# PROSPECTIVE EVALUATION OF OTTAWA ANKLE RULES IN ACUTE ANKLE INJURY

By

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## List of abbreviation

| | |
|---|---|
| OAR | Ottawa Ankle Rules |
| ATFL | Anterior Talofibular Ligament |
| ATFL | Anterior Talofibular Ligament |
| CFL | Calcaneo-Fibular Ligament |
| PTFL | Posterior Talo-Fibular Ligament |
| LTCL | Lateral Talo-Calcaneal Ligament |
| FTCL | Fibulo-Talo-Calcaneal Ligament |
| CPG | Clinical Practice Guideline |
| ED | Emergency Department |
| HUSM | Hospital University Science Malaysia |
| AP view | Antero-Posterior View |
| CT | Computer Tomography |
| MRI | Magnetic Resonance Imaging |

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My Parents

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For Their Patience, Love and Support

## Abstrak

**Tajuk:**

PENILAIAN PROSPEKTIF BERKAITAN PERATURAN OTTAWA DALAM KECEDERAAN PERGELANGAN KAKI AKUT

**Pengenalan**

Kecederaan pergelangan kaki akut adalah merupakan salah satu penyebab utama pesakit dating ke jabatan kecemasan.Pesakit biasanya secara rutin dirujuk ke jabatan radiologi,dimana kurang daripada 15% mempunyai keretakan tulang secara klinikal.

Peraturan Ottawa (OARs) telah dicipta untuk mengurangkan ketidakperluan radiasi radiografi yang telah diarahkan untuk pesakit-pesakit ini.

**Objektif**

Untuk menilai peraturan Ottawa (OARs) dalam meramalkan kepatahan tulang di pergelangan kaki atau dibahagian tengah kaki bagi penduduk Malaysia yang mengalami kecederaan pergelangan kaki akut.

**Kaedah**

Kajian ini telah dijalankan di jabatan kecemasan dan klinik otopedik di Hospital Universiti Sains Malaysia.Kajian kumpulan ini terdiri dari 73 orang pesakit berumur 18 tahun dan ke atas yang mengalami kecederaan pergelangan kaki dan pertengahan kaki akut dalam jangkamasa 12 bulan.Radiografi telah dilakukan ke atas semua pesakit selepas diperiksa dan direkodkan secara klinikal. Perkara utama yang diukur dalam kajian ini adalah : sensitiviti, spesifikasi, nilai ramalan positif , nilai ramalan negatif dan kebarangkalian nisbah (positif dan negatif dalam peraturan Ottawa(OARs).

**Keputusan**

Sebanyak dua puluh dua orang yang patah dibahagian pergelangan kaki dan 12orang patah dipertengahan kaki telah dapat ditentukan.

Hasil keputusan kumpulan ini didapati mempunyai sensitiviti 100%, spesifikasi 73.68% dan nilai ramalan negative 100% dalam mengesan patah pergelangan kaki.Sensitiviti 100%, spesifikasi 84.61% dan nilai ramalan negative 100%dalam menentukan kepatahan dipertengahan kaki. Perlaksanaan peraturan Ottawa (OARs) berpotensi untuk menurunkan radiasi radiograf ke 42.4%.

**Kesimpulan**

Peraturan Ottawa (OARs) adalah sangat tepat dan sangat sensitif untuk mengesan kepatahan dibahagian pergelangan kaki. Perlaksanaan peraturan ini dalam populasi kita telah membawa kepada penurunan yang jitu dari jumlah yang meminta untuk radiograf tanpa diagnosa yang salah untuk kepatahan tulang secara klinikal,justeru mengurangkan kos, dedahan radiasi dan masa menunggu di Jabatan Kecemasan.

# Abstract

## Title

**PROSPECTIVE EVALUATION OF OTTAWA ANKLE RULES IN ACUTE ANKLE INJURY**

## Background

Acute ankle injuries are one of the most common reasons for presenting to emergency departments. These patients are almost always routinely referred for radiography, whereas less than 15% have clinically significant fractures.

The Ottawa Ankle Rules (OARs) have been designed to reduce the number of unnecessary radiographs ordered for these patients.

## Objective

To evaluate the OAR for predicting ankle and/or midfoot fractures in Malaysian population whose sustained acute ankle injuries.

## Methodology

This prospective survey was conducted in the emergency department and orthopedic clinic of hospital university sains of Malaysia. The study group consisted of 73 patients aged 18 years and older who presented with acute ankle and/or midfoot injuries during 12 months. Radiography was performed for all patients after clinical evaluation findings were recorded.

Main outcome measures of this survey were: sensitivity, specificity, positive predictive value, negative predictive value, and likelihood ratios (positive and negative) of the OARs.

## Results

Twenty two ankle and 12 midfoot fractures were diagnosed. The decision rules had a sensitivity of 100% a specificity of 73.68% and a negative predictive value of 100% in detecting ankle fractures, a sensitivity of 100%, a specificity of 84.61%, and a negative predictive value of

100% in detecting midfoot fractures. Implementation of the OARs had the potential for reducing radiographs by 42.4%.

**Conclusion**

OARs are very accurate and highly sensitive tools for detecting ankle fractures. Implementation of these rules in our population would lead to significant reduction in the number of requesting for radiographs without missing any clinically significant fractures, thus reducing costs, radiation exposure and waiting times in emergency departments.

## 1.0 INTRODUCTION

Acute ankle injuries are the most common joint injuries presenting to the Emergency Department (ED) (Stiell *et al.*, 1992). Most ankle injury patients undergo radiography, whereas less than 15% have significant fractures or avulsion fractures (Stiell *et al.*, 1992; Anis *et al.*, 1995). Thus the costs associated with management of ankle trauma are substantial.

In order to reduce the need for radiography in patients with acute ankle trauma prediction rules have been developed. These rules have a purpose to reduce the amount of radiography without the risk of missing clinical significant fractures.

Ottawa Ankle Rules (OAR) is a worldwide well-validated and well accepted clinical practice guideline (CPG) to assess these injuries in making the decision for the need of radiographs. The final aim would be reducing unnecessary radiographs. This can reduce patient's time in ED and unnecessary radiation exposure. The work load of a radiographer in performing it and an ED doctor in reviewing and interpretating the radiographs can also be reduced. Finally, the total healthcare cost will be reduced without an increased rate of missed fracture.

## 2.0 ANATOMY OF ANKLE AND FOOT

### 2.1 Ankles joint

The ankle is a modified hinge joint which consists of three bones (tibia, fibula and talus) and the ligaments which bind these bones as a unit. The tibia and fibula form a mortise. This provides a constrained articulation for the talus. Both the articular surface of the distal tibia (tibial plafond) and the mortise are wider superiorly and anteriorly to accommodate the wedge-shaped talus. The shape of the joint alone provides some intrinsic stability, especially in weight bearing (fig. 2.1). (McCullough *et al*, 1980).

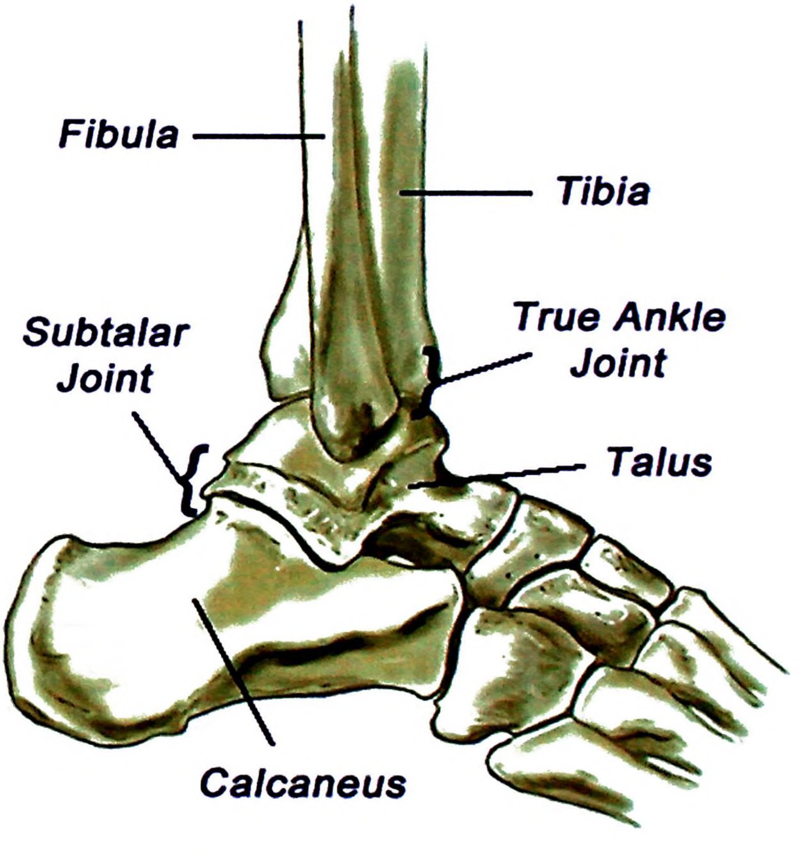


Fig.2.1: anatomy of the ankle joint

### 2.1.1 Bone

The stability of the talocrural–ankle joint is achieved by osseous elements, joint capsule and by the strong ligamentous support. The medial malleolus is an extension of the distal tibia. The inner surface is covered with articular cartilage and articulates with the medial facet of the talus. The distal, inner surface of the malleolus is divided by a longitudinal groove into a large, anterior colliculus and a smaller, posterior colliculus. Each has an attachment site for a portion of the deltoid ligament. There is also a groove on the posterior surface where the posterior tibial tendon passes and where the tendon sheath is attached to.

The fibula provides lateral support for the ankle. Just above the ankle joint, the fibula sits in a groove formed by a broad anterior tubercle and a smaller posterior tubercle of the tibia. There is no articular surface between the distal tibia and fibula, even though there is a small amount of motion between these two bones. The medial border of the fibula is covered by an articular cartilage from the level of the tibia plafond to a point approximately halfway down its remaining length. The distal end is tapered and has a posterior groove for the peroneal tendon.

The talus has a curved head, an intermediate neck portion, and a large trapezoidal body. It articulates with the navicular, calcaneus, tibia, and fibula. The body of the talus is almost entirely covered by articular cartilage. The superior surface is convex from front back and slightly concave from side to side. The dome of the talus is trapezoidal, and its anterior surface is an average of 2.5 mm (a range of 0 to 6 mm) wider than the posterior surface. The articular surface of the malleolus is also wider anterior to support the talus. The medial and lateral articular facets of the talus are continuous with its superior articular surface. The lateral facet is larger than the corresponding facet on the fibula. The majority of the talar neck has no articular surface.

### 2.1.2 Ligaments

Three distinct groups of ligaments support the ankle joint. The lateral collateral, medial collateral and the Syndesmotic ligaments.

#### 2.1.2.1 Lateral ankle ligaments

This consists of the anterior talofibular ligament (ATFL), calcaneofibular ligament (CFL) and the posterior talofibular ligament (PTFL) (fig.2.2). They are not as strong as the medial ligaments as the fibula also provides lateral support for the ankle.
The ATFL is the weakest of these ligaments. It connects the anterior fibula to the neck of talus and prevents anterior subluxation of the talus when the ankle is plantar flexion. The midportion of this ligament is confluent with the capsule of the ankle this area overlies a ridge formed by the anterior border of the lateral articular facet of the talus. This ridge may injure the ligament when the ankle is in plantar flexed position.

The anterior talofibular ligament runs anteriorly to the neck of the talus. It had an average length of 24.8 mm and directed at an average 44.8° medially from the fibula to the talus. The center of the ligament bulk was located at an average of 10.1 mm proximal to the tip of fibula. This was measured along the long axis of the fibula. Its insertion was at an average of 18.1 mm proximal to the subtular joint of the talus.

The calcaneofibular ligament runs vertically downward from the distal fibula to a small tubercle on the posterior and lateral aspect of the calcaneus. This ligament is not associated with either the ankle capsule or the peroneal tendon sheath. It is lax in the normal standing position, owing to the relative valgus orientation of the calcaneus. It acts primarily to stabilize the subtular joint and limit inversion. The calcaneofibular ligament had an average measurement of 5.3 mm wide; 35.8 mm long, and formed an angle of 133 with the fibula when the foot was in plantigrade.

The posterior talofibular ligament is deep-seated and arises from the nonarticular surface of the posteromedial fibula. It runs medially in a more horizontal plane to attach to an eminence on the lateral tubercle of the body of the talus lateral to the groove for flexor hallucis longus tendon. It is the strongest of the lateral ligament complex and prevents posterior and rotator subluxation of the talus.

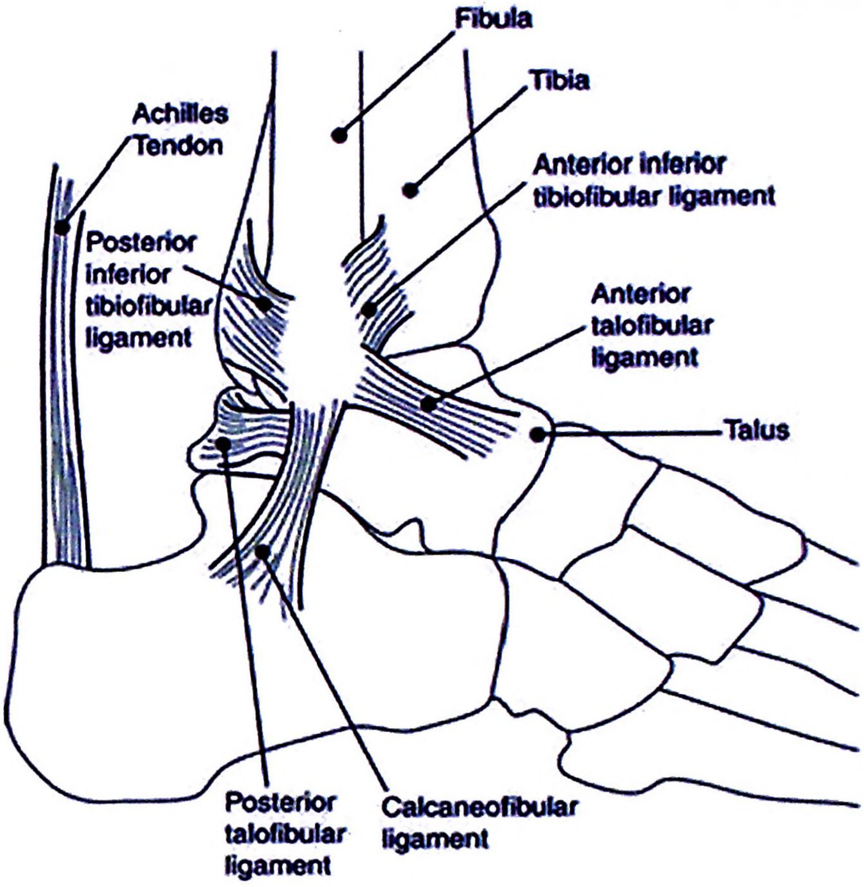


Fig. 2.2: Lateral aspect of the ankle, showing Lateral collateral ligaments

#### 2.1.2.2 Deltoid ligament

This strong, dense, fan-shaped structure arises from the medial malleolus and consists of superficial and deep layer (fig.2.3).

The superficial deltoid is divided into three slips which originate from the anteroinferior medial malleolus and insert into the navicular, calcaneonavicular ligament and the sustentaculum tali and tuberosity of the calcaneum respectively. The superficial deltoid acts mainly to prevent hind-foot eversion.

The deep deltoid ligament originates from the posterior border of the anterior colliculus, intercollicular groove and posterior colliculus before running transversely to insert into the non-articular surface of the medial talus. The posteromedial aspect of the ligament is covered by the tibialis posterior tendon sheath. Sectioning the deep deltoid ligament results in greatly increased lateral talar shift and external talar rotation (Burns *et al.*, 1993).

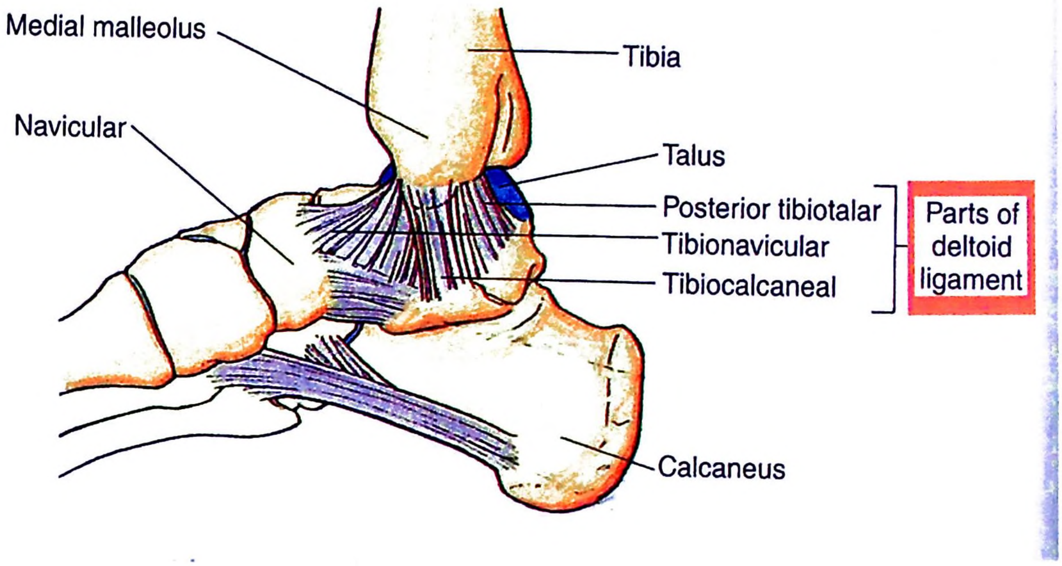


Fig.2.3. Medial aspect of the ankle joint showing deltoid ligament

**2.1.2.3 Syndesmotic ligament**

The ligaments of the syndesmosis form a complex articulation that maintains the fibula closely approximated in the fibular notch. Interosseous membrane runs between the tibia and fibula at the level of the proximal tibiofibular joint. On the other hand the interosseous ligament is an inferior extension of interosseus membrane, and is a key transverse stabilizer of tibiofibular articulation.

The Syndesmotic ligament complex maintains the integrity between the distal tibia and fibula and resists the axial, rotational, and translation forces that attempt to separate these two bones. It is made up of four ligaments: (fig 2.4)

1- The **anterior tibiofibular,**
2- The **posterior tibiofibular** ligament,
3- The **transverse tibiofibular ligament, and**
4- The **interosseous ligament**

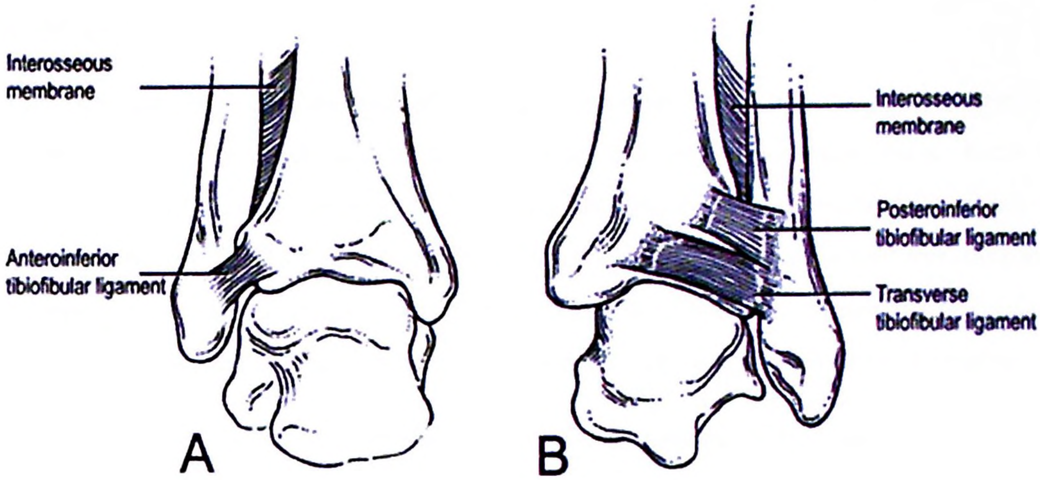


Fig. 2.4: The syndesmotic ligament of the ankle.

The anterior tibiofibular ligament originates from the anterior tubercle and anterolateral surface of the tibia and run obliquely to the anterior fibula.

The posterior tibiofibular ligament originates from the posterolateral tubercle of the tibia and inserts onto the posterior fibula. It is stronger and thicker than its counterpart owing to this difference, torsional or translational forces usually cause an avulsion fracture of the posterior tibia tubercle and rupture of the weak anterior talofibular ligament, while leaving the posterior ligament intact, while the weaker anterior tibiofibular ligament usually ruptures.

The **transverse tibiofibular ligament** is often considered part of the posterior tibiofibular ligament complex and acts to deepen the posterior aspect of the ankle joint.

**The interosseous ligament** is an inferior extenson of interosseus membrane, and is a key transverse stabilizer of tibiofibular articulation. The Interosseous membrane runs between the tibia and fibula at the level of the proximal tibiofibular joint. It stabilizes the fibula, provides additional attachment sites for the muscle and may have some load-bearing functions (Vukicevc *et al.,* 1980). This ligament is more flexible and allows a subtle diastasis of the tibia and fibula during ankle dorsiflexion (Norkus and Floyd, 2001). The Interosseous ligament is triangular with a proximal apex and a broad distal base. It is thinner in its midportion of a perforating synovial pouch from the ankle joint.

## 2.2 Subtalar joint

The subtalar joint allows pronation and supination and consists of two separate joint cavities. Posteriorly the joint is formed between the inferioposterior talar facet and the superioposterior facet of the calcaneus. The anterior articulation is formed between the talar head, anterioresuperior facets, sustentaculum tali and the concave surface of the navicular. This talocalcaneonavicular joint functions as a ball and socket. These two joints are separated by the sinus tarsi and have separate joint capsules although they share a similar axis of rotation.

There are three lateral groups of supporting structures. These are the deep ligaments, peripheral ligaments and retinaculae. The cervical and interosseous ligaments are deep ligaments which lie between the two joint capsules. The cervical ligament runs from the cervical tubercle of the calcaneus anteriorly and medially to the talar neck (Viladot *et al.*, 1984). The interosseous ligament lies posterior to the cervical ligament and runs superiorly and medially. It takes its origin from the calcaneus just anterior to the posterior joint capsule and inserts into the talar neck just medial to the insertion of the cervical ligaments. Lateral support comes in part from the inferior extensor retinaculum. These have three roots which are lateral, intermediate and medial although it is likely that only the lateral root confers stability. The three peripheral ligaments which stabilize the subtalar joint are the calcaneofibular ligament (CFL), which also spans the ankle joint, the lateral talocalcaneal ligament (LTCL) and the fibulotalocalcaneal ligament (FTCL) (Hertel, 2002).

## 2.3 The foot

The foot plays an important role in supporting the weight of the entire body and in locomotion. The bones of the foot are arched longitudinally to help facilitate the support function. The transverse arch helps with movements of the foot. These movements help keep the sole (plantar surface) in contact with the ground despite the unevenness of the ground surface. They also work in concert with the ankle joint to help propel the foot off the ground during toe off portion of gait. It is convenient to speak of 3 segments of the foot: hindfoot, midfoot and forefoot. The calcaneus and talus comprise the hindfoot while the metatarsals and phalanges make up the forefoot. The navicular, cuboid and cuneiform bones make up the midfoot (Love *et al.*, 1995).

### 2.3.1 Anatomy of the midfoot

The midfoot is a relatively rigid structure in comparison to the hindfoot and forefoot and as such it provides a stable structure to transmit load. The bones comprising the midfoot include the cuboid, navicular and the three cuneiforms (fig.2.5).

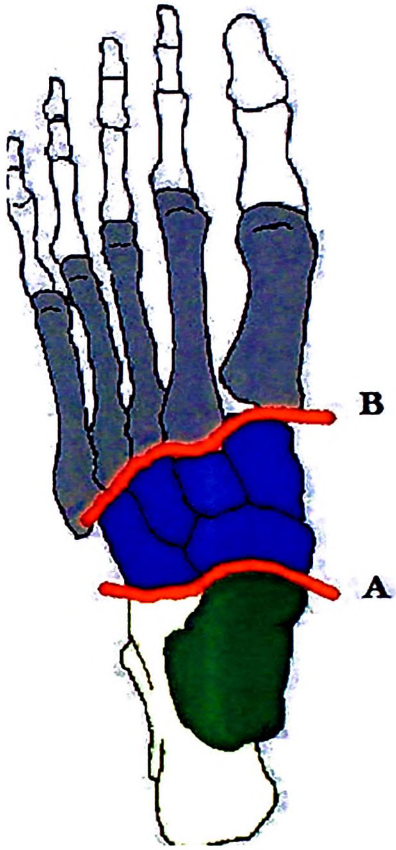


Fig. 2.5: Anatomy of the midfoot (bones between line A and B)

The cuboid supports the lateral column and is positioned between the calcaneum and the base of fourth and fifth metatarsals. The calcaneocuboid joint is saddle shaped. The dorsal surface is traversed by extensor digitorum brevis and peroneus tertius. Ligaments from the dorsum attach widely to the navicular, lateral cuneiform and fourth and fifth metatarsals. On the plantar aspect the cuboid has a groove for the peroneus longus tendon. Ligaments on the plantar surface spread to the fourth and fifth metatarsals and calcaneum as well as to the navicular and lateral cuneiform. The cuboid articulates with the navicular and a facet for the navicular bone exists in 45.5–54.5% of feet (Sarrafian, 1993).

The navicular (scaphoid) is interposed between the cuneiforms and talus. The joint surface is concave proximally and convex distally with facets for the cuneiforms. Similar to the talus most of its joint surface is covered with cartilage. The calcaneonavicular, talonavicular and navicular-cuneiform ligaments attach dorsally. The anterior, tibionavicular, part of the deltoid ligament also supports the anteromedial aspect of the joint. The tibialis posterior tendon inserts into the medial tuberosity. A separate tuberosity from the main navicular is known as the naviculare secundarium. The head of the talus lies in a deep socket or acetabulum pedis formed by the navicular, anterior calcaneum, the bifurcate ligament and calcaneonavicular ligaments. The superomedial calcaneonavicular ligament originates from the sustentaculum tali and inserts on to the navicular. The articular surface is smooth and fibrocartilaginous on the volar aspect. The spring ligament (inferior calcaneonavicular ligament) originates from the coronoid cavity of the calcaneus anteriorly and inserts into the volar aspect of the navicular. The bifurcate ligament (ligament of Chopart) is formed by the lateral calcaneonavicular and medial calcaneocuboid ligament.

The blood supply of the navicular is derived from a branch of the dorsalis pedis artery dorsally and from a branch of the medial plantar artery volarly. The tuberosity receives branches from an anastomosis of these two. A rich anastomosis exists around the circumference of the navicular and a paucity of vessels supplying the central one-third occurs in adults. Torg et al., (1982) showed with microangiographic studies that the lateral and medial third were vascular and the central one-third avascular. This probably accounts for the increased rate of non-union and avascular necrosis seen following fracture.

The three cuneiforms are positioned between the navicular and the first three metatarsals. They form a transverse arch with the cuboid. The medial cuneiform has a plantar-based wedge, whereas the intermediate and lateral cuneiform have a dorsally based wedge. The middle cuneiform is recessed 8mm relative to the medial and 4mm relative to the lateral cuneiform, which creates the mortise for the second metatarsal base, rather like a tenon in a tenon joint. Numerous accessory bones exist around the midfoot and they are thought to be developmental anomalies. The os tibiale (naviculare secundarium) is located on the posteromedial aspect of the navicular and incorporated in the tibialis posterior tendon. It is seen in 3–12% of feet and may have a fibrous, fibrocartilaginous or bony connection. The os supranaviculare (Pirie's bone) is located dorsally to the talonavicular joint and the os vesalianum lies just proximal to the fifth metatarsal tuberosity base. The os peroneum lies in the tendon of peroneus longus under the cuboid. Tendon ruptures often occur in the region and may be misdiagnosed as an avulsion fracture of the fifth metatarsal or cuboid. Awareness of these accessory bones is important to avoid misdiagnosing fractures.

The midfoot joints consist of the Chopart's joints i.e. the talonavicular and calcaneocuboid, and the lesser tarsal bones, the navicular, cuboid and cuneiforms. The cuboid and navicular act as an amphiarthrosis and move together on the anterior calcaneum and talar head.

The medial column, i.e. the talonavicular, naviculocuneiform and first and second tarsometatarsal joint, is relatively rigid compared to the lateral column, i.e. calcaneocuboid, cuboid, fourth and fifth metatarsal joint. Therefore, patients tolerate arthrodesis in the medial column better than in the lateral column.

## 2.4 MOVEMENT OF THE FOOT

### 2.4.1 Dorsiflexion and planter flexion

Vertical movements of the foot involve motion in tibiotalar joint and in the talocalcaneonavicular joint. Having no muscle attachments, talus cannot move alone. It has to follow the motions of the calcaneus and the navicular. Dorsiflexion of the tibiotalar joint is accompanied with pronation of the foot. Upward movement of the foot requires simultaneous relaxation of the triceps and the tibialis posterior. This permits a downward migration of the posterior tubeorsity of the calcaneus as the anterior end of the calcaneus everts while the navicular moves laterally on the talus.

Plantarflexion is a combination of equines, inversion, and adduction. In plantar flexion the foot supinates because the tibialis posterior pulls the navicular medially. Via its attachment to the sustentaculum, tibialis posterior also inverts and pulls the anterior end of the calcaneus downward. At the same time, the triceps surae pulls the posterior tuberosity of the calcaneus upward. The triceps and the tibialis posterior are the only extrinsic muscles that which insert on the calcaneus. As they plantar flex and invert the heel, equines, varus, and adduction take place simultaneously and not as separate isolated movements of the foot.

### 2.4.2 Horizontal motion

Movements at the talonavicular and the anterior and posterior subtalar joints elicit horizontal motion. The anterior end of the calcaneus and the navicular move together around the talar head majority of horizontal motion take place at the talonavicular and the anterior subtalar joints. Less movement occurs in the posterior subtalar joint. The calcaneocuboid joint has a very limited gliding mobility as the cuboid moves with the calcaneus. For normal subtalar motion, the navicular has to be mobile and free to rotate around the talar head. The heel cannot be everted or inverted without simultaneous motion between the navicular and the head of the talus. Movement in the subtalar joint is limited when the talonavicular is transfixed. When displacement of the navicular is prevented, little movement can be obtained in the subtalar joint. Restriction of either the talonavicular or subtalar motion affects the mobility of the other. Neither functions independent of the other. In horizontal motion, both joints move simultaneously.

### 2.4.3 Inversion

When the normal foot is adducted and inverted (supination), the navicular rotates medially around the head of the talus, moving proximally and slightly downward and closer to the medial malleolus. In turn this will diminish the inverted between the navicular and the sustentaculum. At the same time, as the navicular move medially, the calcaneus inverts and lies under the talus. The tibialis posterior tendon by its insertion on the navicular, the spring ligament, and the sustentaculum tali of the calcaneus, is the active force that pulls the navicular and the anterior end of the calcaneus medially. This medial migration of the navicular and the calcaneus diminishes the size of the acetabulum for the head of the talus, and opens the sinus tarsi laterally.

### 2.4.4 Eversion

When the foot is abducted and everted (pronation), movement of the socket is the opposite of inversion. The calcaneus everts and the navicular moves laterally with the calcaneus in relation to the talus. Thus the capacity of the socket is greater as more of the talar head is covered by the acetabulum and the sinus tarsi is closed.

## 2.5 IMAGING OF THE ANKLE AND FOOT

Plain radiograph is the easiest, cheapest and easily accessible imaging modality for ankle and foot injury or any other traumatic injury. Nevertheless, it should only be requested in order to find out any fracture or bony abnormalities after methodical history and physical examination. Majority of traumatic lesions of the skeleton can be documented effectively utilizing standard radiographs (Grainger &Allison, 1997). Rarely other imaging modalities needed in evaluating this injury, except a few specific injuries. At least two orthogonal views (at right angles to each other) are generally required (Grainger &Allison, 1997). (Brandser *et al.*, 2000) emphasized in the necessity of obtaining three radiographs in anteroposterior, lateral and mortise projection as they would result in a small but significant decrease in the detection of fractures. Despite of the use of these three views, some fracture are occult at the time of initial evaluation (Mulligan, 2002). This is where other imaging modalities could play a role in detecting fracture if there is high index of suspicion clinically.

Ultrasound is useful in evaluating effusion, tendons or ligamentous injury. This modality is very useful especially in injury that does not has risk of stress fracture such as jumping or landing, stress fracture might occur. Stress fracture is a fracture due to repetitive stress that insufficient to cause an acute fracture. This fracture will not be detected on ultrasound or plain radiograph. Ultrasound can detect ligamentous injury as they show irregularity or discontinuity of the tendon. However, ultrasound is operator dependent, as it needs skillful sonographer to diagnose ligamentous injury.

MRI is well known of its soft tissue (ligaments, tendons, cartilages and muscles) superiority, which plain film and other imaging modalities are unable to provide. These are the reasons why athletes who sustained sports injury usually need MRI evaluation. Prompt diagnosis is crucial for appropriate treatment to be given in order for them to get back to field as soon as possible. MRI can detect stress fracture and it has the advantage over skeletal scintigraphy in detecting periosteal oedema. Intrasubstance injury (sprain, partial tear and oedema) will show high signal intensity on T2 weighted image as there is increase the water content. Inflamed tendon will be enlarged with increase in intratendinous signal.

Fat suppression or STIR (Short Tau Inversion Recovery) is a sensitive sequence where intramedullary fat can be suppressed to give a better detection of any marrow abnormality such as in stress fracture (Grainger & Allison's, 1997).

Computer Tomography (CT) is used mainly in evaluating bony fragments, coronal or sagittal reformatting and 3D reconstruction. Complex anatomy with subtle and fragmented bones can be portrayed from CT reconstruction, which is imperative for the surgeon for treatment planning.

Skeletal scintigraphy can be used to detect stress fracture such as talar dome or tarsal occult injury. High activity of bone turnover is shown by increased uptake of tracer. This imaging modality is also useful in detecting avascular necrosis earlier than plain radiograph.

Interventional procedures in ankle and foot injury include arthrography and angiogram. Artherogram will demonstrate contrast extravasation outside the joint in ligament tear. Angiogram is vital in patient with vascular injury.

### 2.5.1 PLAIN RADIOGRAPHS -RADIOGRAPHIC TECHNIQUES

The routine views practiced for ankle are AP and lateral while for the foot are AP and oblique. Other additional views for ankle are mortise and stress view. Lateral view for the foot is occasionally performed although it can show calcaneum, talus and base of fifth metatarsal quite well. Additional views for individual bones of the foot are required depending on the clinical assessment.

#### 2.5.1.1 Positioning of the ankle radiograph (Bell & Finlay, 1986)

**Ankle – anteroposterior/frontal projection (figure 2.6)**

The patient is seated on the X-ray couch with the legs extended and unaffected leg abducted. The affected ankle is placed on the cassette with the joint flexed at 90 degrees.
The ankle is rotated medially until both malleoli are equidistant from the couch top. The centering point is midway between the malleoli with the direction of cetntral ray vertical at 90 degrees to the cassette.

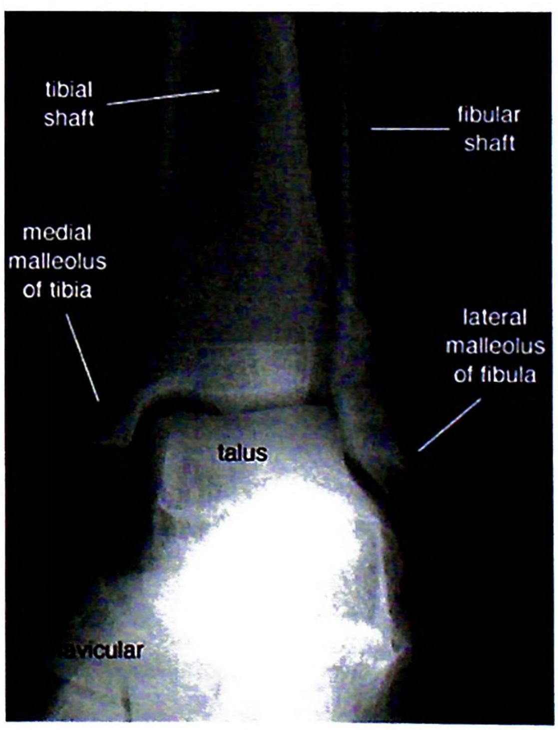


Fig 2.6 AP view of ankle

**Ankle – lateral projection (figure 2.7)**

The patient lies on the affected side on the X-ray couch with the hip and knees flexed. The knee of the affected leg is raised on a pad. The lateral aspect of the affected ankle is placed with the joint flexed 90 degrees. The ankle is rotated laterally so that the malleoli will be superimposed. The unaffected side is rested in front or behind the affected leg. The central ray is directed vertically at 90 degrees to cassette with centring point at medial malleolus.

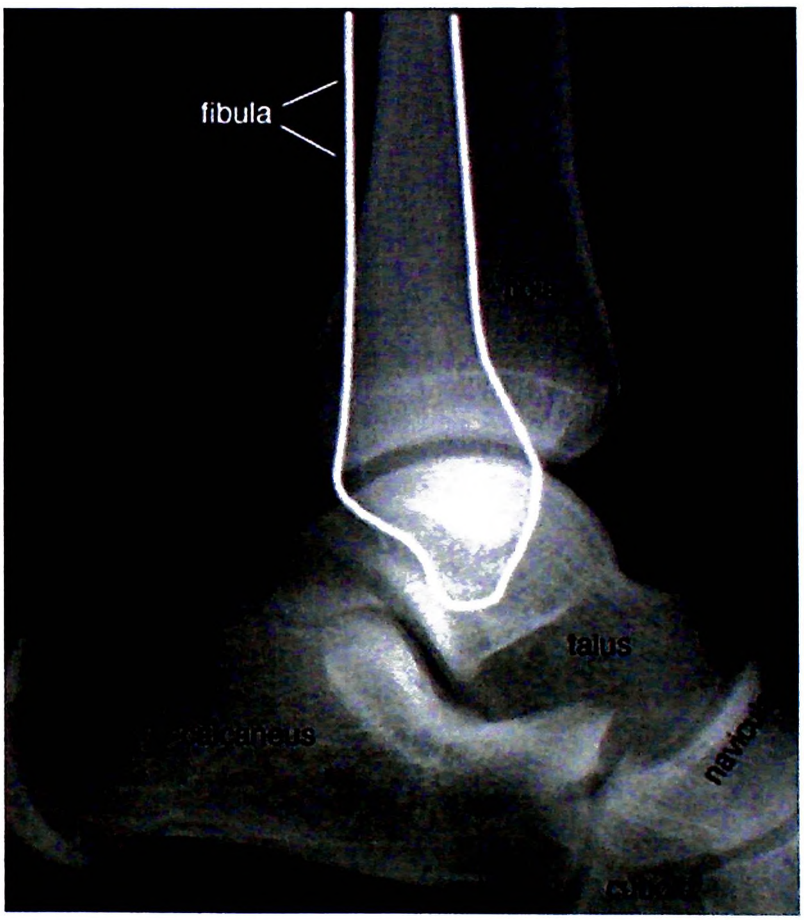


Fig 2.7: lateral view of ankle

Mortise view (figure2.8) is an AP projection of an ankle with the leg is internally rotated about 15 to 20 degrees, with the central beam perpendicular to the ankle joint. The view can show us the entire joint space and distal talofibular articulation.

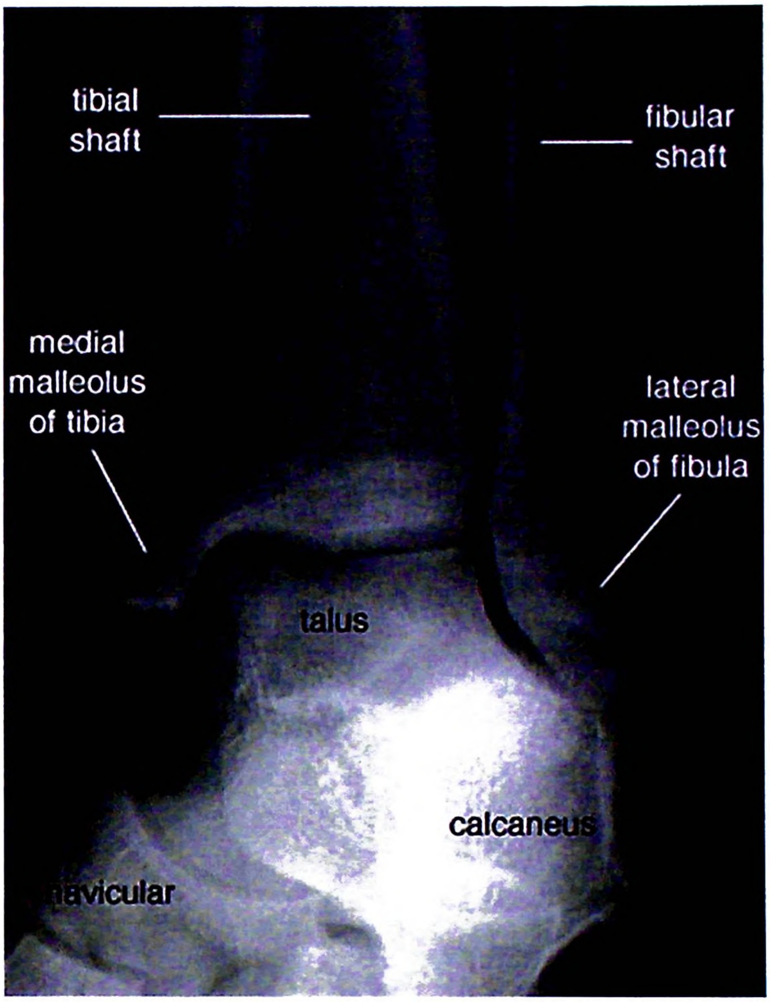


Fig: 2.8 mortise view of ankle

#### 2.5.1.2 Positioning of the foot radiograph

**Foot – Anterioposterior/Frontal Projection** (Figure2.9)

The patient is seated on the X-ray couch with the knees flexed. The sole of the affected foot is placed on the cassette. The centring point is at the dorsum of the foot at cuboid-navicular region with central ray directed 90 degrees vertical to the cassette.

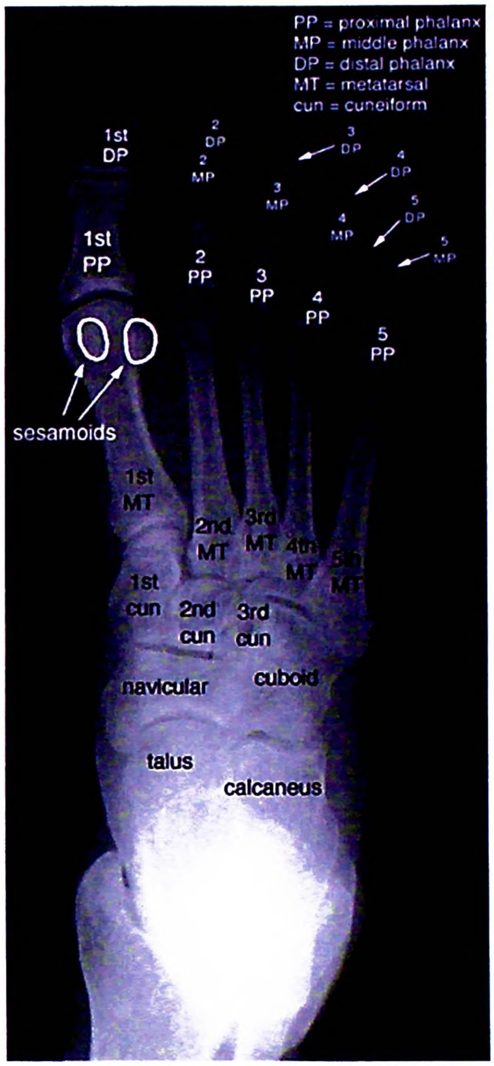


Fig 2.9 show AP view of foot

**Foot – oblique projection (figure2.10)**

The patient is seated on the X-ray couch with knees flexed. The affected foot is placed on the cassette with the lateral border of the foot being raised on a pad to make the dorsum of the foot parallel to the cassette. The centring point is similar as in the anteroposterior projection with central ray at 90 degrees.

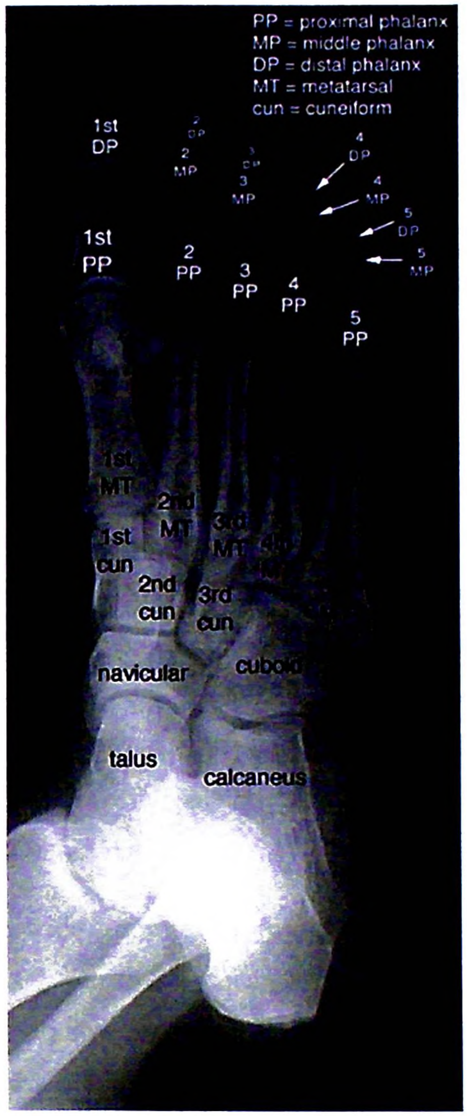


**Fig 2.10**: show oblique view of foot

**The exposure factors for ankle and foot radiographs are shows in (table 2.1)**

**Table 2.1**: Exposure factors for ankle and foot radiographs (Radiology Department HUSM)

| factors | Ankle | Foot |
|---|---|---|
| mA | 200 | 200 |
| KVp | 66(AP) 63(lateral) | 60(AP) 60 (oblique) |
| Exposure time (sec) | 0.016 | 0.033 |
| Source to image distance (cm) | 120 | 120 |

Other additional views can be performed if clinically indicated or if the initial radiographs showed no fracture but the symptoms still persist after 7 to 10 days post trauma. The latter can occur in occult fracture or in ligamentous injury. Stress view will show abnormal joint widening. Modification of the radiographic tevhnique such as magnification or tomography is also useful in certain cases. Tomography can be used in evaluating complex platfond fracture or possibility of articular involvement.

### 2.5.2 PLAIN RADIOGRAPHS – INTERPRETATION

The ankle is a regular structure with a parallelism of its articular margin. The axis of the shaft of the tibia is perpendicular to the horizontal plane of the ankle joint and it is continuous with the vertical axis of the talus. The line tangent to the articular surface of medial malleolus ranges from 45 to 65 degrees and to the articular surface of lateral malleolus ranges from 45 to 65 degrees from the horizontal plane of the ankle joint (Keats et al cited in Keats & Sistrom, 2001). Loss of parallelism of the articular surface with increase distance between the talus and any of the malleoli could indicate medial and lateral ligaments injury although the ligaments themselves are not visualized on plain radiograph.

The average joint space width of an ankle joint (Jonsson *et al* .cited in Keats & Sistrom, 2001) in men is 3.4 mm and 2.9 mm in women. The lateral tibial tubercle overlaps the distal fibula on AP view. This tibiofibula overlap is usually greater than 2.1 mm in women and greater than 5.7 mm in men if measured at a horizontal line drawn 1 cm about the tibial plafond. This overlap is diminished or absent in ligamentous injury.

The talus is better seen on AP ankle rather than the AP foot and vice versa with the distal tarsus, which are not clearly seen on the AP ankle projection. The oblique projection of the foot is good in demonstrating the intertarsal joints, tarsal bones and joint between tarsus and the fourth and fifth metatarsal and structural detail of the base of the fifth metatarsal(Meschan, 1975).

The Boehler's angle for calcaneum is the angle between a line drawn from the posterior superior margin of the talocalcaneal joint to the superior margin of the calcaneus with the line between the posterior superior margin of the talocalcaneal joint to the superior margin of the calcaneocuboid joint. The normal angle ranges from 30 to 35 degrees and a value less than 28 degrees occur in significant structural damage to the calcaneum.

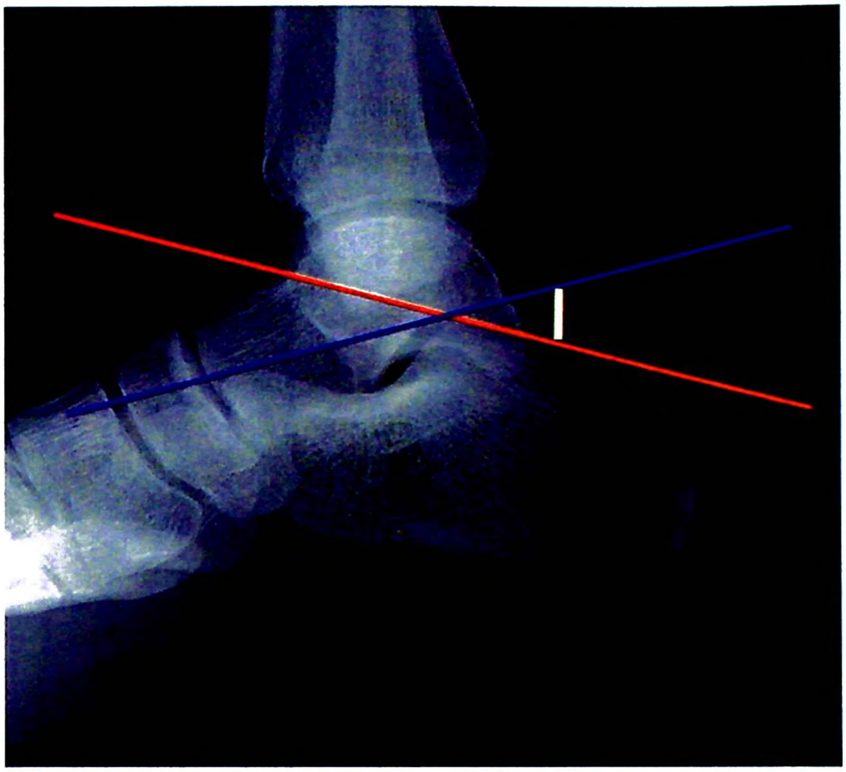

**Figure 2.11**: shows boehlers angle in schematic diagram while figure representing the radiograph measurement.

Multiple sesamoid bones are found in the ankle and foot radiographs. The sesamoids has smooth sclerotic margin and the consistent locations will guide us in differentiating them from fracture. Knowledge of the ossification centres and age of the fusion are important in distinguishing them with fracture lines. With the presence of multiple growth centers or delayed fusion, they may be difficult to recognize metatarsal or phalangeal fractures do occur. Therefore, comparison views of the uninjured foot are quite beneficial. It needs practice in familiarization of the overlapping structures, normal variants, sesamoid bones and radiography technical consideration in interpolating these radiographs.

It is very common for an ankle injury to just involve the soft tissue (tendons, ligaments, cartilages, muscles and subcutaneous tissue) only without any fractures.

Therefore, it is important for us to know the anatomy of the soft tissues although they are not well visualized radiographically. Soft tissue swelling that is seen on the AP view should alert us on subtle fracture. Presence of a large joint effusion on the initial lateral radiograph suggests an occult fracture (Mulligan, 2002). Figure 2.12 shows an example of soft tissue swelling at the lateral malleolus. Avulsion fracture of the tibia and fibula can also detected from the AP view. On the lateral view, there will be a triangular lucency anterior to the Achilles tendon that will be obliterated in Achilles tendon injury or in ankle effusion. The anterior and posterior avulsion fracture of the tibia can be seen from this view.

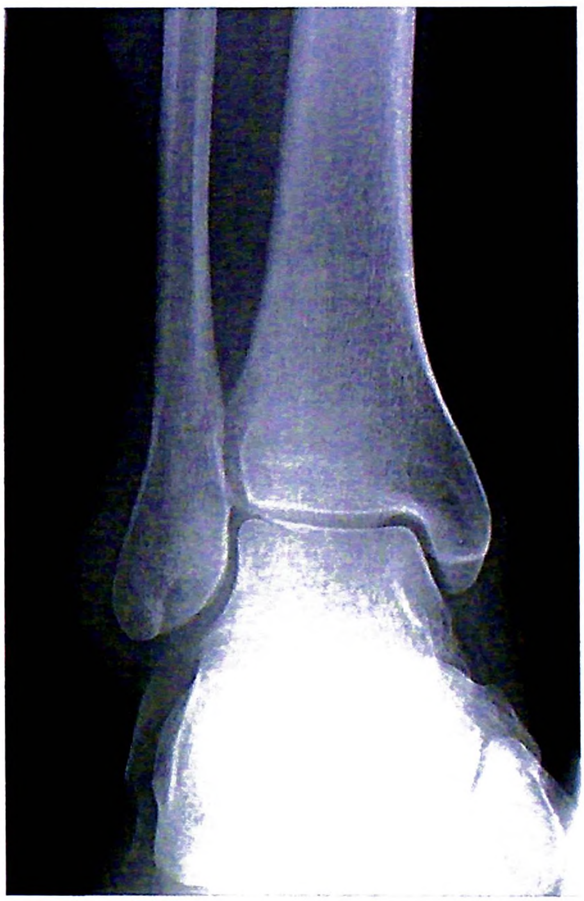

Figure 2.12 soft tissues swelling at lateral malleolus

Heel pad thickness is the distance between the calcaneal tuberosity posteroinferiorly and the skin surface (Figure 2.13). The normal thickness is 21 mm in female and 23 mm in male (Ryan & McNicholas, 1994). An increase in the thickness would give differentials of oedema in trauma setting, or other non-trauma causes such as acromegaly, obesity, infection, myxoedema or epanutin therapy (an antiepileptic drug).


**Fig 2.13**: Show Heel pad thickness measurement