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Plating Technique Outcome Evaluation in Calcaneal Fractures Based on American Orthopaedics Foot and Ankle Score and Bohler and Gissane Angle in Tertiary Centre in North Kerala: A Cross-Sectional Study

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Abstract: ***Introduction: The most frequent tarsal bone damage occurs due to calcaneal fractures (CF) that accounts to around 2% of all fractures in the human body. Bohler and Gissane angles can be used to measure abnormalities in calcaneal height. They serve as important parameter qualities in diagnosis, therapy, and prognosis. Plating has evolved as an important treatment for calcaneal fractures. Objectives: The purpose of the study is to assess the effectiveness of calcaneal plating for calcaneal fractures based on radiological and clinical results. Methods: We conducted a hospital based cross sectional study in the Orthopaedics department, GMC Kannur, Kerala between2021 to 2022. After institutional Ethical Committee approval and informed written consent, around 48 patients who had calcaneal fractures were selected based on the inclusion and exclusion criteria. All patients were evaluated with proper clinical history, thorough clinical examination and Xray evaluation. Results: We reached 48 cases, of whom 43% belonged to 18-30 years, with the mean age of 34.4 (6.7) years. Around 81% were males. More than half (60%) had duration of injury of less than 3 days. Almost 87.6% had fall from height as mode of injury. We observed that there was an increase in the Gissane's angle and decrease in Bohler's angle during the post op period at 6 months and 1 year, and it was found to be statistically significant. (p value <0.05) Incidence of complications was also noted only among 16%. We observed that there was an increase in aofas score during postop period and it was found to be statistically significant. (P value <0.05). Conclusion: Thus, through our study, we recommend the use of plating techniques for the treatment of calcaneal fracture cases. This could possibly improve both the clinical and radiological outcomes among patients with lesser incidence of complications.***

Keywords: Calcaneal fractures, Gissane angle, Bohler angle, Complications, Plating

1. Introduction

The most frequent tarsal bone damage occurs due to calcaneal fractures (CF) that accounts to around 2% of all fractures in the human body.[1] Low energy trauma and high energy trauma, such as falls from great heights and car accidents, account for the majority of injuries. The majority happen to young persons in their first years of employment. Residual pain and the time to for mobilisation serve as significant determinants and causes several financial impact on the patient and society. The largest tarsal bone, the calcaneum, as a result of fracture deformity, frequently develops abnormalities in calcaneal height, varus, and broader heels.[2]

To assess the fracture line and compare it with the AO classification or Sander classification, a radiological examination is required. Bohler and Gissane angles can be used to measure abnormalities in calcaneal height. They serve as important parameter qualities in diagnosis, therapy, and prognosis.[3]

On a lateral x-ray, the angle between the apex of the posterior tuberosity and the apex of the posterior facet and the apex of the anterior process is known as the bohler angle. A fracture with displacement changes is indicated. Normal range is around 20 to 40. Gissane angle measurement is placed below the lateral talar process. It ranges of 120 to 140. Both angles are valuable indicators of the post-operative clinical outcome. The advantages of surgical plating include a quicker healing time, better anatomical reduction, and a much shorter leave from work. Brauer's examination of the cost- effectiveness of surgery versus nonoperative care for intraarticular calcaneal fracture revealed financial benefits of ORIF.[4]

Although current statistics recommend open reduction and internal fixation over conservative treatment, the treatment of displaced intra-articular calcaneal fractures remains equivocal as there are no statistically significant results in the overall outcome. Because it provides adequate exposure and enables direct reduction of the dislocated posterior facet fragment, open reduction and internal fixation (ORIF) with a conventional plate via an extended lateral approach has been regarded as the gold standard treatment for displaced intra-articular calcaneal fractures (DIACF)[5]. Utilizing a locking compression plate has improved functional outcomes, reduced the need for bone grafting, and sped up recovery time.

Restoration of the calcaneus' length, height, and width, anatomical reduction of all joint surfaces, and primary stable osteosynthesis should be the main surgical goals in treating

calcaneal fractures[6]. The restoration of the posterior facet anatomy of the subtalar joint is closely associated to a better functional outcome. In situations where the articular incongruence is larger than 1mm, secondary arthritis and a worse functional outcome that is caused by an increase in contact pressure are typically observed[8]. Surgery- related issues primarily involve slow wound healing[9] However, research on the correlation between calcaneal plating results based on Bohler and Gissane angle and AOFAS score is scarce, especially in Indian settings. The purpose of the study is to assess the effectiveness of calcaneal plating for calcaneal fractures based on radiological and clinical results.

Aims and Objectives

- To evaluate the outcome of calcaneal plating based on AOFAS score and Bohler & Gissane angle
- To assess the complications of calcaneal plating

2. Material and Methods

We conducted a hospital based cross sectional study in the Orthopaedics department, GMC Kannur, Kerala betweenJanuary2021 to June2022.As a part of this research proposal, we intended to evaluate the outcome of calcaneal plating based on AOFAS score and Bohler & Gissane angle among patients with calcaneal fractures operated with plating. Those patients details will be taken from hospital register and case file, contact them through phone and will be called for follow up and assessed at orthopaedics opd. All these will be recorded in case file. After institutional Ethical Committee approval and informed written consent, around 48 patients who had calcaneal fractures were selected based on the inclusion and exclusion criteria.

Selection of cases:

Study participants:
Patients who underwent calcaneal plating at GMC Kannur during study period from January 2021 to June 2022 willing to participate in the study

Inclusion criteria:

- Age between 18-50 irrespective of sex
- Isolated Calcaneal fractures which are closed
- Underwent surgery from GMC Kannur and came up for follow up Consenting to participate in the study

Exclusion criteria:

- Patients less than 18 and more than 50
- Patients with associated lower limb fractures Patients with prior calcaneal surgery
- Patients with diabetic foot Patients with neuropathic joint
- Open calcaneal fractures with soft tissue loss
- Not consenting for voluntary participation

Sample size:
Sample size calculated from the reference article

The sample size (n) is calculated according to the formula
$n=z2*p*(1-p)/e2$

Where Z=1.96 for a confidence level (a) of 95%, p =proportion (expressed as a decimal)
e = margin of error
z = 1.96, p = 0.1, e = 0.05
$n = 1.962*0.1*(1-0.1)/0.052$

The sample size was calculated to be 48

Sampling: Consecutive sampling

Study procedure: The study commenced after obtaining Institutional Ethics Committee clearance. Those patients details will be taken from hospital register and case file, contact them through phone and will be called for follow up and assessed at orthopaedics opd. All these will be recorded in case file. After screening for inclusion and exclusion criteria, the eligible patients were approached for enrolment into the study. After taking informed consent, the patient details were taken from hospital register and case files. All patients were evaluated with proper clinical history, thorough clinical examination and Xray evaluation. We used a semi-structured piloted questionnaire to record all the relevant details and clinical, and radiological examination findings.

Statistical methods:
Data were entered in Excel and analyzed using SPSS version 20 and graphs were depicted using Microsoft excel/SPSS. Continuous variables like the measurement parameters were summarized as Mean ± Standard deviation or median with interquartile range based on normality. Categorical variables were summarized as proportions along with 95% confidence interval. Comparison of continuous variables (AOFAS score and Bohler & Gissane angle) before and after plating was done using paired T test. A p value less than 0.05 was considered as statistically significant

3. Review of Literature

Around 65 percent of tarsal injuries are calcaneal fractures. It is the tarsal bone that breaks most frequently. Approximately 3% of all fractures are calcaneal fractures. The majority of them (70%) are intra-articular. Both of the calcaneum are being affected by several of these fractures. The most common cause, particularly in male construction workers, is falling from a height. Sadly, the majority of these people are the family's only wage earners. In addition to the patient's high morbidity, this increases the financial burden. Thoracolumbar fractures frequently result in calcaneal fractures.[10]

Uncertainty exists over the best way to treat calcaneal fractures. The progression of the method of treatment for these fractures is demonstrated by the initial aggressive surgical fixation and the subsequent use of closed treatment techniques. There have been instances where carefully selected fractures for surgery have produced results that fall somewhere in the middle of these two extremes. Due to them, there were more calcaneal fractures that required surgery. A significant improvement in the treatment of calcaneal fractures occurred between 1990 and 2000, as seen by the sharp decline in complications related to the current therapy of these potentially dangerous injuries.[11]

Calcaneum Surface Anatomy

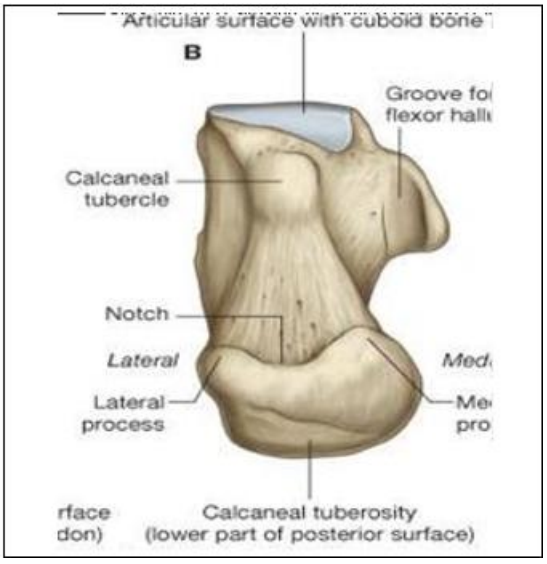
A base or vertical support for the body's weight is provided by the bone calcaneum. It has the most articulations and is the largest of all the tarsal bones. It is attached to numerous ligaments and tendons as well. Additionally, it serves as a lever arm propelled by the gastro-soleus. Additionally, it maintains and supports the length of the foot's lateral column.

A mass of cancellous bone is enclosed in the calcaneum's thin cortical shell, which undergoes numerous forces that cause it to remodel. As a result, it has been likened to a "egg," meaning that it is hard on the outside and soft on the inside.[12]

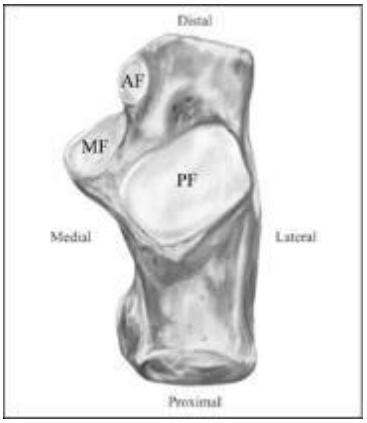
Since the majority of this lateral surface area is exposed during the most common surgical technique utilised for fracture treatment, the anatomy of the calcaneum on its lateral aspect is particularly important.

The calcaneum's tuberosity is its most posterior feature, while the body of the calcaneum is located distal to the tuberosity.

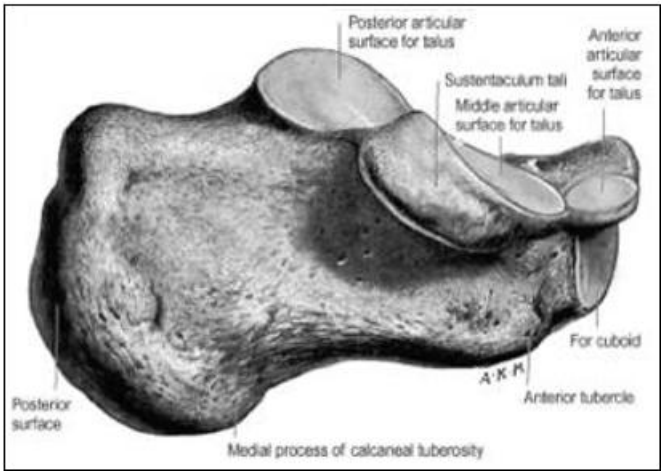
Plantar surface: The lateral process of the plantar surface, which is also known as the calcaneal tuberosity, gives rise to a portion of the abductor digitiminimi, whereas the medial process lends connection to the abductor hallucis. The lateral process of tuberosity, a tiny process on the plantar aspect of the calcaneum, is what provides origin to the muscle connection to the plantar fascia.[13]



Superior surface There are two types of superior surface: articular and non-articular. varies in length, extending posteriorly to create the heel. Anterior, middle, and posterior facet joints are found on an articular part.



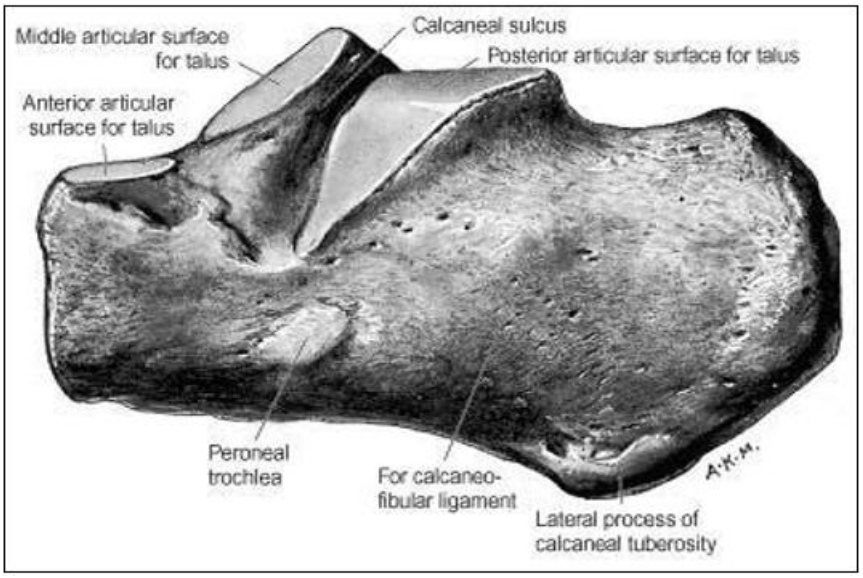
Medial surface: Sustentaculum tali, a shelf-like projection on the medial surface, has an articular surface for the middle calcaneal facet. A mass of Cancellous bone is enclosed in the Calcaneum's thin cortical shell, which undergoes various stresses that cause it to remodel. As a result, it has been likened to a "egg," meaning that it is hard on the outside and soft on the inside.



Anterior Surface: The calcaneo-cuboid joint's front surface is its smallest articular surface.

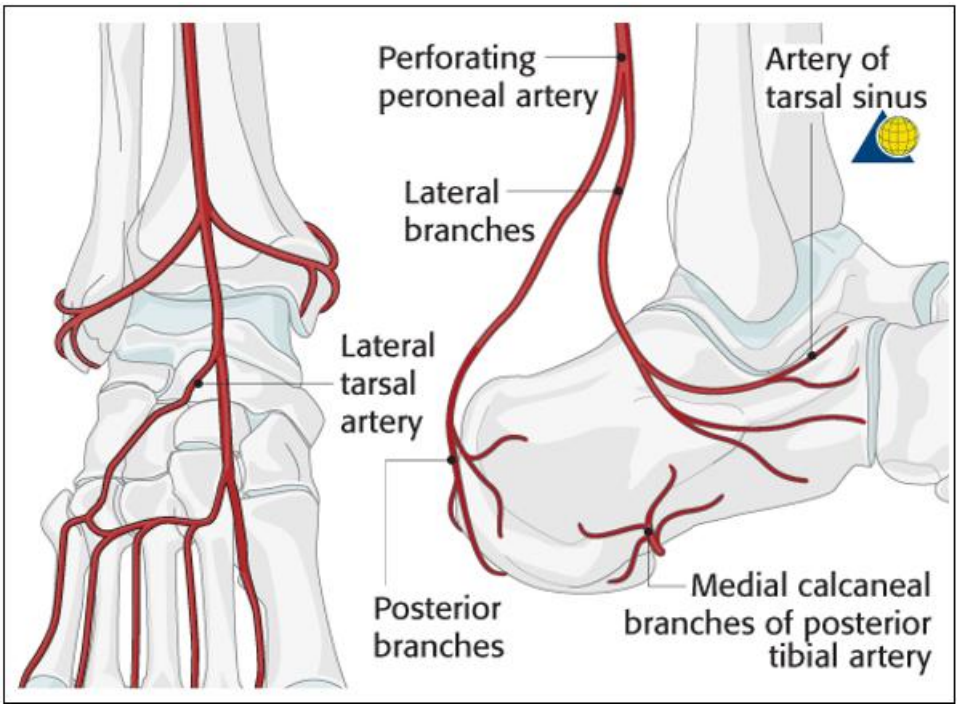
Posterior surface 3 separate sections make up the posterior surface. The upper area is smooth, slopes anteriorly, and supports the bursa; the central section provides the Achilles tendon's insertion. Fibrofatty tissue covers the lowest portion.

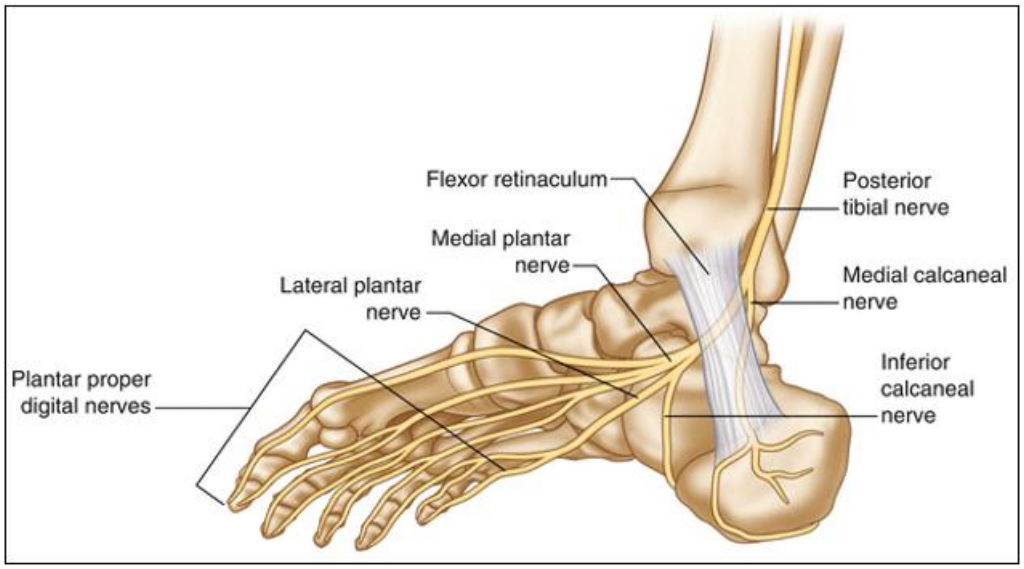
Lateral surface: The lateral surface is rough, nearly flat, broader in the back and narrower in the front. The superior groove for the peroneus brevis tendon and the inferior groove for the peroneus longus tendon are separated by a ridge. The lateral aspect is especially important because the most common surgical method for fracture treatment primarily exposes this lateral surface area.[14,15]



Blood and Nerve Supply of Calcaneum

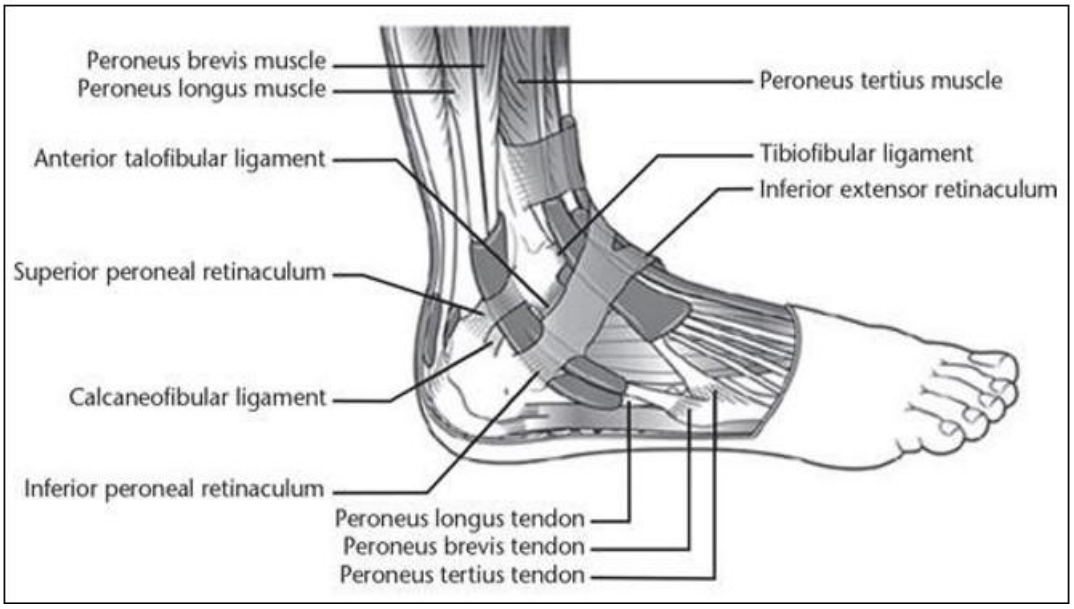
The medial and lateral calcaneal arteries are the source of the calcaneum blood supply. The peroneal artery gives rise to the lateral calcaneal artery, while the posterior tibial artery gives rise to the medial calcaneal artery. There is also some blood supply from the medial and lateral plantar arteries, posterior calcaneal anastomosis, and peroneal artery. Tibia, sural, and deep peroneal nerves supply the calcaneum's nerves.[16]





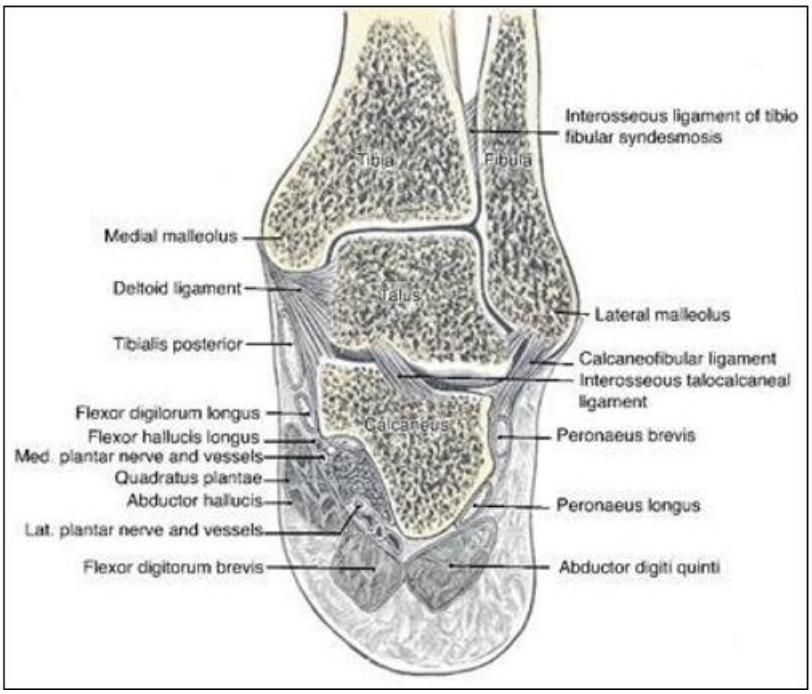
The posterior and middle facets are separated from each other by the inter-osseous sulcus (calcaneal groove). It originates alongside the talar sulcus, the sinus tarsi, and opens widely laterally.

The complicated subtalar joint is formed by the articulation of the anterior middle and posterior calcaneal and anterior middle and posterior talar facets.[17]



Lateral view showing peroneus tendon

The illustration provided below is a posterior or coronal view of the calcaneum and depicts its architecture just anterior to the posterior facet, at the level of the sustentaculum tali.



Coronal section

Of specific significance here are the sustentaculum tali and the middle and anterior articular surfaces of the distal lateral wall of the calcaneus.

The calcaneum has a few unusual anatomical features.

1) The medial side of the calcaneum is concaved out to allow passage of the tendons and neurovascular structures into the foot.
2) As a result, the calcaneal tuberosity's centre will be slightly lateral to the talus's centre.
3) Shear stress is generated throughout the calcaneum's body if a force is applied vertically to the talus with the calcaneal tuberosity attached to the ground.
4) Essentially, the calcaneum fractures into two primary shards along this stress line.
5) Laterally - the tuberosity fragment, and 2. Medially - the sustentacular piece[18]

Soft Tissue Relation

The interosseus talo calcaneal ligament, a thick, strong band of two partially connected fibres that binds the talus and calcaneus, is the primary ligament of the joint. It passes through the canal between the two bones' articulations known as the sinus tarsi.

The talus and calcaneus are connected by four other, less strong ligaments. The superior calcaneus is connected to the anterior talo-calcaneal ligament (also known as the anterior inter osseous ligament) at the neck of the talus on the front and lateral sides.

From the lateral tubercle of the talus to the upper medial calcaneus, the short band of the posterior talo-calcaneal ligament runs.

The medial talo-calcaneal ligament extends from the medial tubercle of the talus to the sustentaculum tali on the medial surface of the calcaneum. The short, strong lateral talo-calcaneal ligament connects from the lateral talus under the fibular facet to the lateral calcaneus and runs parallel to the calcaneo-fibular ligament.[19]

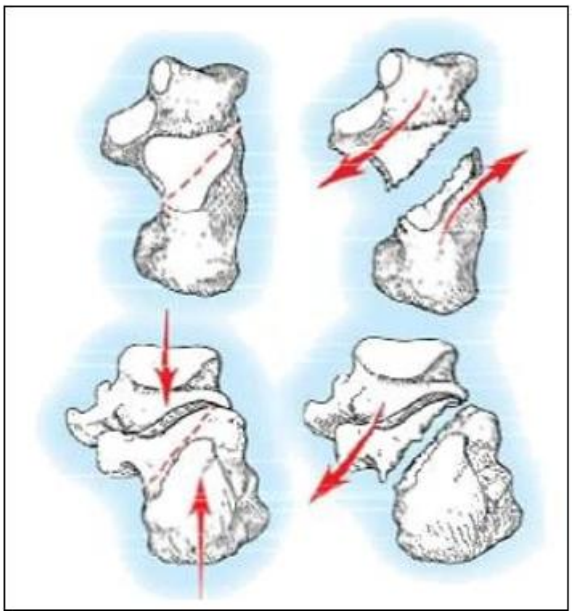
Ossification

During the third month of intrauterine life, the calcaneum ossifies from a single primary. One secondary centre, which arises between the ages of six and eight, fuses between the ages of fourteen and sixteen.[20]

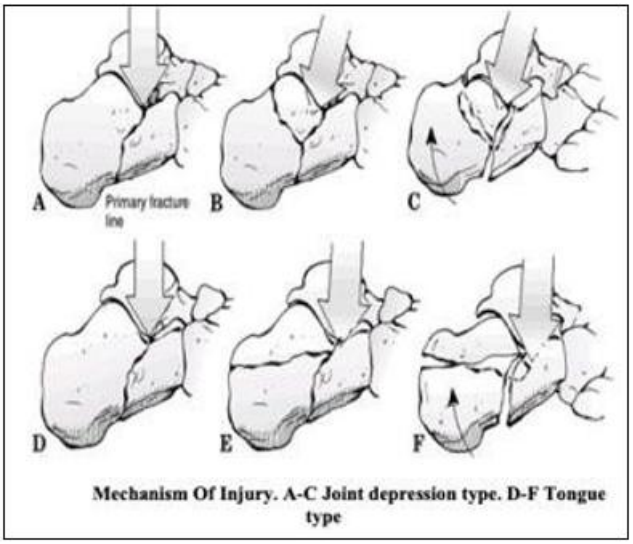
Mechanism of Injury

High velocity damage, which typically results from a fall from a height, can cause calcaneal fractures with intra-articular involvement and displacement. The patient's weight is primarily distributed on the heels during axial loading in this mode of injury. Other mode of injuries include high velocity injuries are due to motor vehicle accidents. Spine and pelvic injuries are linked to axial load injuries. The position of the foot at the moment of impact, the force of the impact, and the quality of the bone all affect the pattern of communition and the location of the fracture lines.[21]

According to Carl et al two primary fracture lines were consistently observed. One line split the calcaneum between medial and lateral portion. The other fracture line separated the calcaneum into anterior and posterior parts, starting laterally from angle of Gissane running medially. Increased force resulted in the formation of a secondary fracture line. The fracture would continue 16 posterior to and into the posterior facet if the force was applied posteriorly, resulting in a joint depression type fracture. If the stress was applied axially, a fracture of the type of a tongue would result.[22]



The Primary Fracture Line



Mechanism Of Injury. A-C Joint depression type. D-F Tongue type

Classification

Calcaneal fractures were initially classified using standard radiographs, however this presented challenges for treatment planning. Today's classifications based on CT have enhanced treatment.

Classification of intra articular fractures of calcaneum[23]

1) Classification based on plain radiographs - Essex Lopresti / Rowe et al / Souer & Remy / Stephenson / Paley & Hall
2) Classification based on CT Scan - Crosby Fitzgibbons / Sanders / De Souza
3) Classification based on CT and plain X-ray - Orthopaedic Trauma Association

Malgaigne was the first to distinguish between intra articular and extra articular calcaneum fractures. Later, Bohler introduced his classification scheme based on the fracture pattern differentiation's predictive value.

Essex Lopresti introduced his straightforward but widely used classification in 1952. However, a significant issue with this classification is that the joint depression type contains an excessive number of fracture types. The fracture categorization and the final clinical outcome cannot be usefully correlated as a result.[24]

By categorising the intra articular fracture of the calcaneum into three categories based on the fracture pattern of the posterior facet, Crosby and Fitzgibbons invented a CT-based classification system for calcaneum fractures.

Later, Sanders established a classification where the calcaneum fracture was split depending on the placement of the primary and secondary fracture lines, which was based on Souer and Remy's work that divided the posterior facet into 3 different columns.

Based on the disintegration of three major components, Eastwood et al. classified calcaneum fractures. Carr analysed the loss of the posterior facet and calcaneo-cuboid junction and split the calcaneum into medial and lateral columns. Levin and Nunley identified six groups after taking into account soft tissue issues.[25]

The calcaneum was divided by Zwipp into 5 major segments and 3 joints. This took into account the quantity of broken joints and fragments as well as the degree of soft tissue damage.

As previously explained, the Essex Lopresetti categorization seems straightforward for clinical usage, but it is insufficient and unable to provide a framework for developing surgical techniques or for estimating the long-term outcome. Sanders' categorization is straightforward, thorough, and has the benefit of allowing prognostication of outcomes for diverse calcaneum fracture forms. Zwipp classification is another another classification that describes the very intricate pattern of calcaneum fractures.

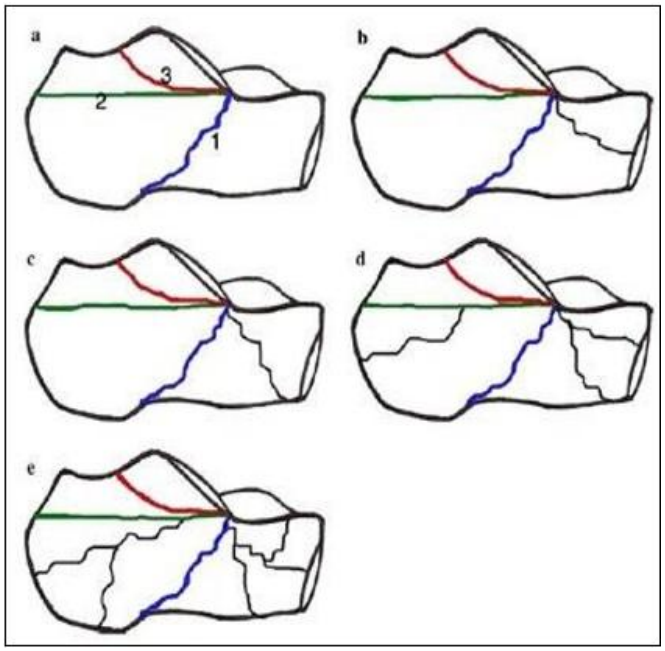
The most often used categorization is Sanders, which is based on the more complicated and descriptive CT coronal picture of the posterior facet.

1) Essex Lopreseti

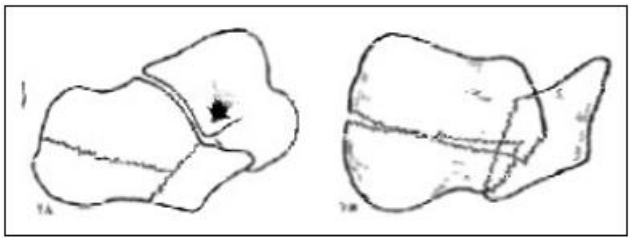
A. Joint Depression Type[26]

Essex- Lopresti Classification.

Primary shear fracture is represented by line 1, secondary compression fracture is represented by line 2, and secondary compression fracture is represented by line 3.



Tongue type Fracture: The articular fragment reached the posterior tuberosity of the calcaneum. Because of a tendon pull the component of the achilles fracture resembles a tongue.



2) Sanders type of Classification

This classification, which is used to describe intra-articular fractures, was created in 1993 after 120 patients were followed for at least a year. It makes use of the axial and coronal CT cuts for the hind foot. The semi-coronal (perpendicular to the posterior facet) and axial planes of reconstruction (parallel to the sole of foot). Taking into account the incision revealing the broadest portion of the undersurface of the posterior aspect of the talus, this is divided into three equal columns by two lines (A & B). The corresponding calcaneus and sustentaculum are separated from one another by a second line C that is drawn from the medial edge of the posterior facet of the talus. The lateral, central, medial, and sustentaculum segments make up the four sections that make up the whole calcaneus.[27]

The number and position of the fracture pieces are then used to categorise four different types of fractures.

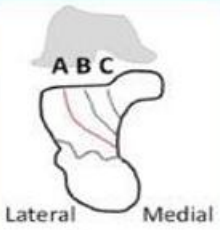
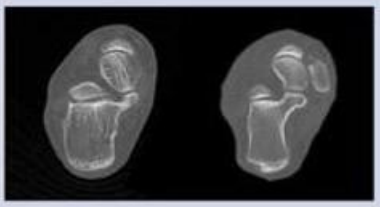
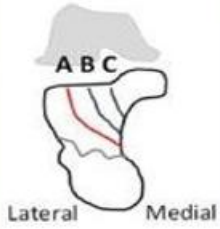
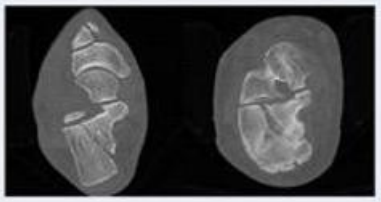
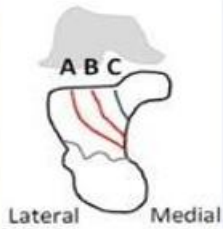
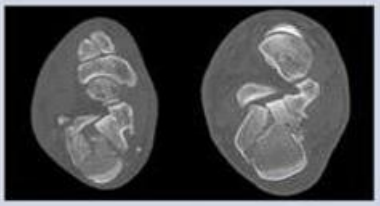
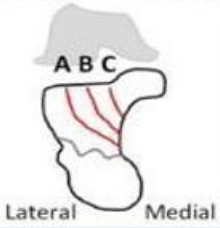
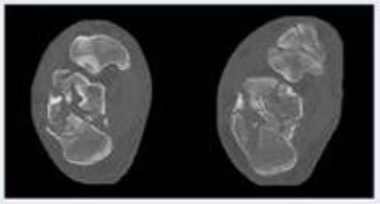
No matter the fracture lines, TYPE I fractures are undisplaced and have a displacement of less than 2mm.

TYPE II: Posterior facet fractures in two halves. depending on where the primary fracture line is. It is further broken down into three categories. IIC, IIA, and IIB.

TYPE III: Posterior facet fractures in three parts. Based on the original fracture line, the typically centrally depressed fragment is further split into three categories. IIIAB, IIIAC, and IIIBC types.

Type IV: An articular fragment that is broken up into four pieces. had more than four articular pieces quite frequently.

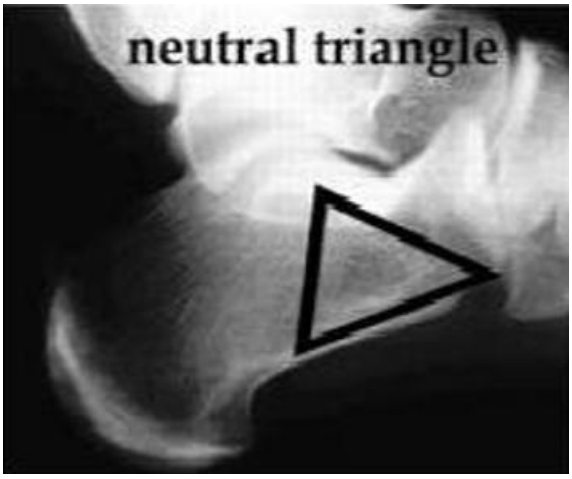
Sander's Classification	
Type I	All nondisplaced articular fractures (less than 2mm)
Type II	Two-part fractures of the posterior facet
Type IIA, IIB, IIC	Based on location of primary fracture line
Type II	Three-part fractures usually featuring a centrally depressed fragment
Type IIIAB, IIIAC, IIIBC	Based on location of primary fracture line
Type IV	Four part articular fracture

Sanders System Label (# image)	Description	Illustration	Example CT Images
Type I (153)	Non displaced or displacement less 2mm		
Type II (221)	2 articular pieces from a single facture lines Subtype: IIA,IIB,IIC		
Type III (178)	3 articular pieces from 2 fracture lines Subtype: IIIAB,IIIBC,IIIAC		
Type IV (208)	4 or more articular pieces		
Total (760)			

Radiological Anatomy

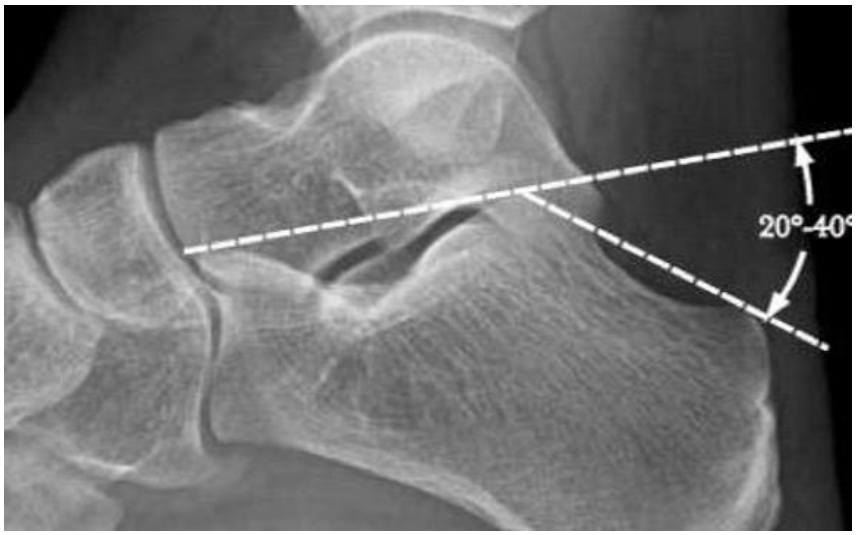
The calcaneus is a crucial bone because it helps the calf muscles contract by acting as a powerful lever and transfers body weight to the ground. The compression trabeculae supporting the rear and anterior articular facets converge over the traction trabeculae extending from the inferior cortex of the calcaneum.

Neutral triangle refers to the region with relatively few trabeculae under the thalamic section of the bone. It is believed that this region has little bearing on the pathological anatomy of fractures. The articular surface, however, may not be supported if the posterior subtalar joint is depressed even after the vacuous neutral triangle has been raised to its initial position. In the location of the depressing fractures impacting this area, the adjuvant is in favour of grafting.[28]



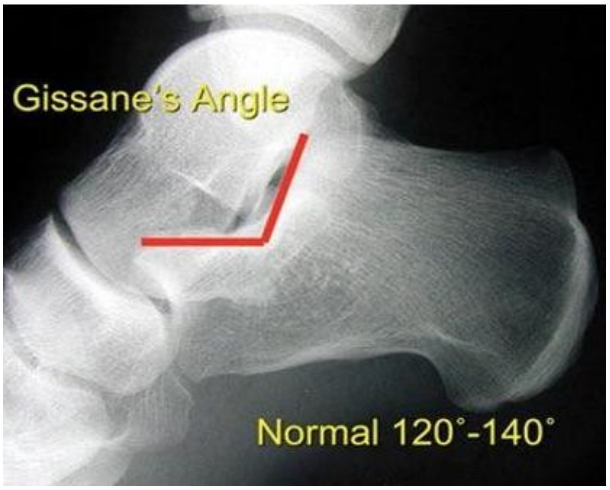
The lateral radiograph of the calcaneus reveals two significant angles. Two lines combine to form the Bohler's tuber angle, which is often between 20 and 40 degrees. The first line is drawn from the highest point on the posterior facet to the highest point on the anterior process of the calcaneus. The second line is tangential to the tuberosity's superior edge. This angle may become less acute if the posterior aspect of the calcaneus, which serves as the body's

weight-bearing surface, has collapsed.



Radiological Lateral view showing Bohler's Angle

The additional angle created by the downward component of the posterior facet joining the upward portion forms the crucial angle of Gissane. At the time of calcaneal fracture, axial compressive pressures perturb the angle that faces the lateral process of the talus. The angle of Gissane typically ranges from 120° to 145°. (29)

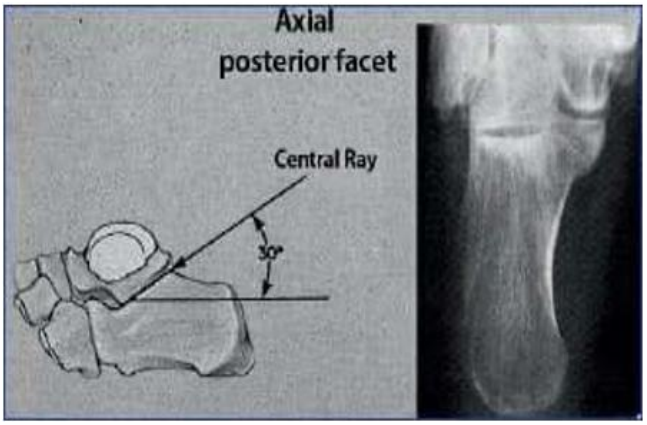


Radiological Lateral view showing Gissane's Angle
An extra proximal coronal view of the calcaneus showing the posterior facet is an important view (CT cut). This demonstrate the quantity of comminution and displacement of the posterior facet with intra articular fracture of calcaneum.[30]

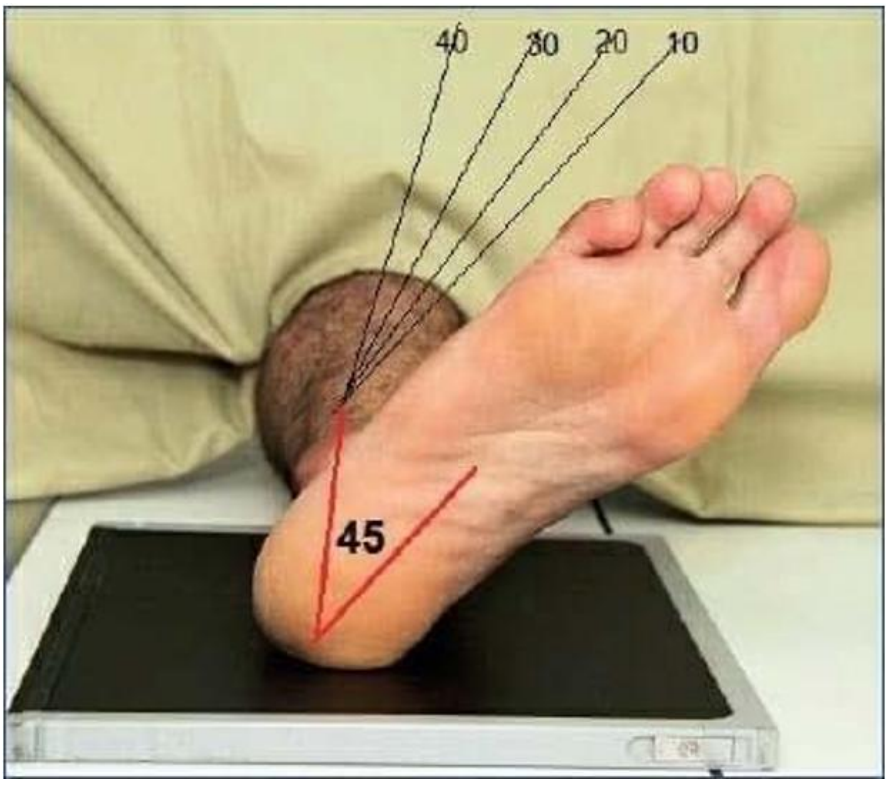
Figure: Normal critical angle of Gissane

Other important and clinically relevant views include:

Harris Axial View
The joint surface, loss of height, increase in width, and angulations of the tuberosity fragment are all visible in the Harris axial view of the heel. An ankle bandage is used to dorsiflex the ankle during an axial view, and the x-ray tube is tilted 45 degrees away from the foot so that its axis is parallel to the posterior compartment of the joint.



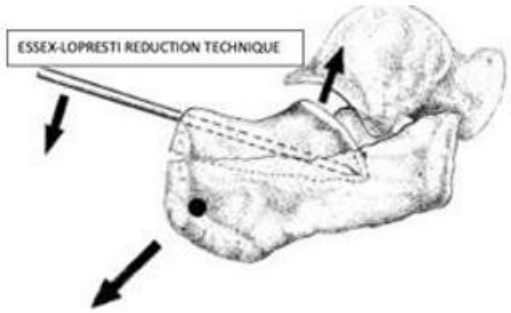
Broden's view:
The subtalar joint can be seen in a special radiographic image. The patient is in a supine posture with one knee slightly bent, one lower leg internally rotated 45 degrees, and the central beam is pointed at the lateral malleolus. 10, 20, 30, and 40 degree films, respectively.[31]



Treatment
The choice of treatment is as follows (32)

1) Closed treatment
a) Accept position, no reduction and early motion.
b) Closed reduction, short-term immobilization, reasonably early motion

2) Semi Open technique
a) Essex Lopresti close reduction by manipulation of the fragment with percutaneous pin and fixation.
b) Percutaneous techniques which are recently popular.
c) Limited open reduction and external fixation technique.



Essex-Lopresti Reduction Technique

Open Surgical Technique
a) Open reduction and internal fixation with a lateral extensile incision.
b) Open reduction and internal fixation with a medial approach.
c) Combined medial and lateral exposure using open reduction and internal fixation.
d) Primary arthrodesis.

Closed treatment
Rest, Ice application, Compression, Elevation of the Limb, and NSAIDS are the components of RICE. It is done in two different methods.[33]
a) Without attempting to reduce the fracture, one must accept it as the surgeon saw it and proceed with immediate immobilisation, non-weight bearing for 6–8 weeks, and then early, progressive motion.
b) Manual or tong-assisted manipulation of the fracture under external pressure is performed for reduction and immobilisation; range-of-motion exercises are then recommended as part of early physiotherapy. After eight weeks, weight bearing is permitted. The Omoto method can be used to manipulate the fracture.

Semi-open procedures are simpler for the surgeon and carry a lower risk of surgical error than open techniques. But proper patient selection (i.e., limiting fracture patterns to those of the tongue type) and assessment of anatomic reduction of the joint surfaces can be predicted to yield in acceptable and positive outcomes.
a) Essex Lopresti and King's technique.
b) Surgical technique of Tornetta, (34)

Open surgical technique. The indications
a) Type II and III Sanders with displacement greater than two millimetres when soft tissue problems are present but do not enhance the risk of complications and the patient is able to follow post-operative instructions.
b) Primary subtalar fusion is the usual treatment for Type IV Sanders.

They are classified into following

1) Lateral approach
a) Benirschke and Sangeorzan
b) Sanders

Sanders popularised the strategy after Benirschke and Sangeorzan had outlined it. The benefit of this strategy is that the posterior facet can be directly reduced and fixed.

Limited approaches are Palmer method, approach of the sinus tarsi, little lateral movement extending the sinus tarsi, Flemister and Geel approach.[35]

2) Medial Approach
a) McReynolds
b) Burdeaux

This is predicated on the idea that only from the medial side can the medial wall of the calcaneal be fully restored. Stability, length and height restoration, as well as a partial width restoration, are all results of a precise reduction. To reestablish the articular surface of the posterior facet, the joint or tongue-type fragment must be decreased.

3) Combined Medial and Lateral Approach (36)
a) Stephenson
b) Johnson and Gebhardt

Stephenson was a pioneer in the use of a combined medial and lateral approach, rigid internal fixation with screws and staples, and immediate range of motion following surgery. Although this method yields good outcomes with high-quality fixation, there is little visual access to the subtalar joint.

4) Early Primary subtalar fusion
For patients with severely comminuted intraarticular fractures, early primary subtalar fusion is encouraged, as was the case with Sander's recommendation for primary arthrodesis in his type IV fractures.

The order of importance is:[37]
a) Reduction and fixation of the posterior facet (reconstruction of the posterior facet platform).
b) Correction for loss of height and increased width.
c) Reduction and fixation of fracture of the calcaneocuboid and anterior and middle facet joints.

Complications of Intra Articular Calcaneal Fracture (38)

It can be divided into
1) **Immediate complications**
Fracture blisters, swelling, and Compartment syndrome
2) **Late Complications**
Malunion, Arthritis, calcaneo–fibular abutment, heel pad problems

3) **Complications with non-operative treatment**
   Arthritis with stiffness and pain
4) **Complications with operative treatment complications**
   Infection, Wound dehiscence, iatrogenic nerve injury

Fracture blisters and swelling

An acute calcaneal fracture is present along with a sizable soft tissue oedema. Blisters with clear fluid or blood may develop anywhere on the foot within 24 to 48 hours of damage. Surgery is not advised if there are several blisters. The possibility of wound infection exists if these blisters are cut through, thus the first swelling elevation is required to reduce. The "wrinkle" test requires that a wrinkle form when the skin of the heel is pinched. Before receiving any surgical care, it should be completed.[39]

Wound infection is another typical consequence of surgical treatment. It could be I superficial (10–27% of cases), (ii) deep, or (iii) both (1.3- 2.5 percent of all cases). Precautions in calcaneal surgery Allgower stitch (atraumatic skin closure technique), no-retraction technique by K wires, timing of surgery, strategies to reduce swelling, and meticulous surgical technique, particularly the lateral approach with sharp dissection to raise full thickness flaps from skin to periosteum, are advised. Sutures should be removed three weeks after surgery. The term "apical" wound necroses has been used to describe how post-operative wound dehiscence typically starts at the angle of incision. When the incision extends to the edges, watershed regions, or the lateral heel, which is a region that receives blood flow from posterior peroneal artery, flap edge necrosis might occur.[40]

Dehiscence of the wound, whether superficial or profound, can take place up to four weeks after surgery. Single-layered closure, a high BMI, a delay between an accident and surgery, smoking, and diabetes mellitus are risk factors.

Compartment syndrome

This is brought on by bleeding from high-energy fractures of cancellous bone fragments combined with anatomic soft tissue constriction by the plantar aponeurosis. The compartment at danger following calcaneal fractures, with a 10% incidence, has been described as being contiguous with the deep posterior compartment of the leg.

There is considerable swelling along with continuous discomfort that is out of proportion to the injury. On passive toe extension, toe flexor weakness and stretch discomfort may occur.[41]

In addition to fracture blisters and plantar ecchymosis, there may also be accompanied plantar hyperesthesia. The most trustworthy physical finding is a constricted foot edoema. Measure the compartment pressure over the affected foot's calcaneal, medial, lateral, superficial, and interosseus compartments.

It is time to do a faciotomy if the compartment pressure reaches 30 mmHg (or) if the diastolic blood pressure is between 10 and 80 mmHg.

Nerve Injury

The most frequent type of damage is an acute neurologic one, as seen in the iatrogenic involvement of the Sural nerve in the lateral approach and the calcaneal branch of the posterior tibial nerve in the medial route. When screws or wires are introduced from the lateral approach, particularly the anteroinferior side of the posterior facet, damage to the medial and lateral plantar nerves may result.

Later nerve entrapment may result from soft tissue scarring, bone malunion, or exostosis development that caused the impingement in the first place. Usually, this results from conservative therapy. The tibial nerve's medial plantar, lateral plantar, and calcaneal branches may be affected and painful. Sural nerve involvement is occasionally also lateralized.

When a nerve is affected, Tinel's sign may be elicited there. At rest and while standing, this soreness around the nerve's distribution may be felt. The diagnosis of nerve involvement may also be aided by targeted nerve blocks with anaesthetics.[42]

Impingement of Tendon and Bone

Tendon impingement and calcaneofibular impingement can

occur by
a) Fracture spikes protruding through the tendons.
b) Dislocation of the tendons from their anatomic grooves
c) Entrapment of tendons between fracture fragments
d) Impingement of tendons between malunited bony fragments.

When a lateral approach is taken, implant discomfort might result in peroneal tendinitis.

After a calcaneal fracture, discomfort on the lateral aspect of the heel is the most typical site of persistent pain. This needs to be distinguished from subsequent pain brought on by (43)

a) Pure peroneal tendinitis
b) Calcaneofibular abutment
c) Subtalar arthritis or
d) Combination of the above three.

Walking with a buckle or giving way could also be a sign of peroneal tendon dysfunction. Confirm the location of pain throughout the peroneal tendon's course, and elicit discomfort with passive dorsiflexion and resistance to everting of the back foot in order to differentiate between pure peroneal tendinitis and calcaneofibular abutment.

By injecting radiographic dye, local anaesthetic, or both, a diagnostic peroneal synoviogram can be performed to show stenosis or narrowing along the affected tendon sheath and to relieve discomfort.

Heel pad pain and heel exostosis
After a calcaneal fracture, heel pad discomfort is the second most frequent location of pain. It is caused by damage to the heel pad that was nearby the calcaneum at the time of the injury. Significant heel discomfort, tenderness over the area of soft tissue and heel pad under the bone, tenderness on the side to side palpation, or thumping over the heel pad are used to make the diagnosis. The heelpad will shrink out and become more mobile. As a result, the heel pad will be less rigid and softer than the wounded area. In patients who have suffered injury to the plantar cortex of the calcaneum, bony calcaneal spurs and heel exostosis form from the underside of the bone.

Malunion Malunions frequently occur with conservative therapy, but they can also happen with surgical reductions that are insufficiently or poorly performed. It leads to
a) Widened heel syndrome
b) Pain and instability secondary to tendon impingement
c) Post-traumatic arthritis of the subtalar or calcaneocuboid joint
d) Hind-foot malalignment and altered gait secondary
e) Nerve impingement

Varus malunion on the lateral aspect of the foot and valgus malunion on the lateral sub- talar region can both cause pain.

When looked at, the foot may have callosities and sores on the lateral side, a widened heel, abnormal shoe wear, and more.(44)

Arthritis The subtalar or calcaneocuboid joint may be affected by arthritis. Late arthritis may be brought on by subtalar incongruity or implant penetration. With as little as 2 mm of articular surface depression, the posterior facet is significantly unloaded, supporting the idea that articular surface reduction should be the primary goal of treatment in surgically treating calcaneal fractures.

Due to cartilage damage brought on by initial trauma, arthritis can develop even in an anatomically reduced fracture. Thus, rather than the precision of articular surface reduction as found in one study, the severity of the initial damage also affects the final result.

Implant placement into the articular surface may take place during surgical therapy, and implant removal is necessary prior to weight bearing or range of motion. If untreated, the patient may experience pain when bearing weight that is exacerbated by valgus or varus tension on the subtalar joint, but there won't be any obvious tenderness on the side of the heel.

Evolution of Implants for Calcaneum (45)
From the original use of supervised neglect through the use of intricate closed reduction devices, the management of calcaneus fractures has changed. Given the complexity of today's internal fixation implants, it is important to comprehend the anatomy of complex fractures as well as the techniques needed to decrease the numerous fracture pieces. Additionally, they require thorough knowledge of the mechanisms underlying damage, improved vascular zone delineation and its relationship to skin incision, improved stability with newer implants, and bolder surgical treatments, whether performed via open or percutaneous methods.

The ideal implant has not been discovered for a specific kind of calcaneal fracture. Additionally, there is no solid evidence about the fixation modality. Again, this is a result of the availability of a wide range of implants, multiple reduction techniques, and numerous surgical techniques for treating the fractured calcaneum.

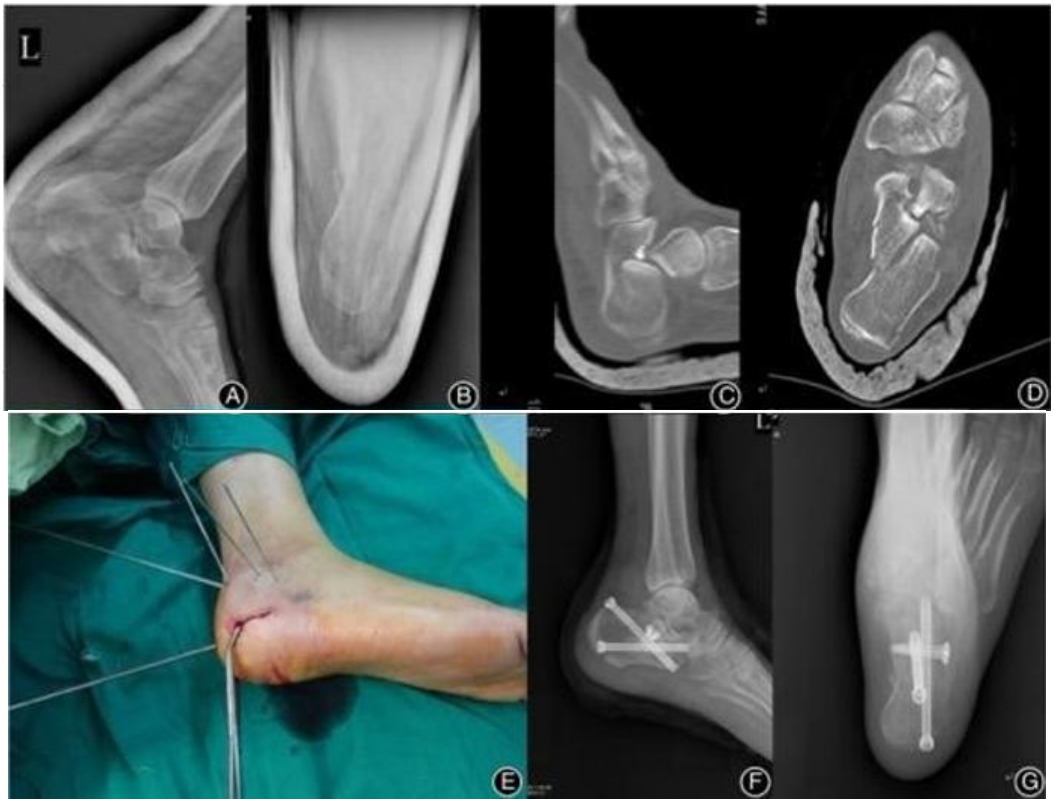
Better anatomical articular reconstruction, preservation of the Bohler's and Gissane angle on the articular surface, less invasive, quicker surgery, minimum wound complications, and early ankle movement are the optimum outcomes in any intra- articular fracture. Improved fixation devices for stability, modified surgical procedures (proper use of the extensile lateral approach), and minimally invasive techniques where necessary.With changes to the procedure described by Essex Lopresti, Gissane, and the other writers, it has also been possible to heal extra articular fractures and fractures of the tongue type. This is helpful for clear understanding of the biomechanics of the hind foot.

Despite the evidence to the contrary supporting both treatment options, there is now a slow transition from conservative to surgical care of calcaneal fractures. This is because radiographic tools like computerised tomography enable a clearer knowledge of fracture patterns. Many challenges still exist, and there is ongoing uncertainty regarding both internal fixation and open reduction.

Inappropriate implant or incision selection is a major factor in surgical intervention failure. Inadequate 3 dimensional reconstruction, poor fixation, and wound-related problems are examples of complications. The choice of an implant is complicated. This is due to the calcaneum's intricate architecture, unusual shape (it breaks like an egg), and difficulty keeping different articular surfaces and tuberosities in place until the healing process is complete. Implant application is challenging due to its peculiar form. Reconstructing the posterior facet and regaining the Bohler's and Gissane angles are both difficult tasks. There is always some soft tissue compromise present.

Implants Screw Fixation of Calcaneal Fracture

Avulsion Extraarticular fractures may usually be stabilised and repaired percutaneously with one or two lag screws with little to no surgical trauma.



Wire Fixation of Calcaneal Fracture

K wires are insufficient for complicated calcaneal fractures. Kwires can provide percutaneous stability in undisplaced body fractures or undisplaced avulsion fractures, however early mobilisation is not possible. For temporary stabilisation, K wires are appropriate. However, external fixation is now added as a support to preserve the fracture reduction of various pieces.[46]

External Fixators of Calcaneal Fracture

These are useful in open fractures and in calcaneal fractures as well; in addition to K wires, they can be utilised as temporary solutions while the open wound heals or to maintain the fracture shape throughout the healing process. The best treatment for comminuted fractures that resemble a bag of bone is image guided percutaneous multiple K wire fixation supported by these external fixators.[47]

Plates and Screw Fixation of Calcaneal Fracture

There has always been disagreement and uncertainty over implants for depressed intraarticular fractures, but there is growing consensus that the depressed facet should be elevated, the tuberosity should be preserved, and the posterior depressed facet and anterior process should be aligned. The calcaneal implant has become increasingly complex as a result of the evolution and alterations of implants, as previously mentioned, and the user is frequently perplexed by the complicated-looking plates. Due to patents and greater technology, implants are expensive. Also in this case, locking plate concepts have been used.

In the beginning, facetal reconstruction was the primary goal of fixation in the 1980s. This was accomplished by two screws operating in compression mode, and it was then offloaded by a single neutralisation plate placed on the lateral surface.

In fact, bone grafting is required because it preserved the arrangement of the tuberosity and the anterior process in relation to the rebuilt facet. When used by experienced surgeons, this gave the doctors reasonably good results; nevertheless, weight bearing had to be delayed. This approach resulted in a late fracture reconstruction collapse and inadequate preservation of the elevated posterior facet. There were lateral difficulties connected to plates as well. As a result, the development of the implant continued.

The creation of single construct H or Y reconstruction plates as well as twin plate combinations emerged in the 1990s. For instance, Bezes created a "Y" configuration by using a second short straight plate in addition to a flat plate. Letournel developed the idea of a single "Y" plate and the anatomic reconstruction plates (with arms) that were constructed specifically for the calcaneus by adapting the ideas used in acetabular and pelvic fracture surgery.[48]

Locking Plates of Calcaneal Fracture

With the dawn of the twenty-first century, the focus switched to discreet but adaptable implants. These implants made it possible for reliable fixation. We were able to limit soft tissue disintegration by reducing the plate profile and thickness. The plates were also made less stiff so that they could be moulded to the calcaneum's irregular surfaces, and their intricate construction allowed for a variety of non-parallel screw placements to guarantee rigid support of the bone pieces at various elevations. As a result, single-construct, thinner calcaneal locking plates were created. These also produce better outcomes in comminuted fractures. The concept was expanded for usage in the foot and ankle with the introduction of the locking plate concept by Wagner and the AO group.[49]

A few studies that have evaluated the use and clinical outcomes of calcaneal fracture cases operated with plates include:

A study by Mahajan et al in 2021, that around 24 cases who had fall from height and sustained closed intra-articular joint depression type of calcaneum fractures. According to a study conducted in 2021 by Mahajan et al, there were around 24 occurrences of calcaneum fractures of the closed intra-articular joint depression variety. The American Orthopaedic Foot and Ankle Society (AOFAS score 10) and the Maryland Foot Score, which takes into account pain, function, and alignment, were used in the study to assess the use of plating techniques and their clinical results. The angle of Bohler and assessing fracture union were used to evaluate the radiological result. The study found that after nine months, the mean AOFAS score was 78.87 + 9.86. At nine months, 16 (66.67%) patients had good outcomes, 5 (20.83%) patients had fair outcomes, and 3 (12.5%) patients had poor outcomes, according to the AOFAS score.[50]

In order to determine whether surgical fixation of open and closed displaced intraarticular fractures and post-operative complications is beneficial in maintaining restoration of Bohler's and Gissane angles, calcaneal height, and anatomical articular reconstruction, Manikandarajan et al conducted a prospective study in Tamil Nadu. Twenty individuals with intraarticular displaced or comminuted calcaneal fractures were sampled for the study. All of the patients had surgery, and were repaired with CC screws, K wires, or anatomical plates. Clinical and radiological follow-up was performed at 6 weeks, 12 weeks, 6 months, and 1 year.[51]

Manikandarajan et al in Tamil Nadu did a prospective study to assess the radiological and functional outcome of surgical fixation of open and closed displaced intraarticular fractures and post operative complications and to determine whether it is beneficial in maintaining restoration of Bohler’s and Gissane angles, calcaneal height and anatomical articular reconstruction. The study included a sample of 20 patients with Intraarticular displaced or comminuted calcaneal fractures. All the patients underwent surgery, fixed with anatomical plates or k wires or CC screw. Follow up was done clinically and radiologically at 6 weeks, 12weeks, 6 months, and 1 year. According to the study's findings, out of the 20 participants, 17 suffered intraarticular fractures and 3 suffered comminuted fractures as a result of height falls. Nine of these patients received calcaneal plates, six received k-wires, and five received CC screws. Out of 20, eight had good results with a score of more than 75, and eleven had exceptional results with a Modified Maryland Foot Score of more than 90. 1 fair with a score below 75, 11 who recovered without any issues, 5 who had subtalar arthritis, and 4 who had Heal Pain.[51]

In a recent study published in 2022, Pradana et al. from Indonesia evaluated the reduction in calcaneal plating of intraarticular calcaneal fractures with Bohler angle and Gissane angle to determine whether this technique should be used to treat calcaneal fractures. Six patients from December 2020 to July 2021 with a calcaneal fracture who underwent surgical plating, primarily by one surgeon, were

included in the study for the same reason. Bohler and Gissane angles ranged from 8 to 65 degrees prior to surgery, respectively. The study's findings demonstrated that all patients who received calcaneal plating surgery had satisfactory outcomes following clinical evaluation using the AOFAS score. Three patients reported AOFAS score fair range results with the lowest score of 88 percent, while three patients reported AOFAS score excellent range outcomes with 95 percent and 99 percent of AOFAS Scores. The majority of the patient's Bohler and Gissane angles returned to normal values after surgical plating, according to the radiological results.[52]

Methods Preoperative Workup

All patients presented to casualty /opdwih calcaneum fractures are admitted in GMC Kannur orthopaedics department. They are clinically evaluated. Xray taken. Bohler and gissane angles are measured after receiving anaesthetic fitness and detailed consent, patients undergo surgery. Post operative day 3, 5, 9, 12 assessed. Patients will be discharged on pod 12 .and reviewed every month with xrays. After 6 months/ one year functional assessment done using aofas score preformed questionnaire**.**

Surgical Steps

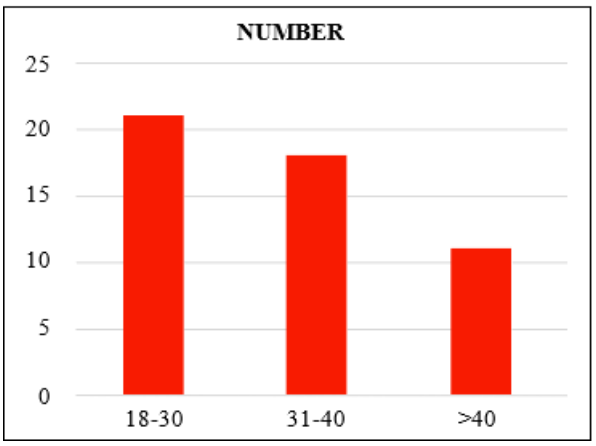
Place the patient in lateral position on operating table. Ensure bony prominences well padded. Place the leg that is to be operated on posteriorly with the under leg anterior.

Exsanguinate the limb either by elevating it for 3-5 minutes or by applying soft rubber bandage. Inflate a tourniquet. Skin incision has two limbs. Begin the distal limb of the incision at the base of the fifth metatarsal and extend it posteriorly, following the junction between the smooth skin of the dorsum of the foot and the wrinkled skin of the sole. Make a second incision beginning approximately 6 to 8 cm above the skin of the heel, halfway between the posterior aspect of the fibula and the lateral aspect of the Achilles tendon. Extend this second incision distally to meet the first incision overlying the lateral aspect of the oscalcis. No internervous planes are available for use. The dissection consists of a direct approach to the subcutaneous bone. Deepen the skin incision through subcutaneous tissue, taking care not to elevate any flaps. Distally, dissect straight down to the lateral surface of the calcaneus by sharp dissection Incise the periosteum of the lateral wall of the calcaneus and develop a full-thickness flap consisting of periosteum and all the overlying tissues. Stick to bone and continue to retract the soft tissue flap proximally. The peroneal tendons will be carried forward with the flap. Divide the calcaneofibular ligament to expose the subtalar joint. Continue the dissection proximally to expose the body of the Oscalcis as well as the subtalar joint. Distally expose the calcaneocuboid joint by incising its capsule. If at all possible, try not to cut into the muscle belly of Abductor digitiminimi. Open reduction done. Maintaining reduction, calcaneum safety locking plates placed and screws passed. Wash given, drain placed& wound closed using AllgowerDonati technique. Sterile dressing applied

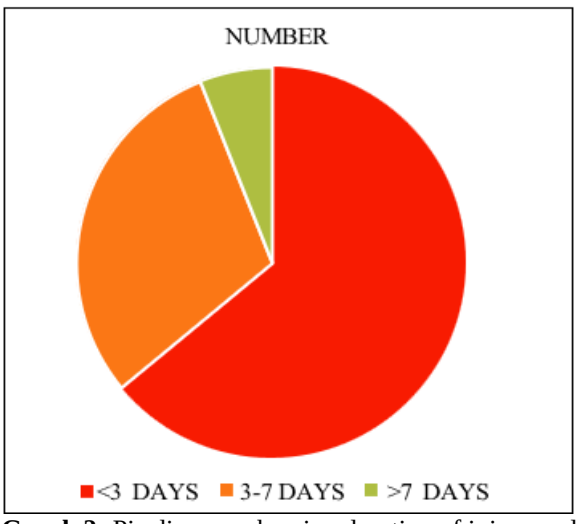
4. Results

Table 1: General characteristics of the study participants (N=48)

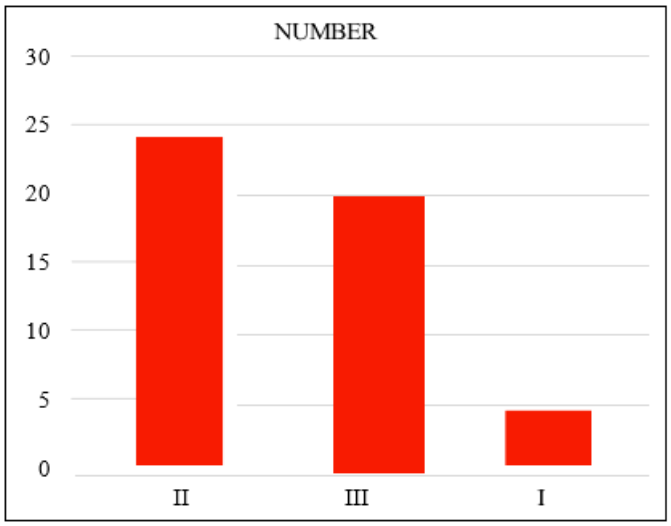
Characteristics	Frequency (%)
Age group	
18-30 years	21 (43.7)
31-40 years	18 (37.5)
41-50 years	11 (22.9)
Sex	
Male	39 (81.2)
Female	9 (18.8)
Duration of injury	
<3 days	32 (66.7)
3 - 7 days	15 (31.2)
> 7 days	3 (6.2)
Mode of injury	
RTA	6 (12.4)
Fall from height	42 (87.6)
Sander's type	
Sander's type II	24 (50.0)
Sander's type III	20 (41.6)
Sander's type IV	4 (8.4)



Graph 1: Clustered column depicting age group and number of cases



Graph 2: Pie diagram showing duration of injury and number of cases



Graph 3: Sanders type and number

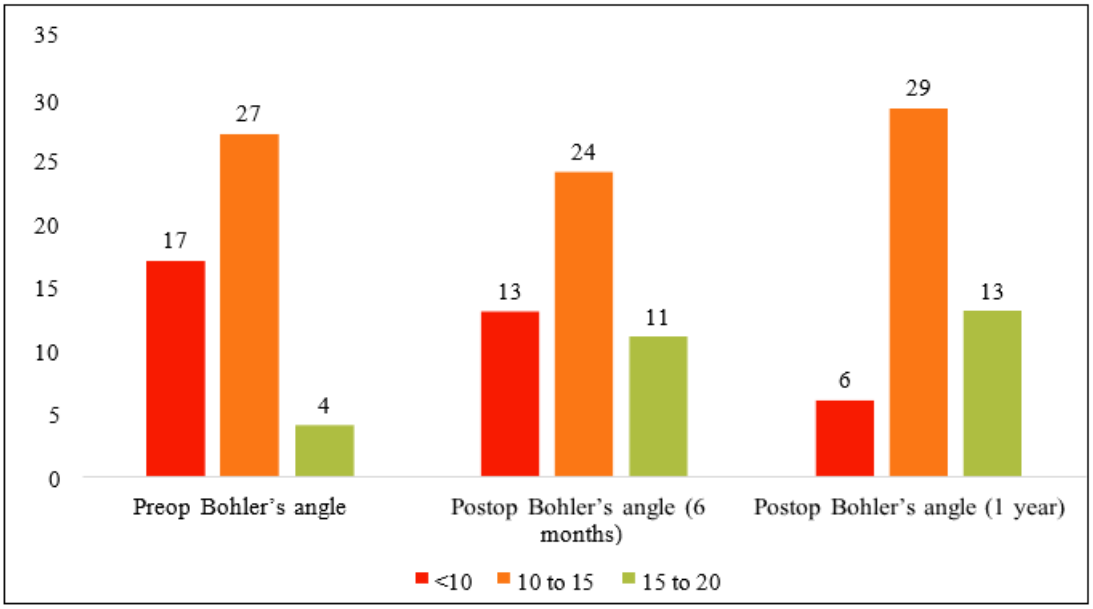
We could reach around 48 participants who fitted the inclusion criteria. Everyone agreed to participate in the study thus accounting for a response rate of 100%. Table 1 depicts the age, gender, comorbidity, fracture type, mode of injury and duration of injury distribution of the study participants. We could see that 43% of the study participants belonged to 18-30 ears, with the mean age of 34.4 (6.7) years. Around 81% of the study participants were males. More than half (60%) of the study participants had duration of injury of less than 3 days. Sander's type II was the commonest type of fracture. Almost 87.6% of the study participants had fall from height as mode of injury.

Radiological parameters:

Table 2: Distribution of Bohler's angle among the study participants (N=48)

Bohler's angle	Preop Bohler's angle	Postop Bohler's angle (6 months)	Postop Bohler's angle (1 year)	P value
Mean (SD)	15 (3.2)	27 (2.9)	27 (3.5)	<0.001
<10	17 (35.4)	13 (27.1)	6 (12.5)	0.03
10-15	27 (56.2)	24 (50.0)	29 (60.1)	
>20	4 (8.3)	11 (22.9)	13 (27.1)	

Table 2 explains the distribution of Bohler's angle among the study participants pre and post op**.** We observed that there was an increase in the Bohler's angle during the post op period at 6 months and 1 year, and it was found to be statistically significant. (p value 0.003)

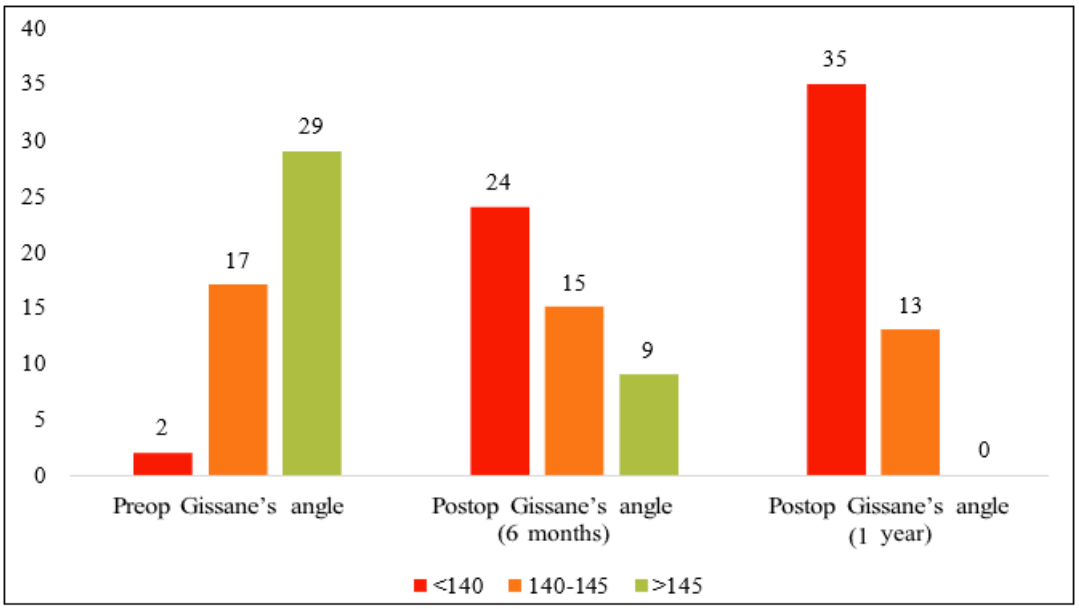


Graph 4: Bar diagram depicting Bohler angle in study participants pre OP and post OP

Table 3: Distribution of Gissane's angle among the study participants (N=48)

Gissane's angle	Preop Gissane's angle	Postop Gissane's angle (6 months)	Postop Gissane's angle (1 year)	P value
Mean (SD)	147 (13.2)	134 (12.9)	132 (11.1)	<0.001
<140	2 (4.1)	24 (50.0)	35 (72.9)	0.002
140-145	17 (35.4)	15 (31.2)	13 (27.1)	
>145	29 (60.4)	9 (18.7)	0 (0.0)	

Table 3 explains the distribution of Gissane's angle among the study participants pre and post op**.** We observed that there was an increase in the Gissane's angle during the post op period at 6 months and 1 year, and it was found to be statistically significant.
(p value 0.002)

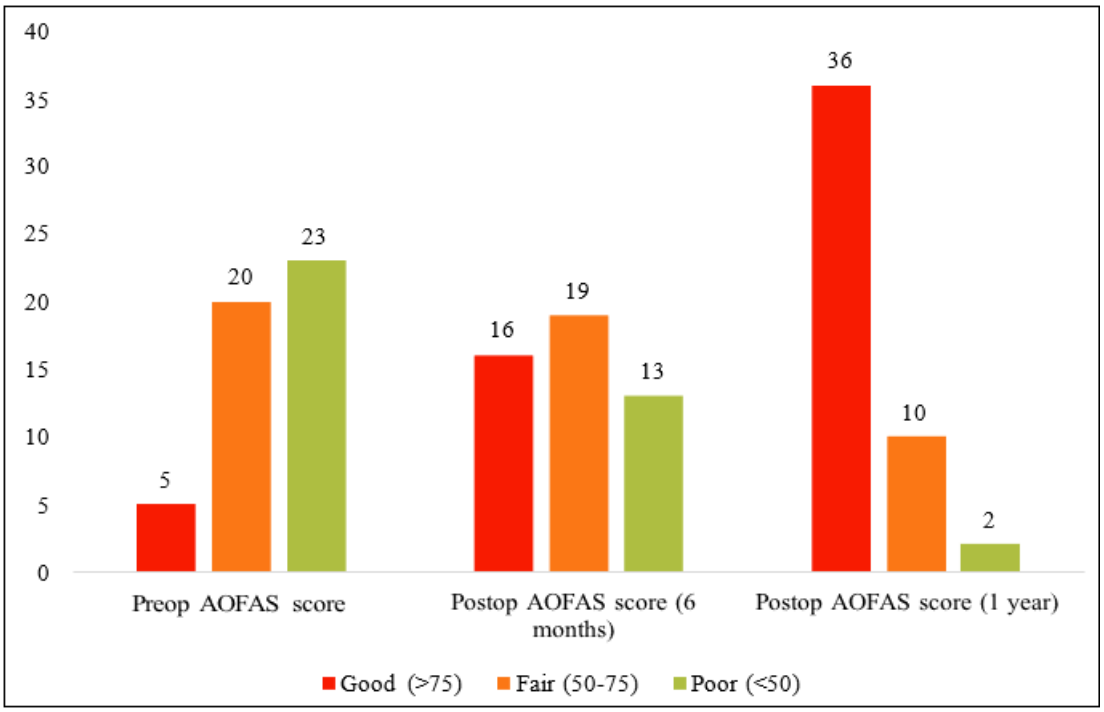


Graph 5: Bar diagram showing Bohler and Gissane Angle among study participants pre OP and post OP

Table 4: Distribution of AOFAS score among the study participants (N=48)

AOFAS score	Preop AOFAS score	Postop AOFAS score (6 months)	Postop AOFAS score (1 year)	P value
Good (>75)	5 (10.4)	16 (33.3)	36 (75.1)	<0.001
Fair (50-75)	20 (41.6)	19 (39.6)	10 (20.8)	
Poor (<50)	23 (47.9)	13 (27.1)	2 (4.1)	

Table 4 explains the distribution of AOFAS score among the study participants pre and post op**.** We observed that there was an increase in the AOFAS score during the post op period at 6 months and 1 year, and it was found to be statistically significant. (p value 0.001) We found that around 75% of the study participants had good score at the end of 1 year

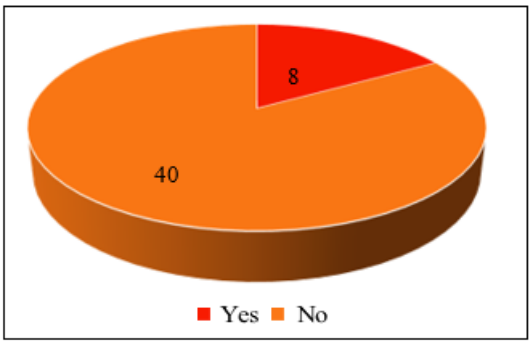


Graph 6: Bar Diagram Showing AOFAS Score among study participants pre and post OP

Table 5: Incidence of complications among the study participants, N=48

Complications	
Yes	8 (16.7)
No	40 (83.3)

We noted that only 16% of the participants developed complications, which were mild in nature. The common complications noted were minor wound dehiscence (2 cases), Superficial wound infection (2 cases), and Sural nerve hypoaesthesia (2 cases)



Graph 7: Pie diagram showing complications

5. Discussion

The most frequent tarsal bone fractures are calcaneal fractures, which account for 2 percent of all fractures overall and 60 to 75 percent of instances of displaced intra-articular fractures. After eccentric axial loading of the talus on the calcaneus, intra- articular fractures develop. Essex Lopresti[54] proposed the first classification that was broadly accepted in 1952 based on the sub-talar joint's participation. In 1975, Soeur and Remy(54) developed an intra-articular fracture classification system based on the mechanism of damage and using the sustentacular fragment as the key to surgery. A new classification method based on the posterior facet was created by Crosby and Fiotzgibbns with the introduction of the CT scan. Using the coronal view of a CT scan, Sanders et al. established a classification method that uses the three fracture lines A, B, and C. Make four possible pieces by cutting the posterior aspect of the calcaneus.[27]

Due to comminution and the intricate fracture pattern, treating Calcaneal fractures is still difficult. Extra articular and undisplaced intraarticular fractures may be treated conservatively with a cast, however surgical therapy offers better outcomes for displaced intraarticular fractures than conservative approaches do. In addition to open reduction and plate fixation, operational management can also be accomplished by closed pinning or screw fixation. Even though closed procedures tend to result in fewer wound complications and better cosmetic results, it can be challenging to achieve anatomic reduction with them. On the other hand, open procedures allow for the manipulation of the fragments under direct vision, making it easier to achieve anatomic reduction.[55]

Patients with sanders types 2, 3, and 4 who underwent surgery had better outcomes than those who received conservative treatment in terms of pain, return to work, heel width, gait problems, and radiological results. The mainstay of treatment is a prolonged lateral approach with open reduction and internal fixation with calcaneal locking plate. The use of CRIF with Cancellous screws is recommended due to the possibility of wound dehiscence. It's critical to have a comprehensive understanding of the surgical indication, contraindications, and timing. CT scans performed before surgery are crucial. During long-term follow-up, subtalar incongruity or implant penetration into the joint may result in late arthritis.[56] Despite availability of literature in this regard, there is paucity of literature from India that has evaluated the clinical and functional outcomes of patients who suffered from calcaneal fractures and operated with locking plates from India.

Our study showed that 43% of the study participants belonged to 18-30 years, with the mean age of 34.4 (6.7) years. Around 81% of the study participants were males. Such findings were found to be similar to findings put for the by previous studies done from India.[57] More than half (60%) of the study participants had duration of injury of less than 3 days.

Our findings on the type and mode of fracture noted that Sander's type II was the commonest type of fracture. Similar studies done from India also suggested comparable findings that established that the commonest type of fracture was observed to be Sander Type II. (50) Almost 87.6% of the study participants had fallen from height as the mode of injury. Other studies have also shown that falling from height was the most common mode of injury.[50,57]

With respect to the distribution of radiological parameters, we noted that there was an increase in the Bohler's angle during the post-op period at 6 months and 1 year, and it was found to be statistically significant. (p value 0.003) Another study done by Manikandarajan from Southern India also showed that there was a significant increase in the mean Bohler's angle noted pre and post-surgery thus indicating improvement in radiological outcome.[51]

With respect to the distribution of radiological parameters, such as the Gissane's angle, we noted that there was an decrease in the Gissane's angle during the post-op period at 6 months and 1 year, and it was found to be statistically significant.(p value 0.002) Similar findings were established by other studies from India also showed that there was a significant decrease in the mean Gissane's angle noted pre and post-surgery thus indicating improvement in radiological outcome.[51,52]

While comparing the distribution of AOFAS scores among the study participants pre and post-op to evaluate the clinical outcome**.** We observed that there was an increase in the AOFAS scoreduring the post-op period at 6 monthsand 1 year, and it was found to be statistically significant. (p-value 0.001) We found that around 75% of the study participants had good scores at the end of 1 year. This finding was observed to be similar to findings put forth by Mahajan et al, which stated that after nine months, the mean AOFAS score was 78.87 + 9.86 and at nine months, 16 (66.67%) patients had good outcomes, 5 (20.83%) patients had fair outcomes and 3 (12.5%) patients had poor outcomes, according to the AOFAS score, which again demonstrated the clinical improvement in patients treated with platting.[50]

Pradana et al also demonstrated that platting was observed to be associated with higher satisfactory AOFAS scores, where 50% of the cases demonstrated excellent scores post-surgery and recovery.[52]

With respect to the other clinical outcome on the incidence of complications, we noted that only 16% of the participants developed complications, which were mild in nature. The common complications noted were minor wound dehiscence

(2 cases), Superficial wound infection (2 cases), Inadequate reduction (2 cases) and Sural nerve hypoaesthesia (2 cases) Such findings were noted to be similar to findings observed by other studies done from India and other western settings. (50,51) However in a previous study by Pradana et al, no surgical site infection was noted, which could be owing to differences in patients characterises, the age groups, co morbidity pattern, or even the differences in the antibiotic usuage that exist between the study settings.[52]

6. Future Research and Implications

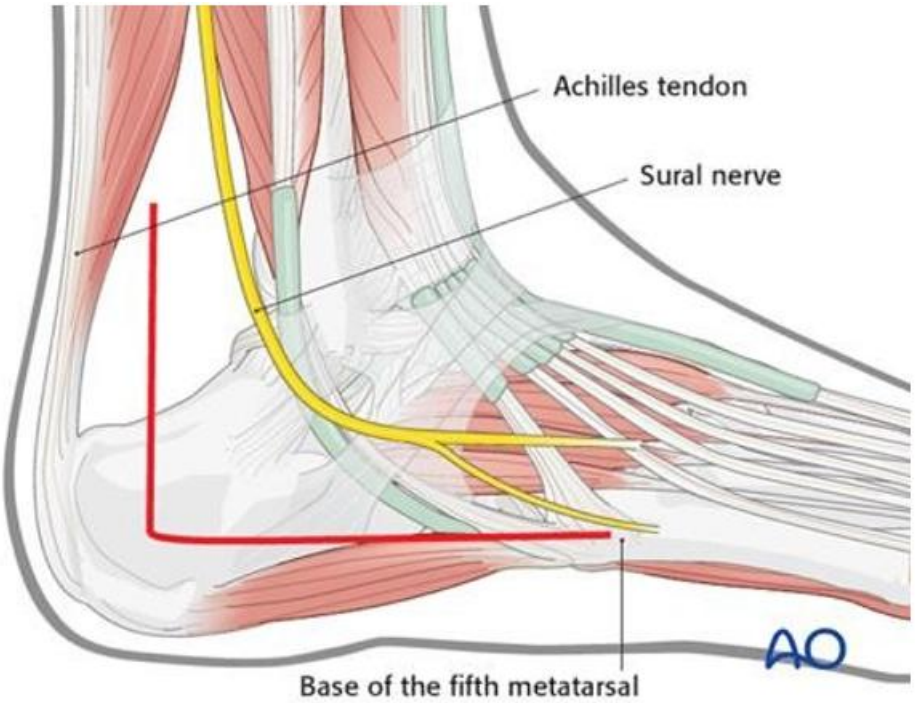
Future efforts should concentrate on perfecting minimally invasive, percutaneous procedures. Polyaxial locking plates, a new type of plate, can be helpful. It is possible to lock screws in multiple directions without being parallel. The screw with extra thread in the head cuts and threads into the plate at an angle decided by the surgeon because the plate itself does not have a thread but rather a lip. The screw locks in this position as a result of the thread diameter expanding. Since the screw and plate are both made of titanium, which has varying degrees of hardness, the plate can be moulded. A special screwdriver is required to tighten the screws and make sure they cut a thread into the plate's lip since the plate is softer than the screws.[58]

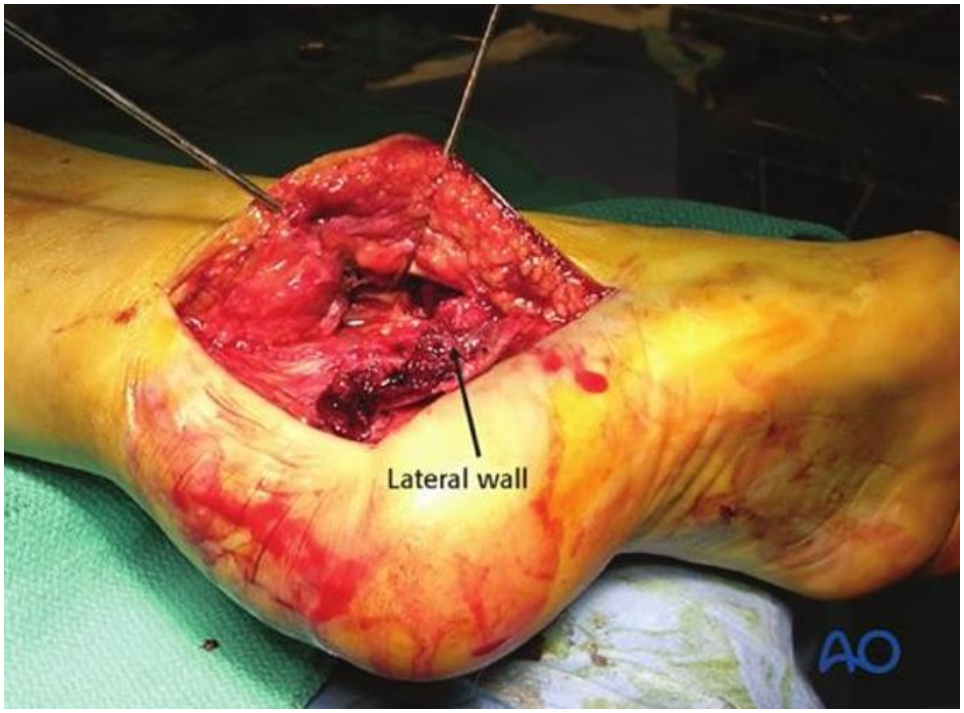
Innovations:

Many medical practitioners now use bioabsorbable implants in a variety of calcaneal fractures because to advancements in this field. The prospect of bioabsorbable implants is theoretically appealing because to the issues with metallic implants, such as their high likelihood of infection, irritation of the plate, and eventual need for implant removal. Yeung and colleagues employed bioscrews in 97 randomised individuals over a two- year period and prospectively compared them with plates. After an average of 23 months of follow-up, they discovered acceptable results. There are currently few indications for bioabsorbable implants in complicated calcaneal fractures because they might not be strong enough to sustain the stress of these displaced calcaneal fractures.

(59) Bioabsorbable pins have been utilised for calcaneal fractures, although they require extensive follow-up and evaluation.

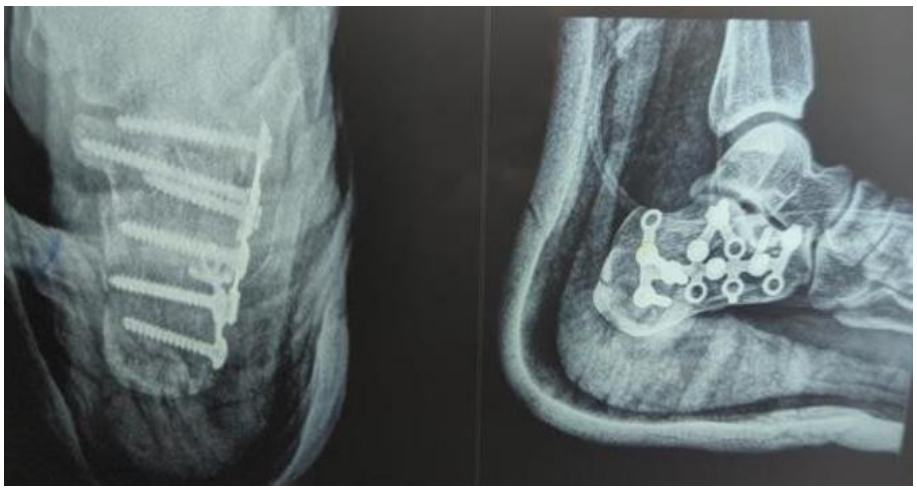
Clinical images and x-rays:





Intraop image

Post op day 5



Post op x-ray **X-ray after 3 days**

Review after one year

7. Conclusion

To conclude, in our study we found that there was a significant improvement in the Bohler and Gissane's angle post-operatively among the patients treated with platting techniques for Sander's type II-IV calcaneal fractures. Our study also showed that not just the radiological parameter, but the patients also improved with clinical outcomes that were evaluated using the AOFAS scores, which showed significant improvement. The incidence of complications was also noted to be one in every 6 cases, and the commonest one was superficial wound infection and minor wound dehiscence.

8. Recommendations

Thus, through our study, we recommend the use of platting techniques for the treatment of calcaneal fracture cases. This could possibly improve both the clinical and radiological outcomes among patients with lesser incidence of complications. Further studies of an RCT-based design may be required to compare the findings with other possible interventions and surgical procedures available.

9. Strengths and Limitations

Strengths:

Our study had several strengths:

1) Ours was one among the very few studies that has evaluated the outcome of calcaneal plating based on AOFAS score and Bohler & Gissane angle from a south Indian hospital-based setting
2) Our study was among of the few literatures that has described complications of calcaneal plating from a north Kerala setting.

Limitations:

Despite all our study had certain limitations:

1) We had a smaller sample size to demonstrate our findings.
2) The findings are generalisable only to similar study settings, as the study was conducted only from one single centre innorth Kerala.
3) We used a pre-post study design to evaluate the change in outcomes pre and post- calcaneal platting, therefore there is a possibility of confounding and we did not compare it with other treatment modalities that are available.
4) We cannot make causal inferences from our findings owing to the nature of our study design.

Declaration by the Candidate

I hereby declare that the dissertation entitled '**Plating Technique Outcome Evaluation in Calcaneal Fractures Based on American Orthopaedics Foot and Ankle Score and Bohler and Gissane Angle in Tertiary Centre in North Kerala: A Cross- Sectional Study'** is a bonafide and genuine research work carried out by me under the guidance of **Dr. RIYAZ N N**, Associate Professor, Department of Orthopaedics, Government Medical College, Kannur.

Certificate by the Guide

This is to certify that dissertation entitled '**Lating Technique Outcome Evaluation in Calcaneal Fractures Based on American Orthopaedics Foot and Ankle Score and Bohler and Gissane Angle in Tertiary Centre in North Kerala: A Cross- Sectional Study'** is a Bonafide research work done by **Dr. Jensen Joseph** in partial fulfilment of the required for the degree of MASTER OF SURGERY in ORTHOPAEDICS.

Copyright Declaration by the Candidate

I hereby declare that the Kerala University of Health Sciences, Thrissur shall have the rights to preserve, use and disseminate the dissertation / thesis in print or electronic format for academic/research purpose.

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Masterchart

Age	Sex	Sander's n	Duration	Mode	Complication	Preop Böhler's	Postop Böhler's (6)	Postop Böhler's (1)	Preop Gissane's angle	Postop Gissane's angle (6)	Postop Gissane's angle (1)	AOFAS (pre)	AOFAS (post)
17	M	2	1	2	1	15	18	18	147	136	136	45	85
46	M	2	2	1	1	15	14	14	149	136	136	75	80
45	M	2	1	2	1	24	15	15	150	137	137	35	85
35	M	4	1	2	1	21	15	15	143	145	145	40	85
46	F	4	2	1	2	8	29	29	139	137	137	40	85
35	F	4	1	2	1	10	28	28	141	140	140	45	80
37	F	3	2	2	2	21	17	17	150	140	140	45	85
37	F	3	1	2	1	8	25	25	143	145	145	60	80
41	M	2	2	1	1	12	19	19	149	140	140	65	85
51	M	2	1	1	1	11	28	28	137	143	143	65	90
66	M	2	1	2	1	14	27	27	151	134	134	40	75
23	M	3	2	1	1	15	28	28	150	150	150	55	90
28	M	3	2	1	1	24	18	18	143	136	136	45	85
29	M	2	1	2	1	21	14	14	139	139	139	80	95
30	M	2	1	2	1	8	15	15	141	139	139	35	85
71	M	2	1	2	1	10	19	19	142	140	140	85	90
72	M	2	1	2	1	10	29	29	137	148	148	85	90
50	M	2	1	2	2	12	28	28	150	131	131	75	45
74	M	2	1	2	1	11	19	19	151	140	140	80	85
45	M	3	2	1	1	14	18	20	149	135	135	65	85
23	F	4	1	1	1	10	19	19	142	140	140	25	45
56	M	4	1	2	1	12	28	28	137	136	136	75	90
47	M	3	1	2	2	11	29	29	150	144	144	65	80
50	F	3	3	2	1	15	27	29	151	134	134	30	85
49	F	2	1	2	1	14	18	18	147	136	136	70	90
35	F	3	1	2	1	8	15	15	141	136	136	45	85
34	F	2	1	2	1	14	14	14	139	139	139	45	80
40	M	2	1	2	1	10	28	28	150	131	131	50	85
51	M	2	2	2	1	11	28	28	137	143	143	25	85
29	M	2	1	2	1	14	14	14	135	135	135	65	85
30	M	2	1	2	1	15	15	15	141	140	140	25	75
71	M	2	2	2	2	10	15	19	142	145	145	85	90
72	M	2	1	1	2	10	29	29	137	148	148	40	65
50	M	2	1	2	2	12	28	28	150	131	131	80	85
74	M	2	1	2	2	11	19	19	151	140	140	75	80
45	M	3	3	2	1	14	18	20	149	135	133	75	80
23	F	4	1	1	1	10	19	19	142	140	140	60	90
56	M	4	1	2	1	12	28	28	137	136	136	35	65
47	M	3	1	2	2	11	29	29	150	144	144	75	88
50	F	3	3	2	1	15	27	29	151	134	131	30	65
44	M	4	1	2	2	10	28	29	141	131	129	90	80
35	F	3	1	2	1	21	15	17	150	140	140	30	75
75	M	3	1	2	1	8	15	15	143	145	145	30	75
37	F	3	1	2	1	10	29	29	139	148	148	70	90
41	F	2	1	2	1	12	19	21	142	140	140	90	85
51	M	2	2	2	1	11	28	28	137	143	143	25	85
66	M	4	1	2	1	14	27	27	151	134	134	65	90

Key to Master Chart
Duration: 1 <3days | 2 3-7 days | 3 >7days
Complication: 1 yes | 2 No
Mode: 1 RTA | 2 fall from height

Annexures

Annexure 1: Questionnaire

Name: age: _____ sex:_____

Address:

Occupation:

Date of admission:

Date of surgery:

Date of discharge:

PAIN 40 points

None	40 points
Mild, Occasional	30 points
Moderate, Daily	20 points
Severe always present	0 point

Function: 45 points

A. Activity

No limitations, no support	15 points
Limited recreational activities	7 points (do not use cane)
Limited recreational activities	4 points (uses cane)
Severe limitation, uses walking aid	0 points

B. Shoe:

Conventional without insole	5 points
Comfortable with insole	3 points
Modified or orthesis	0 points

C. Metatarsophalangeal joint mobility

Normal or mild restriction>75	10 points
Moderate restriction 30-74	5 points
Severe restriction <30	0 points

D. Interphalangeal joint mobility (plantar flexion)

No restriction	5 points
Severe restriction	0 points

E. Metatarsophalangeal joint stability

Stable	5 points
Unstable	0 points

F . Metatarsophalangeal callosity

Absent / present & asymptomatic	5 points Present
& symptomatic	0 points

ALIGNMENT :15 POINTS

Good hallux well aligned	15 points
Fair, some malignment, asymptomatic	8 points
Poor, Severe malalignment	0 points Symptomatic
OVERALL TOTAL	100 POINTS

PRE OPERATIVE BOHLER ANGLE:
PRE OPERATIVE GISSANE ANGLE:
CURRENT BOHLER ANGLE : CURRENT GISSANE ANGLE:

Annexure 2: Proforma

- Name
- Age
- Gender
- Hospital number
- Address and phone number
- Occupation
- Diagnosis
- Side involved
- Mode of injury
- Operated Time since injury
- Associated injuries
- Anaesthesia
- Complications
- AOFAS score
- Bohler and Gissane angle

ANNEXURE 3: CONSENT FORM

I Mr./Mrs./---------- have been informed regarding the research topic work "Plating technique outcome evaluation in calcaneal fractures based on American Orthopaedics foot and ankle score and bohler and gissane angle in a tertiary centre in North Kerala: cross sectional study" in Government Medical College Kannur, Kerala by Dr Jensen Joseph.

For the consent to include me in the study I have been informed about the following in detail:

1) The information disclosed by me will neither be misuse nor harm me in any way.
2) I don't have any additional financial obligation or burden for being part of this study.
3) I permit the investigator to use all the investigation reports for the purpose of this study.
4) I understand that I have complete freedom to withdraw myself from the study at any point of time.
5) Services rendered to me will not be affected in any way if I refuse to participate in the study. I have understood the statements given above clearly and have decided to participate in the study whole heartedly.

I hereby give my written consent for the study. Place:
Date: Pt .name signature

സമ്മതപത്രം

"അമേരിക്കൻഓർമതോപീഡിക്സ്കോൽ ,കണങ്കോൽമ്കോർ ,
വടക്കൻമകരളതിലെഒരുത്യതീയമകന്ദ്രതിലെമbോഹ്ലർ ,
ജിസ്സോൻആംഗിൾഎന്നിവലയഅടിസ്ഥോനോക്കികോൽക്കനിയൽഒടിവുകളിൽമേറ്ിംഗ്ലട ക്ലനിക്കൽഔട്ട് പുട്ട്-
ോുെയനിർണ്ണയം :
മകരളതിലെകണ്ണൂർഗവൺലേന്റ്ലേഡിക്കൽമകോമളജിൽമന്ദ്കോലസ്സക്ഷണൽപഠനം "
എന്നഗമവഷണവിഷയലതക്കുറിച്ച്ഐെിസ്റ്റർ / ോിസ്സി് ---------- / അറിയിച്ചു.
പഠനതിൽഎലന്നഉൾലെടുതുന്നതിനുള്ളസമ്മതതിനോയി , ഇനിെറയുന്നവലയക്കുറിച്ച്
എലന്നവിശദോയിഅറിയിച്ചിട്ടുണ്ട്:

1. ഞോൻലവളിലെടുതിയവിവരങ്ങൾദുരുപമയോഗംലെയ്യലെടുകമയോഒരുതരതി
ൊുംഎലന്നമദോഷകരോയിbോധിക്കുകമയോലെയ്യിെല.
2. ഈപഠനതിന്റലറഭോഗോകുന്നതിന്റഎനിക്ക്അധികസോമ്പതികbോധയതമയോഭോ രമ്മോെല.
3. ഈപഠനതിന്റലറഉമേശയതിനോയിഎെലോഅമനേഷണറിമോർട്ടുകളുംഉപമയോഗി
ക്കോൻഞോൻഅമനേഷകലനഅനുവദിക്കുന്നു.
4. ഏതുേയതുംപഠനതിൽനിന്നുേയംപിൻവോങ്ങുന്നതിന്റഎനിക്ക്പൂർണ്ണസോ
തന്ത്ര്യലുണ്ടന്ന്ഞോനേനസ്സിെോക്കുന്നു.
5. പഠനതിൽപലങ്കടുക്കോൻഞോൻവിസമ്മതിക്കുകയോലണങ്കിൽഎനിക്കുൽകുന്ന
മസവനങ്ങലളഒരുതരതിൊുംobോധിക്കിെല .
ോുകളിൽനൽകിയിരിക്കുന്നന്ദ്പ്തോവനകൾഞോൻവയക്കേതായിനസ്സിെോക്കിയിട്ടുണ്ട്
,പഠനതിൽപൂർണ്ണഹൃദയമതോലടപലങ്കടുക്കോൻഞോൻതീരുോനിച്ചു.
പഠനതിനോയിഞോൻഇതിനോൽമരഖോൊൂെോുള്ളസമ്മതംനൽകുന്നു.
സ്ഥലം മപര് : തീയതി:ങ്കെ

ANNEXURE 4: ACKNOWLEDGEMENT

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Date
Place: Pariyaram **Dr. JENSEN JOSEPH**

ABBREVATIONS

CF - CALCANEAL FRACTURES
ORIF - OPEN REDUCTION INTERNAL FIXATION
DIACF- DISPLACED INTRAARTICULAR CALCANEAL FRACTURES
CT SCAN – COMPUTERIZED TOMOGRAPHY SCAN
K WIRE- KIRSCHNER WIRE
CC SCREW- CANNULATED CANCELLOUS SCREW
AOFAS - AMERICAN ORTHOPEADIC FOOT AND ANKLE SCORE