by open reduction and internal fixation using AO/ASIF method, obtained 90% good results. In a study by Beris et al[15], of 144 patients with ankle fractures, 105 (74.3%) had good to excellent results.

The functional results of the present study were comparable with that of the above cited studies, with 86.6% had good to excellent results, 6.6% had fair results and poor results in 6.6%.

STUDY	GOOD TO EXCELLENT	FAIR	POOR
Burnwell & Charnley[41]	102 (77%)	22 (17%)	8 (6%)
Colton[46]	18 (70%)	4 (15%)	4 (15%)
Beris et al[15]	105 (74.3%)	21 (14.6%)	16 (11.1%)
De souza**Error! Bookmark not defined.**	135 (90%)	9 (6%)	6 (4%)
Present study	26 (86.6%)	2 (6.6%)	2 (6.6%)

Most authors have stated that anatomical reduction of displaced medial malleolus ensures correction of talar displacement and is of paramount importance in treating unstable fractures[47]. However, Heller et al[48]. Stated that talus is more accurately repositioned in mortise by anatomical reduction of lateral malleolus.

Observation in this study support the contention of Yablon et al[48] that lateral malleolus is the key to the anatomical reduction of bimalleolar fractures, because the displacement of the talus faithfully followed that of the lateral malleolus. Poor reduction of the lateral malleolus fracture would result in persistent lateral displacement or residual shortening. This does not necessarily lessen the importance of medial malleolus, but it does serve to emphasize that the lateral malleolus should no longer be ignored. In the current study, one patient with poor outcome didn't have anatomical reduction of the medial malleolus possibly due to soft tissue interposition.

Lateral malleolus can be fixed by various methods. Lateral plate, as advocated by AO group has become widely accepted for treatment of fibular fracture[49]. Hughes et al[50] recommended that lateral malleolus should be fixed first. The medial malleolus is then inspected for stability and fixed if necessary. This allows minimal postoperative immobilization and rapid recovery of function.

In this study, the functional outcome was better in patients who underwent stable internal fixation of the medial malleolus by cancellous or malleolar screw. The results were not equally satisfactory in those patients who had less rigid fixation of the medial malleolus using only Kirschner wires. Tension band wiring of the medial malleolus gave results equivalent of those fixed with screws and lesser reports of skin irritation which was more frequent in those patients with screw fixation.

In many fractured ankles, syndesmosis is stable after reduction and internal fixation of fibula fracture and medial malleolar fracture. Yablon[48] stated that anatomical reduction of the fibula is the key factor in achieving good outcome of the treatment of ankle fractures with syndesmotic disruption. In the current series, three patients underwent trans-syndesmotic screw fixation. Excellent outcome was seen in one patient and good outcome was seen in two patients.

Although early mobilization was advocated by AO group, other studies[41] have found no significant difference in the results produced after early mobilization. In the current study, immobilization was done for 4 weeks. Partial weight bearing was advised for those with early radiological signs of union and full weight bearing when the signs of union were complete. The range of motion of ankle was reduced initially, but improved over few weeks.

In 30 of our patients there was no instability of ankle or subtalar joints, because we allowed sufficient time for the soft tissues around the ankle to heal. We preferred postoperative immobilization rather than allowing active ankle exercise as there was no difference in the results after 6 months of follow up.

Bray noted that incidence of complications are less in patients who underwent immediate surgery when compared to those who underwent delayed surgery.[51] Which also holds good in our study.

Fair to poor results in the current series were seen due to wound infection and delayed union of medial malleolus. Restricted activity level and range of movement without radiological evidence of arthritis was noted in four patients.

Majority of the patients (86.6%) had good to excellent results in the current study,similar to what was observed in other series like Burnwell & Charnley[41], Colton[46] De souza et al[42] Beris et al[15].

The treatment of bimalleolar fractures with accurate open reduction and stable internal fixation using AO method and principles was found to give a high percentage of excellent and good results[15]. This study supports these conclusions and was comparable with those in other studies.

CONCLUSION

In this review, the 30 cases of bimalleolar fractures of ankle that were unstable displaced or both, were treated surgically by open reduction and internal fixation.

Conclusions of our study are:

- Unstable bimalleolar ankle fractures are common due to road traffic accidents.
- Ankle injuries are common in middle aged men.
- Age groups between 19-30 years were most commonly injured. The mean age of present study was 37.3 years.
- Bimalleolar fractures more common in male than female.
- Majority of them, were caused by supination-external rotation (37.5%) injury.
- Understanding the mechanism of injury is essential for anatomical reduction and fixation.
- Fibular alignment (length, rotation) has to be maintained for lateral stability of the ankle.
- Anatomical reduction with restoration of the articular congruence is essential in all intra articular fractures, more so, if a weight bearing joint like ankle is involved. Open reduction and internal fixation restores the articular congruity of the ankle joint.
- The operative results were satisfactory in 86.6% cases, with good to excellent functional outcome.
- Functional results were much better in younger age groups and men. Fair to poor results were seen in those bimalleolar fractures associated with wound infection and those with unsatisfactory reduction of fracture fragments.

- Excellent results are obtained with stable fixation of fracture. Cancellous screws or malleolar screws are better in internal fixation of medial malleolus compared to Kirschner -wire fixation and lateral plating was the best for fibular fractures.
- TBW done for PER and PA injuries showed promising results comparable to that with screw fixation and also gave lesser reports of skin irritation at the wound site. It is the method preferred for small transverse fragments and osteoporotic bones of both malleoli especially in the elderly.
- Functional results improve when the normal bend of the lateral malleolus, is restored while plating.
- Chances of non-union due to soft tissue interposition were avoided by surgical treatment. Delayed union of two cases, were possibly due to unsatisfactory reduction at time of surgery.
- Good functional results are obtained by surgical management of bimalleolar ankle fractures. Early weight bearing and mobilization is achieved in these patients.

Hence we conclude that, surgical management of bimalleolar ankle fractures provides good functional outcome. By stable surgical fixation of the fracture, early mobilization can be achieved.

SUMMARY

30 patients of Bimalleolar ankle fractures were operated at R L Jalappa Hospital attached to Sri Devraj Urs Medical College,Tamaka, Kolar. During the period from December 2012 to May 2014 were studied.

1) Thirty cases of unstable bimalleolar fractures of the ankle, managed surgically by various techniques were studied.
2) The anatomy, classification, clinical features, review of literature, and methods of surgical management have been detailed out.
3) The age distributions were 19 to 80 years (average – 37.3 years), majority of them i.e, 43.3% of the cases were in the age- group 19-30 years.
4) More common in male (83.3%), compared to females (16.6%)
5) Right ankle was more commonly affected (56.6%)
6) Most common mode of injury was Road traffic accident (83.3%), followed by fall from (16.6%).
7) According to Lauge-Hansen's classification, Supination - external rotation injuries were commonest (46.6%) in our series, followed by pronation abduction (20%).
8) According to AO classification, most common types were B (66.6%), type C (26.6%). Type A (6.6%) was least common.
9) Method of fixation of medial malleolus: majority of cases were treated with malleolar and cancellous screw fixation (70.3%). Most of patients with fibular fracture underwent fixation by one-third tubular plate (70%).
10) Three cases of syndemosis injury were reduced and fixed with screw. Weight bearing was delayed till screw removal. No incidence screw break out were encountered.

11) Average time taken for fracture healing was 10.6 weeks.

12) Infection of the wound was the most common complication in our study.

13) We had good to excellent functional outcome results in 86.6% of the cases. Fair results in 6.6% and poor in 6.6%.

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ANNEXURE I

PROFORMA

"STUDY OF OUTCOME OF SURGICAL MANAGEMENT OF BI-MALLEOLAR FRACTURES IN ADULTS"

NAME: **I.P. NO.:**

AGE: **DATE OF ADMISSION:**

SEX: **DATE OF SURGERY:**

DATE OF DISCHARGE:

ADDRESS:

MODE OF INJURY:

a. Road traffic accident

   Industrial accident

   Agricultural accident

   Assaults

   Fall from height

   Sports injury

   miscellaneous

HISTORY OF PRESENTING ILLNESS

MECHANISM OF TRAUMA

Inversion of the foot

Eversion of the foot

Dorsiflexion of the ankle

Plantar flexion of the ankle

Not known

DURATION

History of previous illness if any:

TREATMENT HISTORY:-

Direct:

Taken outside :

METHOD OF FIRST AID GIVEN:-

GENERAL PHYSICAL EXAMINATION

Built- well/ moderate/ poor

Nourishment- well/ moderate/ poor

Pallor, Icterus, Cyanosis, Clubbing, lymphadenopathy, edema

Temperature- febrile/ non febrile

Pulse rate-

Blood pressure-

Respiratory rate-

SYSTEMIC EXAMINATION

1. **R.S.**
2. **C.V.S.**
3. **P/A**
4. **C.N.S.**
5. **SPINE**
6. **PELVIS**

LOCAL EXAMINATION

Site of injury

Right ankle

Left ankle

Bilateral

Deformity

None

Inversion

Eversion

Swelling around the ankle:

Bony tenderness

Medial malleolus

Lateral malleolus

Remaining fibula

Other bones

Movement

Plantar flexion (N = 45) :

Dorsiflexion (N=25) :

Condition of the skin

ANY ASSOCIATED INJURIES/ FRACTURES

INVESTIGATIONS

X- ray : antero posterior

Lateral

Mortise

Type of injury

Pronation abduction injury

Supination adduction injury

Supination external rotation injury

Pronation external rotation injury

Pronation dorsiflexion injury

Miscellaneous

ECG

Routine Blood investigations-

Hb:	PCV:	TC:	DC:	
	RBS:	B.Urea:	S.Creat:	
HIV:	Hbs Ag:	BT:	CT:	BLOOD GP:

DIAGNOSIS

MANAGEMENT

Operative data

Date of operation

Anaesthesia

incision

implants used

drain

duration of the surgery

Intra operative complications

Post-operative data

Analgesics & Antibiotics

drain removal date

Suture Removal date

date of pop cast

date of weight bearing

Post-operative complications

ANNEXURE II

CONSENT FORM

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(surgical and anaesthetical) 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

KEY TO MASTER CHART

1/3TP	1/3 tubular plate
Anat type	Anatomical type
BM	Bimalleolar fracture
DCP	3.5mm Dynamic compression plate
DI	deep infection
DU	delayed union medial malleolus.
E	Excellent
F	Fair
Fe	Female
G	Good
KW	Kirshner wire
L	Left
LM#	Lateral malleolus fracture
M	Male
MM#	Medial malleolus fracture
MOTION	Motion of ankle
MS	Malleolar screw
P	Poor
PA	Pronation-abduction
PER	Pronation-external rotation
R	Right
R-PIN	Rush pin

R-PL	Reconstruction plate
SA	Supination-adduction
SER	Supination –external rotation
SI	Superificial infection
SS	Syndesmotic screw for syndemosis injury.
STP	Semi-tubular plate
TBW	Tension band wiring

MASTER CHART

sl.no	NAME	hospital no	age	sex	side	mode of injury	open/closed	LAUGE HANSEN	AO TYPE	SS	MM#	LM#	time (days) to surgery	union	complications	pain	stability	walking	running	work	motion	radiograph	composite score	result
1	munirathnamma	865048	40	f	rt	RTA	closed	PA	B	YES	MS	1/3TP	4	10wks		12	15	15	10	10	7	25	94	G
2	rathnamma	813617	46	f	rt	RTA	closed	PER	C	NO	TBW	1/3TP	2	10wks		12	15	15	10	10	10	25	97	E
3	gowramma	882341	46	f	lt	RTA	closed	SER	B	NO	TBW	1/3TP	2	8wks		15	15	15	10	8	10	25	98	E
4	krishna reddy	900802	45	m	lt	RTA	closed	SA	A	NO	MS	KW	2	8wks		12	15	15	8	10	10	25	95	G
5	sathish	859887	20	m	rt	RTA	open	PA	B	NO	CS	1/3TP	1	10wks		15	15	15	10	8	10	25	98	E
6	chethan	856151	19	m	lt	FALL	open	SER	B	NO	KW	KW	13	16wks	DI	8	15	8	6	8	7	15	77	P
7	venkatesh	878641	35	m	rt	RTA	open	SER	B	YES	KW	1/3TP	1	12wks	SI	12	15	15	8	10	10	25	95	G
8	nagaraj	875801	35	m	rt	RTA	closed	PER	C	NO	CS	1/3TP	2	10wks		15	15	15	10	8	10	25	98	E
9	amith	901432	27	m	lt	RTA	closed	PER	C	NO	MS	1/3TP	2	8Wks		15	15	15	8	10	10	25	98	E
10	Praveen kumar	904267	47	m	lt	RTA	closed	SER	C	NO	MS	1/3TP	2	8wks		15	15	15	8	10	10	25	98	E
11	khaleel	927847	38	m	rt	RTA	closed	PA	B	NO	MS	1/3TP	3	8wks		12	15	15	10	10	10	25	97	E
12	keshava	912341	30	m	rt	RTA	closed	SER	B	NO	CS	CS	3	8WKS		15	15	15	10	8	10	25	98	E
13	nagappa	935960	68	m	rt	FALL	closed	SER	B	NO	CS	KW	2	14wks	SI	12	15	15	8	8	10	25	93	G
14	nandan	907123	25	m	lt	FALL	closed	SER	B	NO	MS	1/3TP	3	10Wks		12	15	15	8	10	10	25	95	G
15	asif	946316	23	m	lt	RTA	closed	SER	C	NO	MS	1/3TP	2	10wks		15	15	15	10	8	10	25	98	E
16	manjunath	947419	24	m	rt	FALL	closed	SER	B	NO	MS	KW	2	16wks	DU	8	15	8	6	8	7	15	77	P
17	nagaraj	954800	36	m	rt	RTA	closed	SER	C	NO	CS	1/3TP	2	8Wks		15	15	15	10	8	10	25	98	E
18	munivenkatappa	958383	48	m	lt	FALL	open	PA	B	NO	MS	KW	4	12Wks		12	15	15	8	8	10	25	93	G

MASTER CHART

sl.no	NAME	hospital no	age	sex	side	mode of injury	open/closed	LAUGE HANSEN	AO TYPE	SS	MM#	LM#	time (days) to surgery	union	complications	pain	stability	walking	running	work	motion	radiograph	composite score	result
19	girish	947210	22	m	rt	RTA	open	SER	B	NO	MS	1/3TP	1	12wks		12	15	15	10	10	10	25	97	E
20	nagaraj	982450	30	m	rt	RTA	open	PA	B	NO	KW	1/3TP	1	14wks	SI	12	15	12	8	10	10	25	92	G
21	anjineya	982479	26	m	rt	RTA	open	PA	B	NO	KW	KW	1	10wks		15	15	15	10	8	10	25	98	E
22	venkataramana	979348	58	m	rt	RTA	open	SER	C	NO	KW	1/3TP	3	14WKS	DI	12	15	12	8	8	7	25	87	F
23	shrianjeneya	953910	19	m	lt	RTA	closed	SER	B	NO	MS	1/3TP	2	12wks		15	15	15	10	8	10	25	96	E
24	raju	966329	40	m	lt	RTA	closed	SA	A	NO	CS	CS	3	14wks		12	15	12	8	8	7	25	87	F
25	samsher	980750	43	m	lt	RTA	closed	PA	B	YES	MS	1/3TP	2	10wks		12	15	15	10	10	10	25	97	E
26	nanjappa	986122	80	m	rt	RTA	open	PA	B	NO	MS	1/3TP	2	12wks		12	15	15	8	8	10	25	93	G
27	shoba	986802	24	f	lt	RTA	open	SER	C	NO	MS	1/3TP	3	10wks		15	15	15	10	8	10	25	98	E
28	sujathamma	28505	30	f	rt	RTA	open	SA	B	NO	MS	KW	2	10wks		15	15	15	10	8	10	25	98	E
29	venkataravanappa	29604	50	m	lt	RTA	open	PA	B	NO	TBW	1/3TP	3	8WKS		12	15	15	10	10	10	25	97	E
30	ramesh	30254	45	m	rt	RTA	closed	PA	B	NO	MS	1/3TP	1	8wks		15	15	15	10	8	10	25	96	E