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Outcome of Internal Fixation of Comminuted Calcaneum Fractures

Dr.M.Abhinandan Reddy[1], Dr.Ravi Kiran[2]
[1](Department Of Orthopedics, Osmania Medical College, India)
[2](Department Of Orthopedics, Osmania Medical College, India)

Abstract: *Calcaneum fractures account for approximately 2% of all the fractures with displaced intra-articular fractures comprising more than 60% of these injuries, frequently resulting from axial loading. Though literature suggests significant benefit from operative management of these fractures, complications have been shown to be a common problem in many of the studies.All the fractures in our study were joint depression type with 30 patients having sanders type 2 and 8 having sander's type 3 fracture. The patient was then operated with lateral extensile approach, with 3.5mm contoured recon plates and cancellousscrews.All the operated patients had an increase in the Bohler's angle and decrease in the Gissane'sangle. Post operatively all the patients had an increase in heel height and decrease in heel width with a statistically significant 'p' value. Of the 30 patients, using AOFASscoring, 8 had excellent results, 16 had good results, 4 had fair results and 2 had poor results.The operative management of calcaneal intra-articular fractures should be done as anatomical reduction and rigid internal fixation are essential to allow early rehabilitation.*

Keywords : *Calcaneum fractures, internal fixation, lateral extensile approach.*

I. Introduction

Calcaneum fractures account for approximately 2% of all the fractures with displaced intra-articular fractures comprising more than 60% of these injuries,frequently resulting from axial loading with varying degrees of shear force. Of patients with calcaneal fractures 10% have associated spine fractures and 26% are associated with other extremity injuries[1,2].

Fractures of calcaneum remain among the most challenging cases for the treating orthopedic trauma surgeon despite advancement in surgical technique and implant devices. Economic implications of this fracture are profound[3,4].

The primary source of disagreement has been the issue regarding the outcome achieved by operative and non-operative methods. Since early1990's enthusiasm for surgical procedures like open reduction and internal fixation, percutaneous fixation and primary arthrodesis for carefully selected fractures in selected candidates has increased. The difficulty lies in understanding the geometry of calcaneus fractures due to its unique shape and articulation with various tarsal bones.

Although first describe by Malgaigne[5,6] in 1843, routine diagnosis was done after the advent of radiography in1890's[7,8]. Cotton[8],1908, favoured closed manipulation and opposed open reduction of calcaneal fractures. First documented treatment of a series of calcaneal fractures with internal fixation was by LeRiche in 1922[9]. In 1943 Gallies[10]propsed primary subtalar arthrodesis as definitive treatment.

Improvement in imaging technology has allowed for better understanding of fracture pathology and provided the basis for newer classifications which subsequently revolutionised the surgical and non-surgical treatment of calcaneal fractures.There remains however no consensus regarding the surgical approach with many having been described including medial,lateral, combined approach, extended lateral and sinus tarsi approaches. Still, the method of fixation remains a point of debate, with various proponents advocating fixation with pins, screws, screws and plate fixation.

Though literature suggests significant benefit from operative management of these fractures,complications have been shown to be a common problem in many of the studies.The purpose of the present study is to verify the functional outcome of contoured plate fixation in displaced intra articular fractures.

Objectivesof the study

To evaluate the results of surgical treatment of intra articular fractures, treated with contoured plate with reference to

1. Operative procedure and anatomical reduction
2. Post-operative period and early mobilisation
3. Final functional outcome

Mechanism of injury

Intra articular fractures are uniformly caused by axial forces. The tuberosity of the calcaneus is located slightly when axial load is applied to the posterior facet through the talus, shear forces are driven through the posterior facet, towards the medial wall of the calcaneus. The lateral process of the talus is driven downward into the neck of the calcaneus, forcing the subtalar joint into eversion and creates the primary fracture line.

Anteriorly, the facture line may exit laterally, usually at the angle of Gissane but occasionally it may progress distally as far as the calcaneocuboid joint. The sustentacular fragment is usually tethered by its attachment to the extremely strong talocalcanealinterosseous ligament, it is not markedly displaced and remains constant in position.The posterior secondary fracture line creates a "thalamic fragment" which is depressed portion of the subtalar facet,if force continues. When it exits behind theposterior facet and anterior to Achilles tendon it is called joint depression type and when it exits distal to Achilles tendon it is called a tongue type, and may also lead to lateral wall bulge due to blowout fracture and fibula calcaneal impingement and peroneal tendon entrapment.

Radiography

The initial radiographic evaluation of the suspected calcaneal fracture should include a lateral x-ray of the hind foot (to assess the height loss and rotation of the posterior facet), an anteroposterior view and oblique x-ray of foot (to assess the involvement of calcaneocuboid joint and anterior process), Broden's view[11] (to evaluate the congruency of the posterior facet) and an ankle series. Routine lumbar spine x-rays should be obtained[12]. If the x-rays suggest an intra-articular component CT scan is indicated.

The tuber angle of Bohler[13] normally between 20^0 to 40^0, a decrease in this angle indicates that the weight bearing posterior facet of the calcaneus has collapsed and the degree of proximal displacement of the tuberosity, thereby shifting the body weight anteriorly.Thecrucial angle of Gissane[14] usually between 95^0 to 105^0, loss of height of posterior facet will increase the angle. The lateral x-ray also indicates whether the fracture is of joint depression or tongue type.CT scan images are obtained in axial, 30 degree semi coronal and saggital planes.

Classification

Broadly divided into extra articular (25%) and intra articular (75%). Based on plain radiography into joint depression type or tongue type.

Sander's developed a CT scan classification system[15,16] based on the number of the articular fragments and location alone. It was found to be useful in determining both treatment methods and prognosis after surgical fixation. The classification was based on images in coronal plane.

II. Materials And Methods

Our study included adult patients with displaced intra-articular fractures of Calcaneum reporting to Osmania general hospital, Hyderabad from May 2015 to June 2016 treated by internal fixation using recon plates, cancellous screws and k-wires and those who were available for follow up.

Inclusion criteria

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

Exclusion criteria

1. Open fractures.
2. Pathological fractures.
3. Calcaneal fractures with associated other limb fractures.
4. Fractures in children.
5. Fractures in adults>55years of age.
6. Grossly comminuted fractures.
7. Severely osteoporotic fractures.

Goals of treatment

1. Restoration of congruency of posterior facet of subtalar joint.
2. Restoration of height of calcaneus (Bohler's angle).
3. Reduction of width of calcaneus.
4. Decompression of subfibular space available for peroneal tendons.
5. Realignment of the tuberosity into valgus position.

6. Reduction of calcaneocuboid joint if it is involved.

A thorough history and clinical examination was done,status of the skin and swelling around the heel and ankle recorded. X-rays were done as mentioned earlier. CT scan was done and fracture morphology was understood thoroughly. The patient was temporarily put on a blow knee slab with adequate limb elevation till the swelling subsided with a wrinkle sign. The fractures were classified according to Essex-Lopresti and Sander's classification. All the fractures in our study werejoint depression type with 34 patients having sanders type 2 and 8 having sander's type 3 fracture. The patient was then operated with lateral extensile approach, with 3.5mm contoured recon plates and cancellous screws.

Procedure

Patient in lateral position and L shaped incision is made,withgreat care not to elevate skin flaps and carried directly to the bone,sural nerve protected,entire lateral wall exposed and retraction of flap obtained with 'k' wires into talus and fibula.

Reduction and fixation

First step in reduction is to reduce the sustentacular fragment by placing a schantz pin in the tuberosity,applying traction and translation medially. Proximal fixation obtained by kirschner wires from posterolateral to anteromedial into the sustentaculum. Restoration of this fragment reduces the medial wall and allows visualisation of subtalar joint by elevation of the lateral fragments. Fragments in the subtalar joint are gently elevated and reduced to sustentaculum. When stability is achieved lateral wall is replaced and articular fragments are fixed with small fragment 3.5mm cannulated screws into sustentaculum. The final stage is a3.5mm reconstruction plate along the lateral aspect of the oscalcis.

Postop protocol

Short leg splint 3-5 days,early active ROM exercises started once the wound is uncomplicated. Weight bearing is started after 12 weeks of fixation and hardware can be removedafter 1yr if symptomatic.

Follow-up

The patients were followed up clinically and radiologically at 6weeks, 12 weeks, 6 months and 1 year with respect to height of Calcaneum width of the Calcaneum, range of movements at subtalar joint, tubero-talar angles.roentgenograms were taken in lateral and axial views to look for signs of radiological union. Clinical union was said to be achieved when the fracture site had become stable and pain free and radiological union when plain X-ray showed bone trabeculae or cortical bone crossing fracture site on atleast three surfaces on orthogonal radiographs. Time for radiological diagnosis was noted. If there were no signs of clinical or radiological signs of union by 16weeks,the fracture was categorised as delayed union and in the absence of union after 24weeks after injury was categorised as non-union.

The functional outcome was measured by "American Orthopedic Foot and Ankle Society (AOFAS) Ankle Hindfoot scoring system at twelve months. Developed by American Academy Of Orthopedic Surgeons. It is a 100 point scoring system mainly assessing the pain, function, alignment of the foot. The functional outcome decreases as the score decreases.

Result was graded as excellent, good, fair and poor as follows

Excellent	- 89 to 100 points
Good	-79 to 89 points
Fair	-69 to 79 points
Poor	-less than 60 points.

Complications of calcaneal fractures

1. Wound necrosis, dehiscence and infection.
2. Loss of reduction due to early weight bearing.
3. Peroneal tendonitis and stenosis.
4. Peroneal tendon dislocation.
5. Calcaneofibular impingement.
6. Nerve entrapment and tarsal tunnel syndrome.
7. Thickening of calcaneum.
8. Valgus deformity of heel.
9. Ankle and heel pad pain.

III. Observation And Results

There were 30 adult patients who presented with calcaneal fractures to our hospital during the course of the study. Of the 30 patients,28 were male and 2 were female between the age group of 19 to 56years (mean age 37years).

S.no	Age group	No. of patients
1	18 – 24	02
2	25 – 34	12
3	35 – 44	10
4	45 -54	06

Two patients had bilateral fractures. Of the 25patients, 18 (60%) had left sided Fractures, while 12 (40%) had right sided fracture. Mode of injury was fall from height in 24 patients and RTA in 6 of the patients. Of the 30 patients 20 (66.66%) had Sander's type 3 fracture and 10 (33.33%) had Sander's type 2 fracture. All the patients had gross swelling of the foot following the injury.

The number of days from injury to surgery varied from 2 to 14days (mean of 6.3 days). Days of hospital stay varied from 14 to 22 days(mean of 16.04 days).

S.no	Days between fall and surgery	No. of patients
1	0-5	6
2	6-10	14
3	11-15	10

All the 30 patients were treated with lateral extensile approach and fixed with recon plates and cancellous screws. Postoperatively 6 (32%) patients had persistent pain, 2 had superficial infections,treated with appropriate antibiotics. One patient with deep infection was treated with injectable antibiotics and later followed by oral antibiotics.

S.no	Postoperative Complications	No. of patients
1	Persistent pain	6
2	Swelling	14
3	Superficial infection	02
4	Deep infection	01

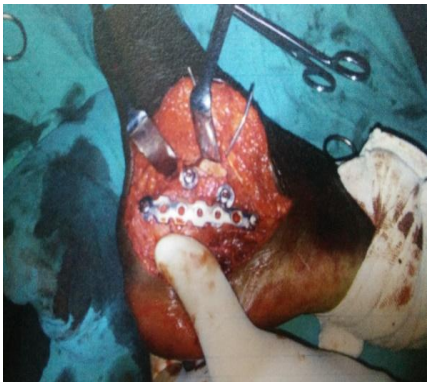
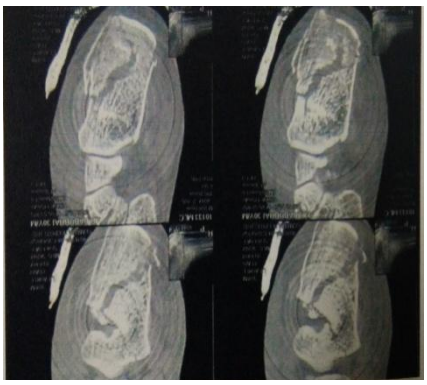
All the operated patients had an increase in the Bohler's angle and decrease in the Gissane's angle with statistically significant 'p' value. The mean pre-op Bohler's angle was 11.52^0 and Gissane's angle was 126.88^0. The mean post-op Bohler's angle was 26.16^0 and Gissane's angle was 119.76^0. The 'p' value for increase in Bohler's angle was 3.13^{-10}, the 'p' value for the decrease in Gissane's angle was 1.10^{-10}.

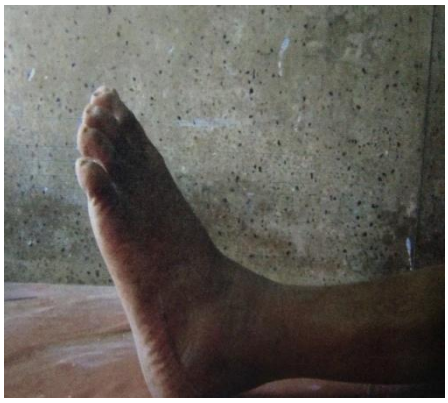
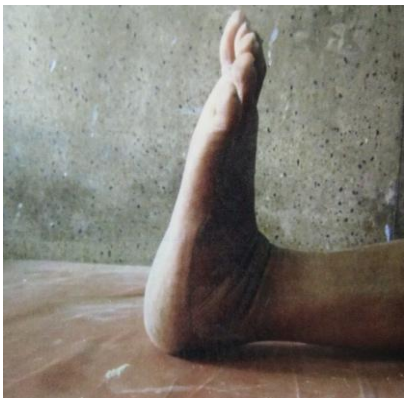
Post operatively all the patients had an increase in heel height and decrease in heel width with a statistically significant 'p' value. The mean pre-op heel height was 5.932 and heel width was 6.832. The mean post op heel height was 6.38 and heel width was 6.272. The 'p' value for increase in heel height was $7.5 *10^{-18}$and the 'p' value for decrease in heel width was $1.2*10^{-11}$.

At 12 weeks follow up,X-rays of 27patients showed radiological signs of union. Mean duration of radiological union was 12.5weeks. Three patients had delayed union radiologically.

Aofas Scoring

Of the 30, 8 had excellent results, 16 had good results, 4 had fair results and 2 had poor results.The mean ROM of subtalar and ankle joints of patients with excellent results, inversion and eversion were 23.66 and 18.90 degrees respectively and the mean dorsiflexion and plantarflexion were 30 and 25 degrees respectively.The mean ROM of subtalar and ankle joints of patients with good results, inversion and eversion were 20.28 and 15.34 degrees respectively and the mean dorsiflexion and plantarflexion were 25 and 20 degrees respectively.The mean ROM of subtalar and ankle joints of patients with excellent results, inversion and eversion were 16.42 and 12.85 degrees respectively and the mean dorsiflexion and plantarflexion were 20 and 15 degrees respectively.The mean ROM of subtalar and ankle joints of patients with poor results, inversion and eversion were 10 and 7.5 degrees respectively and the mean dorsiflexion and plantarflexion were15 degrees each.

IV. Discussion

The calcaneum is the most commonly fractured tarsal bone. Theprognosis for the extra-articular fracture is uniformly good, but that for an intra-articular fracture is varied. There are many systems for classifying the displaced intra-articular fractures but there is no consensus amongst surgeons as to which is the most practical one. Though some studies have demonstrated good results after open reduction and internal fixation of intra articular calcaneal fractures[17,18], the best treatment remains controversial because prospective randomised studies have not shown convincingly better results after surgery[19,20].

It is difficult to compare outcome between studies since different measures of outcome are often used and there is no consensus among surgeons as to which is the most scientific and practical system. Although classifications show positive correlation with outcome,there is no correlation with choice of treatment[21,22]. In our study we have used Essex-Lopresti and Sander's classification.

Historic cohort studies[23,24] have suggested equal clinical outcomes with operative and non-operative treatment of displaced intra-articular calcaneal fractures. While some have shown no advantage of operative treatment,many others have shown superior results with operative treatment[19,25,26]. Earlier surgical treatment was associated with significant incidence of complications particularly wound healing and sepsis[1]. However, conservative treatment is not without its complications of subtalar joint arthritis, heel varus and peroneal tendon impingement.

We believe that displaced intra-articular fractures of calcaneum should be treated on the same principles as anyother weight bearing joint, i.e. anatomical reduction and rigid internal fixation so as to allow

early rehabilitation, though complex anatomy and anatomical constraints have rendered delay in application of these principles.

Lateral approach is the most popular approach. A lateral extensile exposure popularised by Bernischke and Sangeorzan was used in all our cases. We used a 3.5mm contoured reconstruction plate[27] extending from anterior process to most posterior aspect of tuberosity.

In our analysis, we confirmed correlation between the Bohler's angle and Gissane's angle size and patient satisfaction in term of their functional outcome and the role of these angles as apredictive factor for subsequent late complications[28,29,].AOFAS clinical rating system the Ankle hind foot scale for calcaneal area is standard scoring system[30] that takes into account subjective and objective assessments enables to achieve relevant results and comparison of different studies.

Melcher, in his study, subjective and objective results assessed after ten years were better than those achieved in a 3years follow up.Sander's reported excellent or good results in 73% of type 2,70% of type 3 and only 27%of type 4 fractures.in our study 79% of patients had excellent or good and 21% had fair or poor results despite anatomical calcaneal restoration.

Complications occur regardless of the management strategy chosen for displaced intra articular fractures and despite managed by experienced surgeons,complications are a significant cause of morbidity[31]. The rate of complication in this study was 16% comparable to other studies.

There were certain limitations to our study. Only 30 patients with calcaneal fractures were operated and their final outcome scores were measured at a mean follow up of 12 months. A study involving more patients followed for a longer period can more accurately define the functional outcome of calcaneal fractures treated by this method.

V. Conclusion

Fractures of Calcaneum are one of the common fractures affecting present generation and treatmentmodality has to be decided carefully. We are of opinion that the operative management of calcaneal intra-articular fractures should be done as anatomical reduction and rigid internal fixation are essential to allow early rehabilitation. It also shows that anatomical reduction in terms of Bohler's angle and Gissane's angle restoration plays an important role in determining the good functional outcome.

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