ISSN No:-2456-2165

Evaluation of Functional Outcome of Surgical Management of Intra-Articular Calcaneum Fracture

Dr. Manoj Kumar[1] DNB Orthopaedic Surgery, Dr. Gita Kumari[2] MD Anaesthesiology, Dr. Atul Garg[*1] MS Orthopaedic Surgery, Dr. Arvind Agarwal[*1] MS Orthopaedic Surgery and HOD Orthopaedic Surgery.
[1] Department Of Orthopaedic Surgery, Maharaja Agrasen Hospital, Punjabi Bagh, New Delhi, India.
[2] Department Of Anaesthesiology, PBM Hospital, Bikaner, India.

Abstract:-
Introduction: Calcaneum fractures account for approximately 2% of all fracturesand 65% of tarsal injuries, with displaced intra-articular fractures comprising60% to 75% of these injuries. The treatment of calcaneum fractures continues to pose a challenge for the trauma surgeons despite advancement in surgical technique and implant devices. So it is the need of the hour, to identify treatment techniques, which use lesser hardware, and provide better functional outcomes in terms of shorter duration of treatment, better stability and early weight bearing. Thus this study aimed at evaluation of functional outcome of surgicalmanagement of fracture calcaneum who attended the Department of Orthopaedicsof Maharaja Agrasen Hospital during the period of study. Materials and Methods: the study was retrospective as well as prospective, Observational study of 29 patients with intra-articular calcaneum fractures from 18 to 55 years of age, who were operated at Department of Orthopaedics, Maharaja Agrasen Hospital, New Delhi during the period of study, with regular detailed clinical and radiological follow-up for minimum of 6 months. Results: The mean age (mean ± s.d.) of the patients was 37.86±13.08 years with range 18 – 55 years and the median age was 44 years. Most of the patients (51.7%) were in the age group between 40 – 59 years which was significantly higher than other age group (Z=4.03;p<0.0001). Thus intra-articular calcaneum fracture was more prevalentin the age group between 40 – 59 years. The ratio of male and female (Male:Female) was 2.2:1.0. Test of proportion showed that proportion of males (69.0%) was significantly higher than that of females (31.0%) (Z= 5.37; p<0.0001). Thus the males were at higher risk of having intra-articular calcaneum fracture than females. t-test showed that there was the mean age of males was significant higher than females (t_{27}=4.28;p<0.001). Thus females were at risk of having intra-articular calcaneum fracture at younger age than males. Test of proportion showed that most of the mode injury was fall from height (72.4%) which was significantly higher (Z= 6.83; p<0.001). Also, RTA (24.1%) was one of the common causes of injury. Only 1(3.4%) injury was caused by slip from stair. 55.2% of the injuries was left sided injury which was significantly higher than that right sided injury (27.5%) (Z= 3.96; p<0.001). Only 5(17.2%) cases of bilateral injuries were found. In 19(65.5%) of the cases no co-morbidity was found which was significantly higher than patients with co-morbidites (34.5%) (Z=4.38;p<0.001). In most of the cases Percutaneous K wire+Cast (37.9%) were underwent which was significantly higher (Z=2.67;p<0.0001).

Joint depressed (55.2%) was significantly higher than that of tongue (44.8%) butit was not significant (Z=1.47;p>0.05). 69% of the patients were operated within 2 days which was significantly higher (Z=12.67;p<0.0001). In 93.1% of the cases overall outcome of the patients was fair to excellent which was significantly higher (Z=11.24;p<0.0001). Major complications were found in 2 (6.9%) of cases. Conclusion: The mean age of the patients was 37.86±13.08 years with range 18 – 55 years and the median age was 44 years. The younger age of males having risk of intra-articular calcaneum fractures than younger age of females. The left sided intra-particular calcaneum fractures are prevalent in our population. Fall from height is major causae of intra-articular calcaneum fractures. According to essex lopresti, joint depressed was significantly higher than that of tongue in our patient pool. Majority of the patients showed better out come after treatment. Thus, we conclude that surgical management of intra- articular calcaneum fracture is effective for good functional outcome of the patients.

Keywords: *Calcaneum, Intra Articular Fracture.*

I. INTRODUCTION

Calcaneum fractures account for approximately 2% of all fractures and 65% of tarsal injuries, with displaced intra-articular fractures comprising 60% to 75% of these injuries. The treatment of calcaneum fractures continues to pose a challenge for the trauma surgeons despite advancement in surgical technique and implant devices. So it is the need of the hour, to identify treatment techniques, which use lesser hardware, and provide better functional outcomes in terms of shorter duration of treatment, better stability and early weight bearing. Since early1990s, enthusiasm for certain surgical procedure, for carefully selected fractures, in appropriate surgical candidates has increased. Because of its unique shape, difficulties arose in understanding the geometry of the calcaneal fractures. Because of its location, surgical treatment was fraught with complications till recently. However, since the development of 3D computerized tomography scanning, the anatomy and pathology of this fracture has been understood, which has revolutionized the treatment of calcaneum fractures. Plate osteosynthesis of the intra-articular fractures is a standard treatment method, but it has

ISSN No:-2456-2165

potential complications such as, poor wound healing and infection. There are many methods of stabilization of calcaneal fractures, each having their own merits and demerits. The contoured plate fixation has improved the functional results, limited indication for bone grafting, and shortened the duration of treatment. The treatment of displaced intra-articular calcaneal fractures is divided into conservative and operative management. The latter consists of open reduction internal fixation (ORIF), percutaneous reduction internal fixation (PRIF), and the primary arthrodesis (PA). Conservative treatment, functional or using Plaster-of Paris, might be considered in fractures with little displacement or compromised soft-tissues, as well as in patients with physical contra-indications (e.g., diabetes[10], peripheral vascular disease, obesity[1,29], smoking[1,3,10] or psychological (e.g., low anticipated compliance, substance abuse[9]). Since the mid 1990s, ORIF has been considered the gold standard treatment for displaced intra-articular fractures of the calcaneus by most experts, as it generally provides good to excellent functional outcomes and the ability to anatomically restore the subtalar joint[24]. Several open surgical techniques have been described in the past, of which the extended lateral approach has been applied most frequently[4,5,25,35]. The main disadvantage of the open repair is the rate of wound complications, which may occur in up to 30% of patients[2,16]. Alternative surgical approaches to the calcaneus include the limited lateral[8,17], obtuse-angled[14], the medial[6,7], combined lateral and medial[15,23,31,32], plantar[22], Kocher approach[21], U-incision[21], and limited posterior (Gallie) approach[11,20]. The limited lateral approach has been described in various modifications: Palmer approach[18,19,] Smileincision[33], Ollier approach[21,27], and the sinus tarsi approach[8,12,13,28,30]

Thus this study aimed at evaluation of functional outcome of surgicalmanagement of fracture calcaneum who attended the Department of Orthopaedics of Maharaja Agrasen Hospital during the period of study.

II. REVIEW OF LITERATURE

The management of intra-articular calcaneal fractures, includes various modalities from non operative to surgical correction. However, non operative methods of treatment have largely been abandoned. Rigid internal fixation of the fracture, with early mobilization of the patient, is considered as a standard treatment.

The first written report of closed treatment was by **Bailey[42]** in 1980 while **Morestin[43]** in 1902 first reported open reduction and internal fixation of calcaneal fractures.

Cotton and Wilson[44] recommended (1908) that one should not do an openreduction of calcaneal fracture at all. The famous quote by **McLaughlin** compared open reduction and fixation of a calcaneul fracture to "nailing of a custard pie to the wall".

Later in 1931 **Bohler[45]** supported open reduction but still the main reasons for the dominance of non operative treatment were due to the practical problems not only connected specifically with operative treatment of calcaneum but also to other general problems like ineffective anaesthesia, deficiency of good quality intra- operative radiography like fluoroscopy and the type of antibiotics at that period. Also the poor understanding of the principles of internal fixation leads to more complications. Discontented was with either conservative or late surgical management of the calcaneal fractures.

In 1943, **Gallie**[11] championed subtalar arthrodesis as a definitive treatment but only for fractures that had healed.

Palmer[19] tried operative treatment of acute displaced intra articular calcaneal fractures using a standard **lateral Kocher's approach**. He reconstructed the joint by elevating the fracture fracture fragment with bone graft and published his workin 1948. Later 1952**, Essex Lopresti[47]** reported similar findings.

Essex- Lopresti[46] had assessed the results of 31 fractures of the calcaneum treated by accurate reduction and had made comparsons with the results of other methods in a series of 173 cases. Reduction had been secured either by manipulation through a sagittal spike in the posterior fragment or by open reduction and spike fixation. He also used a plaster shoe in preference to the moreusual below knee plaster after reduction and it had the advantage of permitting limited tarsal movements. His conclusions were;

1. **That** in patients under 50 years the results after accurate reduction were better than those obtained by immediate exercises without reduction.
2. **That in patients** over 50 years of age the results after exercises without reduction were better than those from reduction and plaster.

Not all surgeons were contented with the results of open reduction and fixation, **Dick[48] and Harris[49]** began started using **Gallie's[11] technique** of subtalar arthrodesis for malunited fractures of calcaneum as the treatment of choice, even for acute calcaneal fractures. They showed excellent results with patients returning to work early. Following this many surgeons performed sub-talar arthrodesis for acute calcaneal fracture.

Even after all these in a long term follow up **Lidsay and Dayer[50]**, concluded that sub-talar arthrodesis was not only unneccessarly but also resulted in problems. They concluded that best results were got only with conservative treatment of patients. So only later, between 1960s and 70s most workers advocacted ofconservative management.

Poupa and Pribyl[51] in 1971 reviewed 34 cases of tounge type fracture of calcaneum and evaluated the surgical results of Essex-Lopresti method of percutaneous Steinmann pin fixation and closed reduction. Using the Creighton-Nebraska scoring system there were 58% excellent, 29% good and 13% fair results. They concluded that Essex-Lopresti spike fixation is useful technique for treatment of tounge type fracture of calcaneum.

ISSN No:-2456-2165

In the last 20 years, because of improved anaestheia, introduction of antibiotics, principles of internal fixation and preoperative imaging CT and intra operative imaging intensifier have permitted surgeons to employ operative fixation formany intra articular fracture, obtaining good results.

Leung and his colleagues[36] compared 44 patients with fractures of calcaneum treated operatively, with 19 treated non-operatively in a non randomized retrospective study, with an average follow up of three years. They concluded that, open reduction and internal fixation was significantly better with respect to pain, activity, return to work, and swelling.

While studying the treatment of calcaneal fractures with open reduction and plating, **Monsey RD and his colleagues**[37] concluded that contoural plates, provided rigid internal fixation for rapid healing and comparable functional outcomes to significantly less soft tissue dissection.

Laughlin RT and his colleagues[38] in their study of displaced calcaneal fractures treated with Galveston plates, found a good percentage of results to be excellent, with respect to the functional outcome.

Tornetta[39] did a study on 37 intra-articular displaced fractures fixed by minifragment plates and concluded that calcaneum fractures treated with plating, yielded 77% good to excellent results with respect to the functional outcome.

Sharma *et al.*,[40] reported their results using specially designed, side specific calcaneal locking plate in 27 consecutive patients with displaced intra-articular fractures. They concluded that, calcaneal locking plates act as a stable internal fixator, and achieved excellent to good results in 72% of cases.

Prats *et al.*,[41] studied 20 displaced intra-articular calcaneum fractures treated by open reduction and internal fixation. With an average follow up of 5(2-8) years, the results were excellent or good in 15 cases, and fair or poor in 5 cases.

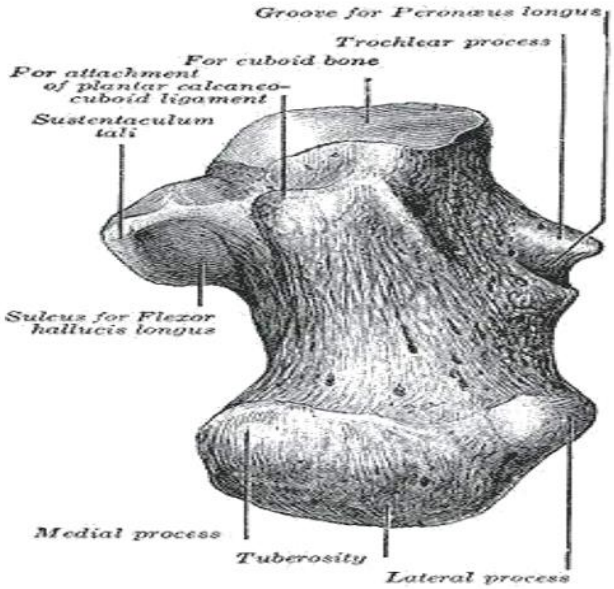
Currently, open reduction and internal fixation through the lateral L-shape extensile incision has been considered as the gold standard surgical therapy for calcaneum fractures. This approach provides a large view to expose the fractures, allowing accurate reduction of the deformed posterior facet and convenient placement of the plate to achieve a stable fixation. However, the high incidence (approximately 30%) of complications associated with this approach, including wound dehiscence and deep infection, remains a non-negligible problem.

- ***Surgical Anatomy***

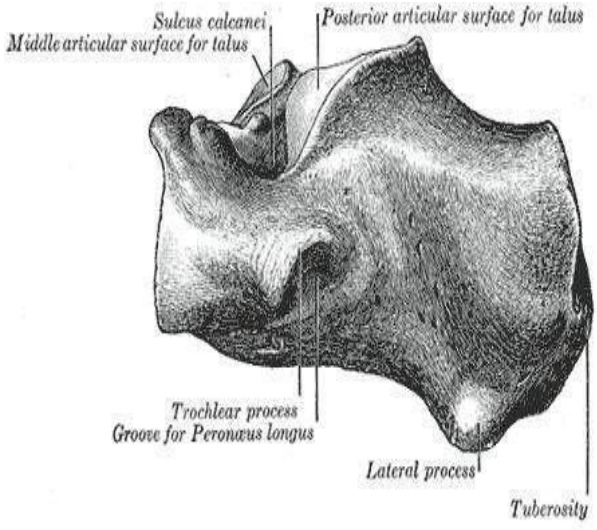
Calcaneum as a bone forms a base or vertical support for body weight. It is the biggest of all tarsal bones with many articulations. It also has many ligaments and tendon attachments. It also functions as a lever arm powered by gastro-soleus. It also supports and conserves the length of lateral column of foot.

Calcaneum has a thin cortical shell which encloses a mass of cancellous bone thatremodels with various stresses applied to it. The anatomy of the calcaneum on its lateral aspect is particularly vital as mainly this lateral surface area is exposed during the most common surgical approach used for fracture fixation. Tuberosity is the most posterior aspect of calcaneum, distal to the tuberosity is body of calcaneum.

In the planter aspect of calcaneum, a small process in slightly lateral portion is called the lateral process of tuberosity gives origin to muscles and attachment to planter fascia.



Axial view

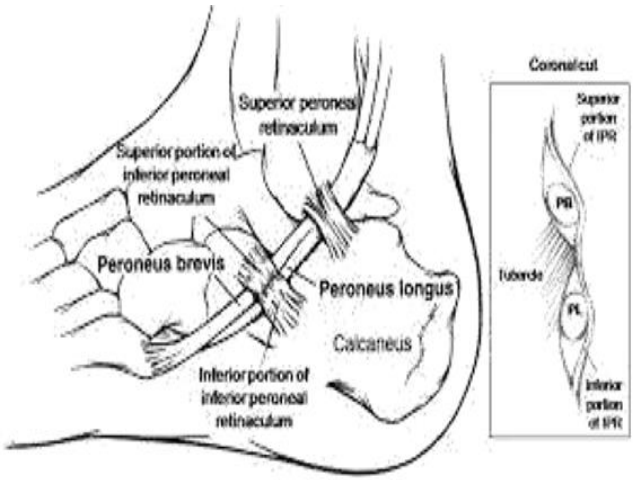


Lateral view

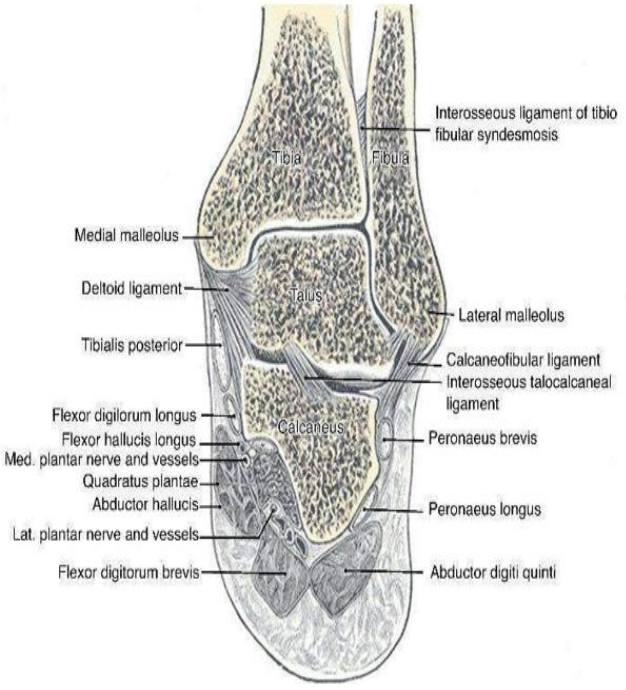
Peroneus longus tendon pass in the lateral aspect of in the groove just under the peroneal trochlea (tubercle). The lateral margin of posterior facet is observable in the middle part of calcaneum on lateral side. This is important in open

ISSN No:-2456-2165

reduction and internal fixation of intra-articular fractures of calcaneum as more lateral portion of the posterior facet usually has to be reconstructed and fixed with screws. Distally on lateral side, the articular surface of the calcaneocuboid joint is found. The superior surface of the calcaneum has the three articular facets in the anterior half. The largest facet is the posterior facet and is convex. The middle facet which is slightly concave is situated on the sustentaculum tali. This facet frequently continues anteriorly as the anterior facet, also slightly concave. The inter-osseous sulcus (calcaneal groove) lies between the middle and posterior facets. It opens broadly laterally and forms with the talar sulcus, the sinus tarsi. These anterior middle and posterior calcaneal facets articulate with anterior middle and posterior talar facets to form the complex subtalar joint.

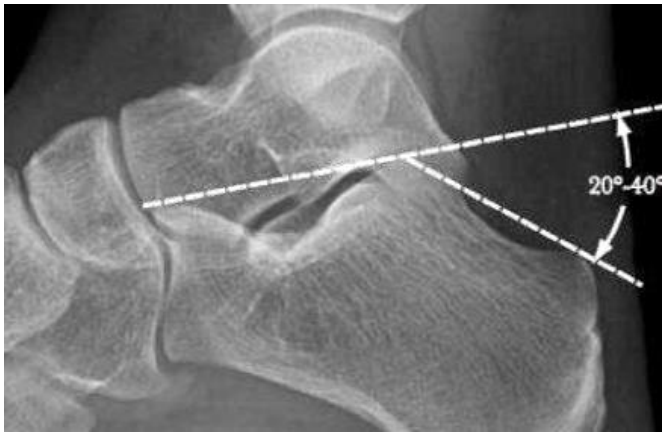


Lateral view showing peroneus tendon

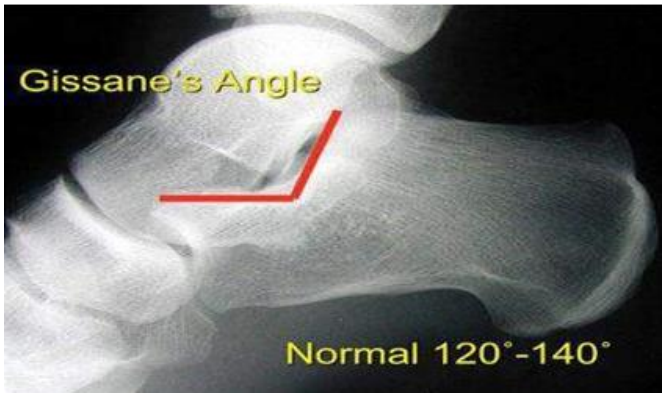


Coronal section

The diagram given above is a posterior or coronal view of the calcaneum, showing the anatomy of calcaneum at the level of the sustentaculum tali just inthe anterior portion of the posterior facet. Of special significance here are the sustentaculum tali and the middle and anterior articular surfaces of the distal lateral wall of the calcaneus. The lateral view shows 2 angles on X-ray. Bohler's angle (Tuber joint angle) is the complement of an angle produced by two lines. First line is drawn between the highest point of anterior process connecting to the highest part of the posterior facet or articular surface. A similar line is drawn between the same point on posterior facet connecting to the most superior pointof the tuberosity of the calcaneum. It usually measures between 25-40°. Loss of this angle on plain lateral radiographs means there is loss of calcaneal height. Crucial angle of Gissane is an additional angle "formed by the downward portion of the posterior facet where it joins the upward portion. This angle faces thelateral process of the talus and is disturbed at the time of calcaneal fracture by axial compressive forces. The normal measure of the angle of Gissane is about 120-145º.



Radiological Lateral view showing Bohler's Angle



Radiological Lateral view showing Gissane's Angle

There are few unique anatomical aspects of calcaneum.

1. To permit passage of the tendons and neurovascular structures into the foot, the calcaneum is concaved out on the medial side.
2. Thus the centre of calcaneal tuberosity to be a lateral to the centre of talus.
3. If a force is applied vertically to the talus, with the calcaneal tuberosity fixed to the ground, then shear stress take place all the way through the body of the calcaneum.

➢ ***Mechanism Of Injury***

Calcaneal fractures are most often brought about as a

ISSN No:-2456-2165

result of fall from a height. This mechanism is responsible for 80 to 90% of cases. Since the calcaneus is selectively a hollow structure composed of cancellous bone enclosed in a thin cortical shell, any fall, even a short one may result in fracture as the talus is driven downwards into the calcaneus[47]. When a person falls from a height, the compressive forces fracture not only the calcaneus but may produce a proximal injury as well. According to Cave[52], 10% of the calcaneal fractures are associated with compression fractures of the dorsal or lumbar spine and 25% are associated with other injuries of lower extremity.

Twisting forces may cause many of the extra-articular calcaneal fractures particularly fractures of the anterior process, sustentaculum, and the medial process. Fractures of the tuberosity are most commonly caused by avulsive muscle forces as the triceps surae pulls loose a variable sized portion of the tuberosity. Direct blows, closed or open, can result in fracture of any part of the calcaneus[53].

- ***Intra-Articular Fractures:***

The forces that produce the fracture of the calcaneus are a combination of compression and shear. Essex-Lopresti concluded that as these forces are applied, the fracture begins laterally and then advances medially. The force that is generated by the weight of the body is initially transmitted to the calcaneus through the wedge like anterior process of talus. This process splits the calcaneus through its crucial angle and the outer part of the wall, causing a vertical fracture that is located anterior to the posterior facet. As the force continues, the fracture progress medially and by a shearing mechanism the calcaneus is split into an anteromedial fragment that includes the sustentaculum tali and a posterior fragment that includes the tuberosity[54]. Palmer[19] described this vertical shear fracture as the initial line of fracture that divides the bone into two parts. Warrick and Bremner[55] concluded that sagittal fracture may take one of described this vertical shear fracture as the initial line of fracture that divides the bone into two parts. Warrick and Bremner[55] concluded that sagittal fracture may take one of thethree paths, all extending from the medial side that varies in position and is located posterior to sustentaculum tali. The 3 paths are lateral to the posterior facet, through the posterior facet or along the calcaneal sulcus, anterior andmedial to the facet. Thoren found that the location of the sagittal fracture was dependant on the position of the foot at impact.

When foot was in pronation, the sagittal fracture passed posterolateral to the posterior facet. When it was in neutral position, the fracture went through the posterior facet; and when the foot was supinated, the fracture passed along the calcaneal sulcus anterior to the facet. The final pattern of the fracture that results from any given injury is dependant on the location of the primary sagittal fracture line and on any secondary compression fractures of the main lateral fragment that develop as will be described[53].

If the shearing force is dissipated by production of the primary sagittal fracture, the result is one of the undisplaced primary fractures. If the shearing force is not so dissipated, but continuous, the fragment of the tuberosity is displaced superolaterally and distally as a result of impact. When foot is in pronation at impact, the sagittal fracture passes lateral to the posterior facet and a two part extra-articular shear fracture is the result. The two parts are the superomedial fragment of the calcaneus which includes an intact posterior facet and the fragment of the tuberosity. When the foot is in neutral position at impact and the sagittal fracture enters the posterior facet, a two part intra-articular shear fracture occurs. The two parts in this instance are superomedial fragment which includes the sustentaculum tali as well as the medial portion of the posterior facet,and the posterolateral fragment, which includes both tuberosity and lateral portionof the posterior facet. If the force is not dissipated by production of such a two- part intra- articular shear fracture, a secondary compression fracture occurs as the portion of the posterior facet that is continuous with the fragment of the tuberosity is depressed by descending posterior facet of the talus. The result of displacement is the distinct pattern of the fracture[56].

In the first, which is called a joint depression fracture, the secondary fracture line is propagated in a posterior direction until it reaches the upper surface of the calcaneus, posterior to the posterior margin of the posterior facet, and the lateral portion of the posterior facet is depressed and rotated. In the second pattern calleda 'tongue fracture', the secondary fracture line is horizontal and extends posteriorly from the anterior margin of the posterior facet, all the way to the end of the tuberosity. This fracture involves the medial and posterior cortices of the tuberosity, so that the resulting superior fragment of the tuberosity rotates as the posterior facet that is attached to it is depressed[56].

Where the foot is in supination at impact the sagittal fracture enters the calcaneal sulcus, the entire posterior facet remains intact, but is compressed resulting in a two-part compression fracture. One part is composed of superomedial fragment and the fragment of tuberosity which are separated by a fracture that is virtually undisplaced, and the other is composed of the fragment of the posterior facet which may be of either of the joint depression or the tongue type.

In severe injury to a foot that is in supination at impact, the fragment of the tuberosity may be displaced superiorly, resulting in a three part compression fracture whose components are superomedial fragment, the fragment of the tuberosity, and the entire fragment of the posterior facet which is of either the joint depression or the tongue type. Supination of the foot at impact seems to prevent the fragment of tuberosity from being displaced laterally[56].

When the foot is in neutral position at impact the force is sufficient to produce not only sagittal fracture of the posterior facet (a two-part intra-articular fracture) but also secondary compression fracture of the lateral portion of the posterior facet; the result is a 3 part shear compression fracture that is composed of superomedial fragment and the medial portion of posterior facet-fragment of the tuberosity and the fragment of the posterior facet, which may be of either joint depression or the tongue type. Thoren's studies showed that joint depression fractures occur when the foot is in dorsiflexion at impact where as tongue fractures occur,

when thefoot is in plantar flexion position[56].

Essex-Lopresti[47] and **Palmer**[19] noted that because of the strong ligaments that attach the superomedial fragment of the talus, when recoil of the talus occurs afterimpact the superomedial fragment is pulled back to its normal position while the other part of the foot remains depressed. This produces a step-off in the surface ofthe joint of the posterior facet that ranges in depth from 3mm to 10mm

➢ ***Extra-Articular Fractures:***

The common fractures of the calcaneum which are not involving the subtalar jointare:

- Fracture of the anterior process
- Fracture of the tuberosity
- Fracture of the medial calcaneal process
- Fracture of the sustentaculum tali
- Fracture of the body.

➢ ***Fracture of the anterior calcaneal process:***

Two distinct fracture patterns involve the anterior process.

- Avulsion fracture of the anterior process
- Compression fracture of the anterior process involving a variableportion of the calcaneocuboid joint.

Avulsion fracture is more common. This type of injury occurs when the foot is abducted and plantar flexed and tension is placed on the bifurcate ligament. This ligament connects the anterior process of the calcaneus to both the cuboid and navicular bones. Inversion stress of the foot will result in stretch of the ligament or avulsion fracture of the anterior process[57].

In compression fracture of the calcaneal process, the mechanism of injury is forceful abduction of the forefoot, with compression of the calcaneocuboid joint. The anterior articular surface of the calcaneus is fractured and a variable sized fragment can be displaced superiorly and posteriorly resulting in significant joint incongruity.

➢ ***Fractures of the tuberosity:***

Comparatively rare injury and older people are more prone. Usual mechanism is afall from height, and avulsion of the fragment of the calcaneus by a sudden pull ofthe Achilles tendon. In elderly patients osteoporosis facilitates this type of injury. Very rarely direct trauma also causes fracture of the tuberosity[57].

➢ ***Fractures of the Medial calcaneal process:***

Watson Jones called this injury as a vertical fracture of the tuberosity and believed that it was caused by shearing force produced from a fall on the heel when in valgus position. Bohler thought it was due to avulsion of plantar fascia[57].

➢ ***Fractures of the sustentaculum tali:***

Fractures of the sustentaculum tali are the result of 2 forces: Landing on the heel combined with acute inversion of the foot.

➢ ***Fractures of the body not involving the subtalar joint:***

Mechanism of injury mostly associated with the fracture of the body is a fall fromheight, with the patient landing directly on the heel[47.]

➢ ***Classifications***

There is a broad agreement that the degree of joint destruction at the time ofinjury decides the results of the calcaneal fracture management. Radiological information has limitations like the position of the limb during the radiography, lack of adherence or standardization of the radiographic procedure .There is no handy classification system. Thus the assessment of every calcaneal fracture and comparison of fracture patterns becomes difficult.

➢ ***Classification of intra articular fractures of calcaneum***

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/DeSouza
3. Classification based on CT and plain X-ray - Orthopaedic TraumaAssociation

Malgaigne first described two different types of calcaneum fractures as intra articular and extra articular. Later Bohler launched his classification system basedon the prognostic value of the fracture pattern differentiation.

In 1952 Essex Lopresti, introduced his simple but extensively used classification. However a major problem in this classification is the joint depression type comprises too many fracture patterns. This does not permit useful correlation between the fracture classification and the ultimate clinical result.

It was Crosby and Fitzgibbons who pioneered a CT based classification of calcaneum fractures by the fracture pattern of the posterior facet, dividing the intra articular fracture of calcaneum in to three types.

Later based on Souer and Remy's work which divided the posterior facet into 3 different columns, Sanders developed a classification where the calcaneum fracture was subdivided based on location of the primary and secondary fracture lines.

Eastwood et al. — classified fractures of calcaneum based on destruction of three main fragments. Carr divided the calcaneum into medial and lateral columns and considered the destruction of posterior facet and calcaneo-cuboid joint. Levin and Nunley considered soft tissue problems and found six groups.

Zwipp classified calcaneum into 5 main fragments and 3 joints. This considered the number of destroyed fragment and joints and the degree of soft tissue damage.As already elaborated, for clinical use, Essex Lopresetti classification appear simplest but it is inadequate and cannot offer a outline

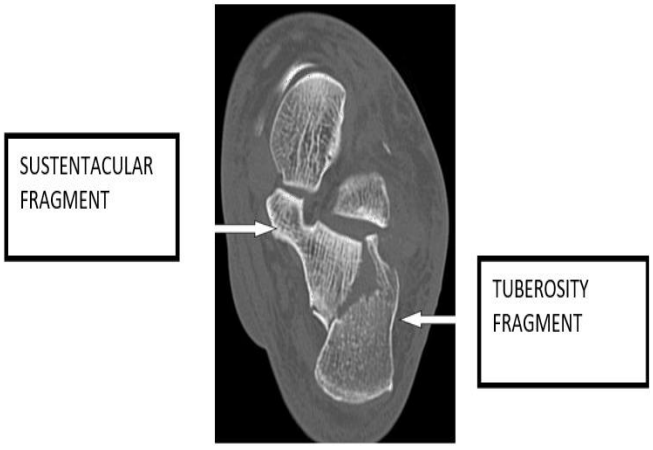
ISSN No:-2456-2165

for forming surgical strategies or for calculating the long term result. Sanders's classification is simple, comprehensive and has the advantage of allowing prognostication ofresults for various fracture types of calcaneum. Yet another classification called Zwipp classification, describe the typically complex pattern of calcaneum fracture.

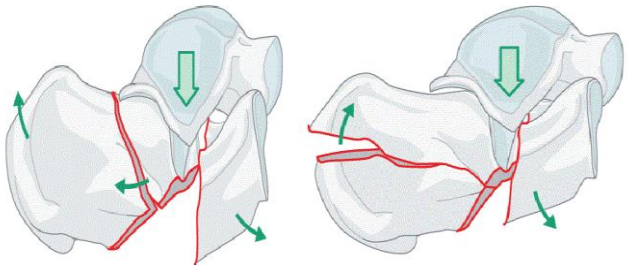
➢ ***Essex-Lopresti Classification[47]:***

The calcaneum essentially breaks along this stress line, forming two main fracturefragments,

1. Medially- the sustentacular fragment and
2. Laterally- the tuberosity fragment



Radiological axial view


Depressed Type Tounge Type

➢ ***Types of Essex-Lopresti****.Essex-Lopresti****:***

- Joint depression type with a single verticle fracture line through the angle of Gissane separating the anterior and posterior portions of the calcaneus.
- Tongue type which has the same verticle fracture line as a depression type with another horizontal fracture line running posteriorly, creating a superior posterior fragment.

➢ ***Fractures not involving the subtalar joint Tuberosity fractures***

1) Beak type
2) Avulsion of the medial border
3) Vertical fracture
4) Horizontal fracture

➢ ***WARRICK AND BREMNER CLASSIFICATION[55] (1953):***

➢ ***Fractures of the calcaneum not involving the subtalar joint.***

1. Vertical fracture of the tuberosity
2. Horizontal fracture of the tuberosity
3. Fracture of the sustentaculum tali
4. Fracture of the anterior end of calcaneus.

➢ ***Fractures of the calcaneum involving subtalar joint***

1. Fractures adjacent but not entering the subtalar joint
2. Fractures with displacement of lateral part of the subtalarjoint
3. Fractures with central crushing of the whole of subtalar joint
4. Crush fracture of the subtalar and calcaneocuboid joint.

➢ ***Sander's Classification***

The common classification followed is Sanders, which is based on the CT coronalimage of the posterior facet which is more descriptive and complex.

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 III	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

➢ ***Orthopaedic Trauma Association Classification (1996)***

This classification system uses both plain radiography and coronal CT images of the posterior facet.

Type A: Extra-articular fractures **Type B:** Isolated body fractures **Type C:** Intra- articular fractures
Further subdivision is based on the location, the amount of communition and the number of fragments. This system is complex and has not been used extensively by most orthopedic surgeons.

➢ ***Implants***

➢ ***Screw Fixation Of Calcaneal Fracture***

Avulsion extraarticular fractures are comparatively easily stabilized and fixed with 1 or 2 leg screws can be applied percutaneously with minimal surgical trauma

➢ ***Wire Fixation Of Calcaneal Fracture***

For complex calcaneal fractures K wires are inadequate. While in undisplaced avulsion fractures or undisplaced body fractures, if carefully applied K wires give subcutaneous stabilization, though early mobilization cannot be achieved. K wires are ideal for temporary stabilization. But now these are supplemented with external fixation as a support to maintain the fracture reduction of differentfragments.

➢ ***External Fixators Of Calcaneal Fracture***

These are handy in open fracture, in calcaneal fractures also, they can be used asa temporary device till the open wound heals or to maintain the fracture geometrytill fracture healing,

ISSN No:-2456-2165

in addition to K wires. In comminuted fratures which appear as a bag of bone the ideal management is by image guided percutaneous multiple K wires fixation and supported with these external fixators.

➢ ***Plates And Screw Fixation Of Calcaneal Fracture***

Implants for depressed intraarticular fractures have always created controversy and confusion but there is aggrement developing regarding that the depressed facet should be elevated and the tuberosity should be maintained, the posterior depressed facet and anterior process should be aligned.

As already told the evolution and modifications of implants have made the calcaneal implant more complex, and the user is ofen confused by complexloching plates. the implants are costly due to patents, better technology. Locking plate principles has been applied to this area also.

Initially in the 1980s, the main goal of fixation was the facetal reconstruction which is achieved by 2 screws in compression mode and this is followed by offloading by a single neutralization plate on the lateral surface. It also maintained the configuration of the tuberosity and the anterior process in relation to the reconstructed facet, bone grafting is needed indeed. This gave the surgeons fairly good results when employed by surgeons with experience; however weight bearing needed to be postponed.

In this method, there was poor maintenance of elevated posterior facet and late collapse of the fracture reconstruct happened. There were also plate related lateralcomplications. Thus the implant development progressed further.

In the 1990s there is an emergence of double plate configurations, and the development of single construct H or Y reconstruction plates. (e.g) Bezes used a 2nd short straight plate in addition to a flat plate, forming a "Y" construct. Letournel used the principles used in acetabular and pelvic fracture surgery,modifying them to develop the concept of a single "Y" plate and the anatomic reconstruction plates (with arms) which were made particularly for calcaneus.

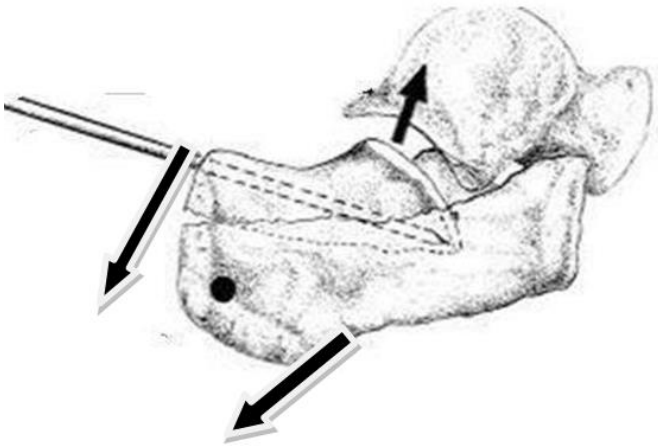
➢ ***Locking Plates Of Calcaneal Fracture***

With the turn of 21st century the emphasis and importance shifted to low profile but versatile implants. These type of implants allowed stable fixation .The plate profile/thickness was reduced which in turn allowed us to minimize soft tissue breakdown. The plates were also made less rigid for moulding to irregular surfaces of calcaneum, and their complex structure allowed varied non parallel screw placement to ensure rigid support of the bone fragments at various levels. This lead to the development of thinner, single construct calcaneal locking plates. These have better results in comminuted fractures also. With the emergence of locking plate concept by Wagner and AO group, the concept was extended for use in foot and ankle. Synthesis Medical GmBH, Solothurn Switzerland marketeda versatile locking calcaneal plate with 15 locking holes.

➢ ***Treatment***

The choice of treatment is as follows

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 withpercutaneous pin and fixation.



Essex-Lopresti Reduction Technique

b) Percutaneous techniques which are recently popular.
c) Limited open reduction and external fixation technique

3. 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 internalfixation.
d) Primary arthrodesis.
e) Closed treatment

It consists of "**RICE**" Rest, Ice application, Compression, Elevation of limb and NSAIDS. It is accomplished in two ways.

a) One has to accept the fracture as it presented to the surgeon without making an attempt to reduce, with short term immobilization, non weight bearing for 6-8 weeks followed by gradual early motion.
b) By external pressure fracture is manipulated manually or with tongs forreduction and immobilization done, later early physiotherapy for range of motion exercises are advised. Weight bearing is allowed after 8 weeks. Manipulating the fracture can be done by Omoto technique.

Semi Open Techniques are easy for the surgeon with low surgical risk to the patient than open techniques. But correct patient selection (i.e) only tongue type fracture patterns and determination on anatomic reduction of the joint surfaces can be expected to cause acceptable and good results.

a) Essex Loprestti and King's technique.

ISSN No:-2456-2165

b) Surgical technique of Tornetta,

➢ ***Open surgical technique***.

The indications

a) Type II and III Sanders with displacement more than two millimeters inthe setting of soft tissue conditions that have no increased risk of complications and a patient — who can comply with post operative care and advise.
b) Type IV Sanders usually treated by primary subtalar fusion.

They are classified into following

a) **Lateral approach**
(i) Benirschke and Sangeorzan
ii) Sanders

The approach was described by Benirschke and Sangeorzan and popularized by Sanders. The advantage of this approach is that the reduction and fixation of the posterior facet can be done directly.

Limited approaches are

Palmer approach, Sinus tarsi approach, Small lateral approach, Extensile sinustarsi approach, Geel and Flemister approach.

b) **Medial Approach**
i) McReynolds
ii) Burdeaux

This is based on the principle of restoring the medial wall of the calcaneal which can be done adequately only from the medial side. An accurate reduction produces stability, restores length and height and partially restores a width. The joint or tongue type fragment is reduced to restore the articular surface of the posterior facet.

c) **Combined Medial and Lateral Approach**
a) Stephenson
b) Johnson and Gebhardt

Stephenson pioneered a combined medial and lateral approach with rigid internal fixation with screws and staples, followed by early range of motion post operatively. Good results, with the good quality of fixation are achieved but there is limited visualization of the subtalar joint in this approach.

d) Early Primary subtalar fusion for those patients with severely comminuted intra articular fracture is advocated e.g. Sander's advised primary arthrodesis in his type IV fractures.

The order of importance is:

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 calcaneo-cuboid and anterior and middle facet joints.

➢ ***Complications Of Intra Articular Calcaneal Fracture***

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***

Acute calcaneal fracture accompanies significant soft tissue swelling. Fracture blisters may occur anywhere over the foot usually within 24-48 hours after injury and have clear fluid or blood. If there are extensive blisters then surgery is contra indicated. If incision is done through these blisters then wound infection is possible, so initial swelling must be reduced by elevation. By pinching the skin ofthe heel a wrinkle must appear this is called the "wrinkle" test. It should be done before any surgical treatment.

An another common complication of surgical treatment is wound infection.It may be (i) superficial (in 10-27% of all cases) (ii) Deep (1.3-2.5% of all cases). Safety measures in calcaneal surgery Timing of surgery, methods to decrease swelling and meticulous surgical technique especially the lateral approach with sharp dissection to raise full thickness flaps from skin to periosteum, use of no- retraction technique by K wires, using Allgower stitch (atraumatic skin closure technique), and suture removal after 3 weeks are recommended. Post operative wound dehiscence usually begins at angle of incision and has been called 'apical' wound necroses. Flap edge necrosis can happen when the incision extends to the edges or watershed areas or the lateral heel, which is an area that receives blood supply from posterior peroneal artery. Superficial or deep wound dehiscence can happen as late as four weeks postoperatively. The risk factors are single layered closure, high BMI, lag of time between injury and surgery, smoking, diabetes mellitus.

➢ ***Compartment syndrome.***

This is caused by bleeding from cancellous bone fragments crushing high energy injury coupled with anatomic soft tissue constraint by the plantar aponeurosis. The calcaneal compartment, continuous with the deep posterior compartment of the leg has been described to be the compartment at risk after calcaneal fractures,incidence is 10%.

There is persistent pain, which is out of proportion to injury with severe swelling.There may be toe flexor weakness and stretch pain on passive extension of toes.

ISSN No:-2456-2165



Figure 1 showing blisters over the ankle

There may also be associated plantar hyperesthesia apart from fracture blistersand plantar ecchymosis e present. Most reliable physical finding is tense swelling of the foot. If compartment pressure should be measured over calcaneal, medial, lateral, superficial and interosseus compartment of involved foot the compartmentpressure reaches 30 mmHg (or) with is under 10-80 mmHg of diastolic blood pressure, then it is the time to do a faciotomy.

- ***Nerve Injury***

Acute neurologic injury most commonly occurs. e.g iatrogenically in the lateral approach, Sural nerve involved and in the medial approach - calcaneal branch of posterior tibial nerve is involved. Injury to both medial and lateral plantar nerve can happen when screws or wires are inserted from the lateral approach especiallyanteroinferior aspect of the posterior facet.

Nerve Entrapment also can happen later due to soft tissue scarring or bony malunion or exostosis formation causing the impingement. This is usually from conservative treatment. The medial plantar, lateral plantar and calcaneal branch oftibial nerve medially may be involved and cause pain. Sometimes the sural nerve laterally also may be involved. When examined, Tinel's sign may elicit over the area of the involved nerve. This pain around the distribution of the nerve, may be apparent both at rest and while standing. Selective nerve blocks with anesthetics also may help to diagnose nerve involvement.

- ***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 groves
c) Entrapment of tendons between fracture fragments
d) Impingement of tendons between malunited bony fragments.

Peroneal tendinitis can be caused by implant irritation when a lateral approach isused.

Pain over the lateral aspect of the heel is the most common site of persistent painafter calcaneal fracture. This should be differentiated from secondary pain due to

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

Buckling or giving way when walking also may suggest peroneal tendon dysfunction ' To distinguish between pure peroneal tendinitis and calcaneofibular abutment ,confirm localization of pain along the course of the peroneal tendon and eliciting pain with passive dorsiflexion and resistance to evertion of the hind- foot.

Diagnostic peroneal synoviogram by injecting radiographic dye or localanesthetic or both to demonstrate stenosis or narrowing along the involved tendonsheath and induce pain relief.

- ***HEEL PAD PAIN AND HEEL EXOSTOSIS***

Heel pad pain is the second most common site of pain after a calcaneal fracture. Itis due to injury to the heel pad close to calcaneum during the time of injury. Diagnosis is done by the presence of significant heel pain, over to the area of soft tissue and heel pad under the bone, tenderness on the side to side palpation or thumping over the heel pad. There was thinning and increased mobility of the heelpad. Thus the heel pad was softer and less firm compared to the uninjured site. Bony calcaneal spurs, heel exostosis develop from the undersurface of calcaneum in patients with injury to the plantar cortex of calcaneum after injury. It is due to proliferative bony changes at the origin of the plantar fascia.

MALUNION occur commonly in conservative treatment but may occur in inadequately or improperly done reduction in surgeries. It results in

a) Widened heel syndrome
b) Pain and instability secondary to tendon impingement
c) Post traumatic arthritis of subtalar or calcaneocuboid joint
d) Hind-foot malalignment and altered gait secondary
e) Nerve impingement.

Pain can be due to varus malunion on lateral aspect of foot valgus malunion onlateral sub-talar area.

When examined there may be a) Callosities and sores over lateral aspect of foot
b) Widened heel c) Abnormal shoe wear

ARTHRITIS may affect - subtalar or calcaneocuboid joint .Subtalar incongruity or penetration of implants into the sub-talar joint may cause late arthritis. There is significant unloading of the posterior facet with as little as 2 mm of articular surface depression, supporting the concept of articular surface reduction as aim oftreatment in operative treatment of calcaneal fracture.

Even in an anatomically reduced fracture, arthritis can occur due to cartilage injury that is caused by initial trauma. Thus it is also the severity of initial injury that determines the ultimate outcome and not the accuracy of articular surface

reduction as obtained in one study.

Placement of implants within the articular surface may occur after operative treatment and implant exit is a must before weight bearing or range of movements. If left the patient might develop pain on weight bearing, aggravated by valgus or varus stressing of subtalar joint but with no significant tenderness onthe lateral aspect of the heel.

➢ ***Lacunae Of The Previous Studies:***

The existing studies are based on the patients from western countries. Also avery few studies had been found to find the evaluation of functional outcome of surgical management of intra-articular calcaneum fracture and its implication based on the patients from the Indian sub-continent specially based on the patients of NCR region. The patients mainly from the NCR region are coming to our hospital for their treatments. Thus this study was the one of pioneer studiesfor evaluation of functional outcome of surgical management of fracture calcaneum based on the patients of NCR region.

➢ ***Research Question:***

Is surgical management of intra-articular calcaneum fracture effective for good functional outcome?

➢ ***Aim And Objectives***

Aim:

To evaluate the results of surgical management of intra-articular calcaneumfractures with reference to:

1. Mechanism of injury
2. Intra-operative difficulty
3. Post-operative complications
4. Final functional outcome

Objectives:

1. Results of early mobilization
2. To define the approach for fixation of these fractures

III. MATERIAL AND METHODS

❖ **Material:**

Study Site: Department of Orthopaedics, Maharaja Agrasen Hospital, PunjabiBagh, New Delhi.

Study Population: All the patients with intra-articular calcaneum fracture who were operated at Department of Orthopaedics, Maharaja Agrasen Hospital, New Delhi during the period of study.

Study Design: the study was retrospective as well as prospective, Observational study of 29 patients with intra-articular calcaneum fracture who were operated at Department of Orthopaedics, Maharaja Agrasen Hospital, New Delhi during the period of study.

Time Frame To Address The Study: 1st January 2015 to 31st December 2018.

➢ ***Inclusion And Exclusion Criteria:***

Inclusion Criteria:

- All patients above 18years of age with intra-articular calcaneum fractures
- Fresh fractures
- Patients should be walking prior to the fracture

Exclusion Criteria:

- Open fractures
- Pathological fractures
- Fracture in children
- Fractures in adults >55years
- Severely osteoporotic bone
- Patients not giving written consent for surgery

❖ ***Methodology***

➢ ***Data Collection:***

Cases were selected by diagnosis on history, clinical examination, x-rays and routine investigations. Specific mention about the presence or absence of vascular or neurological deficits, open or closed injury, associated spine or extremity injuries were made. Performa specially made for this study was used. Clinical diagnosis was confimed by Antero-Posterior, Lateral and Harris axial views.Special views were taken only when the interpretation of these routine x-rays were difficult.

All intra-articular calcaneal fractures were classified and assigned to particular group based on Essex-Lopresti's classification system.

➢ ***Investigations:***

Patients were evaluated clinically and radiologically, lateral, axial radiographs of calcaneum taken. A pre operative computeriz were fixed internally by percutaneous cancellous canulated screws with washer after reduction under fluoroscopic guidance, intra-articular fractures fixed with multiple k-wire and below knee cast, for intra articular fractures open reduction and internal fixation done and also with extensile lateral approach with ipsilateral aliac crest graft wasused to fill the defect after elevating the depressed posterior articular facet which were internally fixed with plating. Axial and broden views were assessed under fluoroscopy intra operatively. Also intra-articular fractures fixed with sinus tarsi approach and fixed with screws with washers. For comparison of corrected bohlers and gissane angles, post-operative radiographs were taken. Post operatively limb elevation was maintained for 72 hours. Compressive bandage was applied over sterile dressing. Complete suture removal was done at an average of 2-3 weeks. All operated patients were kept on absolute non weight bearing for 4-6 weeks, full weight bearing was allowed from 12 weeks. Regular clinical follow up examination was performed monthly in all cases and functional outcome was assessed by using Maryland foot score after following cases over a mean period of 6-12 months.

On admission demographic data was recorded and

ISSN No:-2456-2165

thorough history and clinical examination done. We assessed the neurovascular status and radiological assessment of fracture limb. Further investigations was done depending general condition of patient and the routine pre-operative protocol as per our hospital guidelines.

So careful pre-operative planning regarding selection of implants and the technique and appropriate instrument was decided prior to surgery.

The physical examination of the patient on admission to the institution includes complete general and local examination as per detailed proforma specially was prepared for study. Any open wound, deformity and neurovascular deficit all recorded.

Study requires the following investigations-
. Haemoglobin
. Bleeding time/ clotting time
. Random blood sugar
. blood urea/ serum creatinine
.Urine routine
.HbsAg/HIV/HCV
.ECG
. X-RAY foot - AP view
-Lateral view
- Aaxial calcaneal view
-3D CT

➢ ***Surgical Techniques Used***

Open reduction internal fixation

a) With plating with multiple screws with bone grafting via lateral extendedapproach
b) With plating with multiple screws with bone grafting via sinus tarsi approach
c) With Steinmann pins

Reduction under image intensifier and internal fixation

a) With percutaneous kirschner wires
b) With percutaneous cancellous cannulated screws with washers
c) With combination of percutaneous cancellous cannulated screws with kirschner wires or with Steinmann pins
d)With combination of percutaneous kirschner wires with Steinmann pins

➢ ***Postoperative Management And Evaluation***

Postoperatively, prophylactic antibiotics was given to prevent surgical site infection and plaster immobilization performed to protect the wound. The patientswas encouraged to do toe flexion and dorsiflexion exercises 24 h after the operation. Stitches was removed after 2 weeks of surgery, and weight bearing wasgradually advanced to regain full range of motion and strength at 6 to 8 weeks after surgery, during which the plaster cast was removed.

The operative data was recorded, including operative time (min; measured from the cut to the suture of the incision), hospital stay (days), cumulative intraoperative radiation time (min; provided by the fluoroscopic apparatus), fracture healing time (days), and the incidence of complications. Fracture healing is defined as the bridging of the trabecular bone and the disappearance of the trabecular fracture line on the radiograph. The lateral and axial radiographs was also obtained preoperatively, postoperatively, and at the last follow-up to judge the reduction of the calcaneus, including the Böhler angle (i.e. the angle between the line drawn from the highest point of the anterior process to the highest pointof the posterior facet and the line tangent to the tuberosity); Gissane angle (i.e. theangle between the line tangent to the articular surface of the medial posteriorfacet and the line of the anterior end of the posterior facet to the dorsal edge of the calcaneocuboid facet); calcaneal height (i.e. the perpendicular distance from the inferior cortex of the calcaneus to the top of the medial posterior facet); calcaneal width (i.e. the distance between the external cortex of the medial malleolus and the lateral cortex of the most lateral calcaneal fracture fragment); and calcaneal length (i.e. the orthogonal distance from the most posterior aspect of the calcaneus to the most distal edge of the calcaneocuboid joint).

The clinical functional outcomes assessed by using the Maryland foot score(MFS), which is a 100-point scoring system with 40 points for function, 45 pointsfor pain, 10 points for cosmesis, and 5 points for movement of the ankle, subtalar,midfoot, and metatarsophalangeal joints. The scores is defined as follows: 90–100excellent, 75–89 good, 50–74 fair, and <50 poor . All data collection and measurement procedures was performed . Measurement of reduction parameters was accomplished with the DWRuler software.

➢ ***MARYLAND FOOT SCORE***

PAIN	SUPPORT (WALKING AID)	STAIRS	COSMESIS
• None, includingsports(45) • Slight, no change in ADL or work ability (40) • Mild, minimalchange in ADLs or work (35) • Moderate, significant decreasein ADLs (30) • Marked, duringminimal ADLs(10) • Disabled, unable towork or shop (5)	▪ None (4) ▪ Cane (3) ▪ Crutches (1) ▪ Wheelchair (0)	Normally (4) With banister (3) Any method (2) Unable (0)	Normal (10) Mild deformity (8) Moderate deformity (6) Severe deformity/multiple deformities (0)

ISSN No:-2456-2165

DISTANCE WALKED	LIMP	TERRAIN	MOTION
▪ Unlimited(10) ▪ Slight limitation (8) ▪ Moderate limitation(2 or 3 blocks) (5) ▪ Severe limitation (1block)(2) ▪ Indoors only (0)	▪ None (4) ▪ Slight (3) ▪ Moderate (2) ▪ Severe (1) ▪ Unable towalk (0)	□ No problemwith any surface(4) □ Problems on stones or hills(2) □ Problems on flat surfaces (0)	**(ANKLE,SUBTALAR, METATARSOPHALANGEAL, MIDFOOT)** □ Normal (5) □ Slightly decreased (4) □ Markedly decreased (2) □ Ankylosed (0)

STABILITY	SHOES		TOTAL
▪ Normal(4) ▪ Weak feeling, no true giving way(3) ▪ Occasional giving way (1-2 months) (2) ▪ Frequent giving way(1) ▪ Orthotic device	▪ Any type (10) ▪ Minor concessions(9) ▪ Flat, laced (7) ▪ With orthotics(5) ▪ Space shoes(2) ▪ Unable towear shoes (0)		**SCORE**

➢ ***Statistical Methods:***

Statistical Analysis was performed with help of Epi Info (TM) 7.2.2.2 EPI INFO is a trademark of the Centers for Disease Control and Prevention (CDC).

Descriptive statistical analysis was performed to calculate the means with corresponding standard deviations (s.d.). Test of proportion was used to find the Standard Normal Deviate (Z) to compare the difference proportions and Chi-square (χ^2) test was performed to find the associations. t-test was used to compare two means. $p<0.05$ was taken to be statistically significant.

IV. OBSERVATION AND RESULTS:

Table-1: Distribution of age of the patients

Age Group (in years)	Number	%
<20	4	13.8%
20 - 29	7	24.1%
30 - 39	3	10.3%
40 - 49	9	31.0%
50 - 59	6	20.7%
Total	29	100.0%
Mean ± s.d.	37.86±13.08	
Median	44	
Range	18 - 55	

The mean age (mean ± s.d.) of the patients was 37.86±13.08 years with range 18– 55 years and the median age was 44 years.

Most of the patients (51.7%) were in the age group between 40 – 59 years which was significantly higher than other age group ($Z=4.03; p<0.0001$). Thus intra- articular calcaneum fracture was more prevalent in the age group between 40 – 59years.

Table-2: Distribution of gender of the patients

Gender	Number	%
Male	20	69.0%
Female	9	31.0%
Total	29	100.0%
Male:Female	2.2:1.0	

The ratio of male and female (Male**:**Female) was 2.2:1.0. Test of proportion showed that proportion of males (69.0%) was significantly higher than that of females (31.0%) ($Z= 5.37; p<0.0001$). Thus the males were at higher risk of having intra-articular calcaneum fracture than females.

Table-3: Distribution of age and gender of the patients

Age Group(in years)	Gender		TOTAL
	Male (n=20)	Female(n=9)	
<20	0	4	4
Row %	0.0	100.0	100.0
Col %	0.0	44.4	13.8
20 - 29	7	0	7
Row %	100.0	0.0	100.0
Col %	35.0	0.0	24.1

30 - 39	2	1	3
Row %	66.7	33.3	100.0
Col %	10.0	11.1	10.3
40 - 49	7	2	9
Row %	77.8	22.2	100.0
Col %	35.0	22.2	31.0
50 - 59	4	2	6
Row %	66.7	33.3	100.0
Col %	20.0	22.2	20.7
TOTAL	20	9	29
Row %	69.0	31.0	100.0
Col %	100.0	100.0	100.0
Mean ± SD	40.00±11.58	33.11±15.59	
Median	44.5	32.0	
Range	23 - 55	18 - 54	

χ^2=12.38; p=0.0147 S- Significant

Corrected Chi-square (χ^2) test showed that there was significant associationbetween age and gender of the patients (p=0.0147).

t-test showed that there was the mean age of males was significant higher than females (t_{27}=4.28;p<0.001). Thus females were at risk of having intra-articular calcaneum fracture at younger age than males.

Table-4: Distribution of mode of injury of the patients

Mode of injury	Number	%
Fall from height	21	72.4%
Road traffic accident	7	24.1%
Slip from stair	1	3.4%
Total	29	100.0%

Test of proportion showed that most of the mode injury was fall from height (72.4%) which was significantly higher (Z= 6.83; p<0.001). Also, RTA (24.1%) was one of the common causes of injury. Only 1(3.4%) injury was caused by slip from stair.

Table-5: Distribution of laterality of injury of the patients

Laterality of injury	Number	%
Bilateral	5	17.2%
Left	16	55.2%
Right	8	27.6%
Total	29	100.0%

55.2% of the injuries was left sided injury which was significantly higher than that right sided injury (27.5%) (Z= 3.96; p<0.001). Only 5(17.2%) cases of bilateral injuries were found.

Table-6: Distribution of co-morbidities and associated fractures of thepatients

Co-morbidity	Number	%
# D12	1	3.4%
L4+Left Tibia	1	3.4%
Left bb leg+#L1	1	3.4%
Left Tibia	1	3.4%
Right Ankle	1	3.4%
Right Patella + Left Acetabulum + Left Nof	1	3.4%
Sc femur + Hbsag	1	3.4%
St femur	1	3.4%
Tibia	2	6.9%
Nil	19	65.5%
Total	29	100.0%

In 19(65.5%) of the cases no co-morbidity/associated fractures was found which was significantly higher than patients with co-morbidites/ associated fractures (34.5%) (Z=4.38;p<0.001).

Table-7: Distribution of Procedure of the patients

Procedure	Number	%
Percutaneous K wire+Cast	11	37.9%
Percutaneous CC screw with washer	6	20.7%
ORIF lateral exteded approach plating + Multiple screws + bonegrafting	5	17.2%
Percutaneous cc screws + k wire	2	6.9%
ORIF sinus tarsi approach plating + multiple screws with bonegrafting	2	6.9%
Percutaneous CC screw + Steinmen pin	1	3.4%
Percutaneous K wire+ Steinmen pin	1	3.4%
ORIF + Steinmen pin	1	3.4%
Total	29	100.0%

In most of the cases Percutaneous K wire+Cast (37.9%) were underwent which was significantly higher

ISSN No:-2456-2165

(Z=2.67;p<0.0001).

Table-8: Distribution of Essex lopresti type of the patients

Essex lopresti type	Number	%
Joint depressed	16	55.2%
Tounge	13	44.8%
Total	29	100.0%

Joint depressed (55.2%) was significantly higher than that of tongue (44.8%) butit was not significant (Z=1.47;p>0.05).

Table-9: Distribution of Time interval between injury and surgery of thepatients

Time interval between injury and surgery (days)	Number	%
1	4	13.8%
2	16	55.2%
3	5	17.2%
4	1	3.4%
6	3	10.3%
Total	29	100.0%
Mean ± SD	2.52±1.38	
Median	2	
Range	1 – 6	

69% of the patients were operated within 2 days which was significantly higher(Z=12.67;p<0.0001).

Table-11: Distribution of overall outcome of the patients at 6th months aftertreatment

Overall Outcome	Number	%
Excellent	2	6.9%
Good	16	55.2%
Fair	9	31.0%
Poor	2	6.9%
Total	29	100.0%

In 93.1% of the cases overall outcome of the patients was fair to excellent which was significantly higher (Z=11.24;p<0.0001).

Table-12: Distribution of complications of the patients after treatment

Complication		Number	%
Major complications	**Pain and deformity of heelrequire implant removal**	2	6.9%
Minor complication	Superficial wound dehiscence	2	6.9%
Nil		25	86.2%
Total		29	100.0%

In 93.1% of the cases overall outcome of the patients was fair to excellent which was significantly higher (Z=11.26;p<0.0001). Major complications were found only in 2 (6.9%) of the cases and minor complication were also found in 2 (6.9%)of cases

V. DISCUSSION

The aim of the present study is to evaluate the functional outcome of the surgical management of intra-articular calcaneum fractures. For this purpose, we have analysis different demographical and clinical parameters of the patients followed by correlated with Mechanism of injury, procedural difficulties, post-operative complications, results of early mobilization, to define the approach for fixation of these fractures and short term final functional outcome through different statistical methods. In the current study, significant high (51.7%) old age ofpatients with range 40 – 59 years than the younger age indicates calcaneum fractures is more prone to old age than younger age of the people. Similarfindings were reported by **Chandramurthy MS et al[35]** in 2017. In their study the highest affected age groups were lay between 35-44 years, followed by 25-34 years with mean age 37 years and range 18-60 years. On the other hand, significant higher proportion of male(69.0%) than female(31.0%) (Z= 5.37; p<0.0001) in Test of proportion indicates that males were at higher risk of having having intra-articular calcaneum fracture than females. Similar high proportion ofmales (5.1%) than females (1.2%) in intra-articular calcaneum fracture was evident in Salar O et al 2018 study. The t-test showed that there was the mean ageof males was significant higher than females (t27=4.28;p<0.001). This suggested that females were at risk of having intra-articular calcaneum fracture at younger age than males. Similar result was reported by Salar O et al 2018.

In case of mode of injury, significant high of the injury was occurred through fall from height (72.4%) followed by RTA (24.1%), slip from stair 1(3.4%) injury. This suggests that fall from height more prone to intra-articular calcaneum fracture. Similarly, fall from height was the cause of intra-articular calcaneum fracture in British and Brazil patients population(Robert S et al 1975 and Leite CBG et al 2018). According to laterality, 55.2% of the injuries was left sided injury which was significantly higher than that right sided injury (27.6%) (Z= 3.96; p<0.001). This might be due to less control on left sided body part. Similar high frequency of left sided injury were reported by **Chandramurthy MS et al[35]** in 2017. In the intra-articular calcaneum fracture, 6(34.5%) of the cases associated injuries was found but in most of the cases there was no associated injuries. Similar result was

reported by Harvey EJ et al 2001 and Rak V et al 2009. In case of treatment procedure, majority of the cases have done with percutaneous 21(72.41%) followed by ORIF plating 7 (24.14%) indicating standard percutaneous is surgical method for treatment of intra-articular calcaneum fracture. In line with our data, frequent percutaneous surgical method was evident in worldwide meta analysis(Fan B et al 2016). According to the Essex-Lopresti classification, intra-articular fractures can be tongue-type or joint depression type. In the present study, joint depressed (55.2%) was significantly higher than that of tongue (44.8%) indicating joint depression is the most frequent type of fracture. In most series, , accounting for 43%–61% of intra-articular fractures. Smilarly, da Silva LC et al 2016 reported that 76% of fractures were joint depression-type and 24%, tongue-type. High frequency joint depressed accounting for 43%–61% of intra-articular fractures (Chhabra N et al 2013; de Vroome SW et al 2014). In the current study, significant high frequency (69%) ofthe patients were operated within 2 days. However, Gadhavi M et al 2018 showed injury surgery interval was 6.87 days. It might be due to the cases with poor local condition and significant swelling and which are to be operated by open reduction method, should be operated only after subsidence of oedema and positive wrinkle test. After treatment, significant high frequency (93.1%) of the patients showed better out come indicating percutaneous surgical procedure is better for treatment of intra-articular calcaneum fracture. Better outcome of the intra-articular calcaneum fracture patients was also reported by **Chandramurthy MS et al**[35] in 2017. However, Major complications were found only in 2 (6.9%) of the cases both of these cases are joint depressed type operated with percutaneous fixation. Minor complication were wound dehiscence also found in2 (6.9%) cases which was joint depressed type of fractures operated with ORIFvia lateral extended approach.

VI. CONCLUSION

Based on this study, the following conclusions can be made:

1) The mean age of the patients was 37.86±13.08 years with range 18 – 55 yearsand the median age was 44 years.
2) The younger age of males having risk of intra-articular calcaneum fracturesthan younger age of females.
3) The left sided intra-particular calcaneum fractures are prevalent in our population.
4) Fall from height is major causae of intra-articular calcaneum fractures.
5) According to essex lopresti, joint depressed was significantly higher than thatof tongue in our patient pool.
6) Majority of the patients showed better out come after treatment.

Thus, we conclude that surgical management of intra-articular calcaneum fractureis effective for good functional outcome of the patients.

RECOMMENDATIONS

From this study that intra-articular calcaneum fracture can be managed in better way with proper way of surgical management. It may be recommended that surgical intervention is necessary for the management of intra-articular calcaneum fracture.

LIMITATION OF THE STUDY

This study was based on small number of samples due to limitation of time period. Thus the study with a comparatively larger number of samples may be conducted to get a more accurate result.

REFERENCES

[1]. Abidi NA, Gruen GS. Operative techniques in open reduction and internal fixation of calcaneal fractures. Oper Tech Orthop. 1999;9:239–246.
[2]. Abidi NA, Dhawan S, Gruen GS, Vogt MT, Conti SF. Wound-healing risk factors after open reduction and internal fixation of calcaneal fractures. Foot Ankle Int. 1998;19:856–861.
[3]. Assous M, Bhamra MS. Should Os calcis fractures in smokers be fixed? A review of 40 patients. Injury. 2001;32:631–632.
[4]. Benirschke SK, Sangeorzan BJ. Extensive intraarticular fractures of the foot. Surgical management of calcaneal fractures. Clin Orthop Relat Res. 1993;292:128–134.
[5]. Buckley R, Tough S, McCormack R, Pate G, Leighton R, Petrie D, et al. Operative compared with nonoperative treatment of displaced intra-articular calcaneal fractures:a prospective, randomized, controlled multicenter trial. J Bone Joint Surg Am. 2002;84:1733–1744.
[6]. Burdeaux BD. Jr. The medical approach for calcaneal fractures. Clin Orthop. 1993;290:96–107.
[7]. Burdeaux BD Jr. Fractures of the calcaneus:open reduction and internal fixation from the medial side a 21-year prospective study. Foot Ankle Int. 1997;18:685–692.
[8]. Carr JB. Surgical treatment of intra-articular calcaneal fractures:a review of small incision approaches. J Orthop Trauma. 2005;19:109–117.
[9]. Court-Brown CM, Schmidt M, Schutte BG. Factors affecting infection after calcaneal fracture fixation. Injury. 2009;40:1313–1315.
[10]. Folk JW, Starr AJ, Early JS. Early wound complications of operative treatment of calcaneus fractures:analysis of 190 fractures. J Orthop Trauma.1999;13:369–372.
[11]. Gallie WE. Subastragalar arthrodesis in fractures of the os calcis. J Bone Joint Surg. 1943;25:731–736.
[12]. Gould N. Lateral approach to sinus tarsi. Foot Ankle. 1983;3:244–246.

[13]. Holmes G. Treatment of displaced calcaneal fractures using a small sinus tarsiapproach. Foot Ankle Surg. 2005;4:35–41.
[14]. Hussain T, Al-Mutairi H, Al-Zamel S, Al-Tunaib W. Modified obtuse-angled lateral exposure of the calcaneum. Foot Ankle Surg. 2004;10:145–148.
[15]. Johnson EE, Gebhardt JS. Surgical management of calcaneal fractures using bilateral incisions and minimal internal fixation. Clin Orthop. 1993;290:117–124.
[16]. Lim EVA, Leung JPE. Complications of intraarticular calcaneal fractures. Clin Orthop. 2001;391:7–16.
[17]. Lutz M, Gabl M, Horbst W, Benedetto KP, Kunzel KH. Wound margin necroses after open calcaneal reconstruction. Anatomical considerations of surgical approach. Unfallchirurg. 1997;100:792–796.
[18]. Maxfield JE, McDermott F. Experiences with the Palmer open reduction of fractures of the calcaneus. J Bone Joint Surg Am. 1955;37-A:99–106.
[19]. Palmer I. The mechanism and treatment of fractures of the calcaneus. J Bone Joint Surg. 1948;30-A:2–8.
[20]. Park IH, Song KW, Shin SI, Lee JY, Kim TG, Park RS. Displaced intra- articular calcaneal fracture treated surgically with limited posterior incision. Foot Ankle Int. 2000;21:195–205.
[21]. Patnaik VVG, Singla RK, Gupta PN. Surgical incisions— their anatomical basis, part III - lower limb. J Anat Soc India. 2001;50:48–58
[22]. Poigenfürst. The dorsoplantar approach to the calcaneus. Oper Orthop Traumatol. 1991;199:254–264.
[23]. Romash MM. Open reduction and internal fixation of comminuted intra- articular fractures of the calcaneus using the combined medial and lateral approach. Oper Tech Orthop. 1994;4:157–164.
[24]. Sanders R. Displaced intra-articular fractures of the calcaneus. J Bone Joint Surg Am. 2000;82:225–250.
[25]. Sanders R, Fortin P, DiPasquale T, Walling A. Operative treatment in 120 displaced intraarticular calcaneal fractures. Results using a prognostic computed tomography scan classification. Clin Orthop. 1993;290:87–95.
[26]. Schepers T, van Lieshout EM, Ginai AZ, Mulder PG, Heetveld MJ, Patka P. Calcaneal fracture classification:a comparative study. J Foot Ankle Surg. 2009;48:156–162.
[27]. Schepers T, Kieboom BCT, Bessems GHJM, Vogels LMM, Van Lieshout EMM, Patka P. Subtalar versus triple arthrodesis after intra-articular calcaneal fractures. Strat Traum Limb Recon. 2010;5:97–103.
[28]. Sclamberg EL, Davenport K. Operative treatment of displaced intra-articular fractures of the calcaneus. J Trauma. 1988;28:510–516.
[29]. Shuler FD, Conti SF, Gruen GS, Abidi NA. Wound-healing risk factors after open reduction and internal fixation of calcaneal. 2001; 702.
[30]. Soeur R, Remy R. Fractures of the calcaneus with displacement of thethalamic portion. J Bone Joint Surg Br. 1975; 57:413–421.
[31]. Stephenson JR. Treatment of displaced intra-articular fractures of the calcaneus using medial and lateral approaches, internal fixation, and early motion. J Bone Joint Surg Am. 1987; 69:115–130.
[32]. Stephenson JR. Surgical treatment of displaced intraarticular fractures of the calcaneus. A combined lateral and medial approach. Clin Orthop. 1993; 290:68– 75.
[33]. Tallon C, Coleman BD, Khan KM, Maffulli N. Outcome of surgery for chronic Achilles tendinopathy. A critical review. Am J Sports Med. 2001; 29:315–320.
[34]. Wiley WB, Norberg JD, Klonk CJ, Alexander IJ. "Smile" incision:an approach for open reduction and internal fixation of calcaneal fractures. Foot Ankle Int. 2005; 26:590–592.
[35]. Zwipp H, Tscherne H, Thermann H, Weber T. Osteosynthesis of displaced intraarticular fractures of the calcaneus. Results in 123 cases. Clin Orthop. 1993; 290:76–86.
[36]. Leung KS, Yuen KM and Chan WS. Operative treatment of displaced intra- articular fractures of calcaneum: medium term result. Journal of bone and joint surgery. 1993; 75:196-20.
[37]. Monsey RD, Levine BP, Trevino SG. Operative treatment of acute displaced intra-articular calcaneum fractures. Foot ankle int. November 1996; 17:2-9.
[38]. Laughin RT, Carson JG and Calhoun JH. Displaced intra-articular calcaneum fractures treated with the Galveston plate. Foot ankle int. 1996; 17:71-78.
[39]. Tornetta P. Open reduction internal fixation of calcaneum using a minifragment plates. Journal of orthopaedic trauma. 1996; 10:63-67.
[40]. V. Sharma, R Shahid and M. Masqood. Early results of calcaneal locking plate for displaced intra-articular calcaneal fractures. Injury extra. May 2008; 39 issue 5:183.
[41]. A Darder Prats, A Silvestre Mu oz , E Segura Llopis, E Baixauli Perell , ADarder Garccia. Acta Orthopaedica. April 1993; 64:161-164.
[42]. Bailey FA. Fracture of Os calcis. Proc.Oregon M. Soc.1880;7:68.
[43]. Moerstein. Quoted by Schwartz MA. Bull Soc Nat Chir. 1921;55:148.
[44]. Cotton FJ, Wilson LT. Fractures of the Os Calcis. Boston Med Surg J.1908;159:559-565.
[45]. Bohler L. Diagnosis, Pathology and Treatment of fractures of the Os calcis. J Bone Joint Surg. 1931;13:75-89.
[46]. Essex-Lopresti P. Results of reduction in fractures of the calcaneum. J Bone Joint Surg. 1951;33:284.
[47]. Essex-Lopresti P. The mechanism, reduction technique and results in fractures of the Os Calcis. Br J Surg. 1952;39:395-419.
[48]. Dick IL. Primary fusion of posterior subtalar joint in treatment of fractures of the calcaneum. J Bone Joint Surg. 1953;35 part 3:375-380.
[49]. Harris RI. Fractures of the Os Calcis:their treatment by tri-radiate traction andsubastragalar fusion. Ann Surg. 1946;124:1082-1100.
[50]. Lindsay WRN, Dewar FP. Fractures of the Os Calcis. Am J Surg. 1958;95:555-576.
[51]. Poupa J, Pribyl J. Surgical results of Essex-Lopresti in calcaneum fractures. Acta Chin Orthop Traumatol Cech. 1971;38 p5art 1:23-25.

ISSN No:-2456-2165

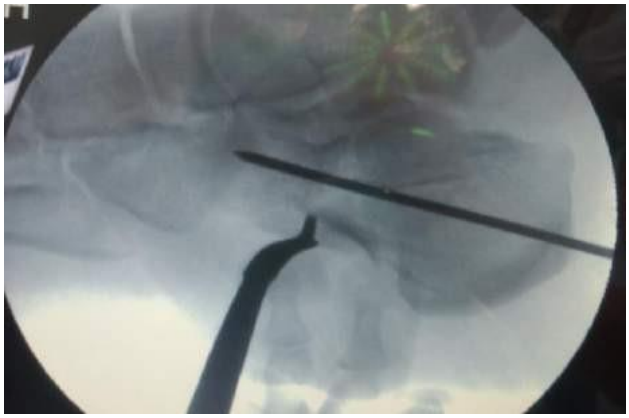
[52]. Cave EF. Fractures of the Os Calcis:the problem in general. Clin Orthop. 1963; 30:64-66.
[53]. Fitzgibbons TC, Mcmullen ST, Mormino MA. Fractures and Dislocations of the Calcaneus. In:Bucholz RW, Heckman JD, editors. Rockwood and Green's Fractures in Adults Vol 2. 5th edition. Philadelphia:Lippincott, Williams and Wilkins; 2001. p.2133-2156.
[54]. DeLee J. Fractures and dislocations of the foot. In:Mann R, Coughlin M, editors. Surgery of the foot and ankle Vol 2. 6th edition. Philadelphia:Mosby; 1997. p.1451-1544.
[55]. Warrick CK, Bremner AE. Fractures of the calcaneum:with an atlas illustrating the various types of fracture. J Bone Joint Surg. 1953;35:33-45.
[56]. Carr JB. Mechanism and pathoanatomy of the intra-articular calcaneum fracture. Clin Orthop. 1993;29:36-40.
[57]. Colton CL. Injuries of the foot. In:Wilson JN, editor. Watson-Jones Fractures and Joint injuries Vol 2. 6th edition. New Delhi:Churchill Livingstone; 1992.p.1152-1205.
[58]. Wilson DW. Functional capacity following fractures of the Os calcis. Can Med Assoc. 1976;95:908-911.

ILLUSTRATIONSCASE 1

Neeraj Garg 34 yr male came with alleged history of fall from height withcomplaints of pain swelling right heel, clinical and radiological examinationdone, joint depressed type calcaneum fracture found, patient operated by open reduction and internal fixation via sinus tarsi approach under guidance of image intensifier and internal fixation with locking plate with multiple screws done, bone grafting retrieved from ipsilateral iliac crest done, below knee slab given after wound closure and dressing, limb elevation and iv antibiotic given for 3days post operatively. Pt discharged on oral medication for 5 days and advisednon weight bearing for 6 weeks, stitches removal done after 14 days of surgery. Patient follow up every months till six months. Full weight bearing started at 12 weeks. Patient had excellent final outcome. Post operative finding was

1. bohler's angle = 18.4
2. gissane angle = 126.9
3. Maryland foot score = 91

Figure 2 pre operative x ray calcaneum ap and lateral view



ISSN No:-2456-2165

Figure 3 intra operative c-arm image reduction technique by k wire

Figure 4 intra operative image showing fracture site through sinus tarsi approach

Figure 5 intra operative c-arm image plate fixation with multiple screws

Figure 6 follow up x ray lateral view calcaneum after 4 weeks

ISSN No:-2456-2165

Figure 7 follow up x ray ap view after 4 weeks

Figure 8 wound condition after 4 weeks

Case 2

Akash Goel 27 year male admitted with alleged history of self fall followed by complaints of pain swelling bilateral heel, on investigation found fracture bilateral calcaneum fracture right side intra articular joint depressed type and left side was extra articular which managed conservatively by rest ice fomentation limb elevation and anti inflammatory drugs, right side operated with minimum invasive percutaneous approach and fixed with 2 cancelous cannulated screws with washer and one cancellous screw without washer applied. Patient have pain and deformity in right heel so implant removal done after months follow up dueto severe pain in right heel. Post operative final outcome is poor. Post operative finding was

1. **bohler's angle = 22.7**
2. **gissane angle = 110**
3. **Maryland foot score = 49**

Pre operative x ray image

Figure 9 x ray right ankle ap and lateral view

ISSN No:-2456-2165

Figure 10 post operative follow up image lateral view

Figure 11 post operative follow up image axial view

Case 3

Dhani Ram 49 year male admitted with alleged history of fall from height, had fracture L4 vertebrae with neurological loss with right calcaneum fracture depressed type, spine decompression and fixation with pedicle screw with rods done next day of injury patients recovering from nerological loss on 6 th day openreduction internal fixation right calcaneum via lateral extended approach with calcaneum plate done, patients discharged after 1 week of calcaneum surgery after stiches removal of spine surgery. Stiches of heel removed after 16 days of surgery, weight bearing started at 12 weeks, regular follow up done monthly till 8months. Minor complication was superficial wound dehiscence, but overall result was good. Post operative finding was

1. **bohler's angle = 38.5**
2. **gissane angle = 106.8**
3. **Maryland foot score = 79**

Figure 12 pre operative lateral view showing depressed type fracture

Figure 13 pre operative x ray axial view

Figure 14 intra operative image showing lateral extended approach

Figure 15 intra operative image showing lateral extended approach

Figure 16 post operative x ray lateral view

Figure 17 post operative x ray axial view

Figure 18 follow up picture showing dorsiflexion

Figure 19 follow up picture showing planter flexion