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Outcome of calcaneum fractures treated with minimally invasive fixation techniques

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Abstract

Background

Incidence of calcaneum fractures are more due to fall from height and road traffic accident are on rise. Majority of the extraarticular calcaneal fractures may be treated non surgically while displaced intraarticular calcaneum fractures needs surgical fixation for optimal outcome. Surgical fixations with open reduction and internal fixation are more prone for wound healing complications and leads to increased morbidity. Minimally invasive fixation techniques have gained popularity in the recent times due reduced wound complications. We assessed the functional and radiological (Bohlers and Gissanes angle) outcome of calcaneum fractures treated with minimally invasive fixation techniques.

Methods: 40 Patients of displaced intraarticular calcaneum fractures were treated with minimally invasive fixation techniques and followed up at 3 weeks, 6 weeks, 3 months, 6 months and one year. Functional outcomes were assessed using American association of foot and ankle score system (AAFAS) and radiological outcome were assessed by measuring Bohlers and Gissanes angle.

Results: Out of 40 patients treated with minimally invasive fixation techniques bony union occurred in all patients, functional outcome by American association of ankle and foot score (AAFAS) were 30 good, 9 fair and 1 poor. Radiological outcome showed restoration of Bohlers angle and Gissanes angle in 38 patients.

Conclusion: Minimally invasive technique for the treatment of intra articular fractures (Sanders type 2 & 3) gives good clinical and radiological outcome on short term follow up. Restoration of Bohler's and Gissane's angle is correlated to good functional outcomes. The complications for Essex Lopresti technique and percutaneous techniques are less compared to sinus tarsi approach in our study.

Keywords: calcaneal fractures, screw fixation, minimally invasive, infection, bohlers angle

Introduction

Treatment of Calcaneal fractures has been a topic of controversy for a long time. Calcaneal fractures make up about 2% of all fractures. The calcaneus is the tarsal bone most often fractured (60%)^[1]. It has been common and often disabling injury since humans assumed the erect posture and began to defy gravity^[2]. The most common mode of injury being axial load shedding due to vertical fall in intra-articular fractures where as in extra-articular fractures it is twisting forces and direct blows^[2]. Intra-articular fractures comprise 75% of all Calcaneal fractures.² Fractures of the body of the os calcis involving the subtalar joint are, at the least, severe and complex injuries, can cause considerable difficulty and marked economic loss, and warrant very careful evaluation in an effort to carry out adequate treatment^[3, 4].

Management protocols for Calcaneal fractures have evolved from non-operative treatment with bandaging and elevation, through open reduction and plate fixation, to minimally invasive surgeries at present. Currently the most common approach for ORIF of Calcaneal fractures is the extended lateral approach (Letournel^[5] modification of Palmer's approach) which provides excellent exposure of posterior facet and lateral wall of calcaneus. A big problem with open reduction of Calcaneal fractures noted was the development of major wound complications owing to the vulnerable soft tissue envelope on the lateral aspect. Various studies report 0.4 to 14% incidence of wound edge necrosis and 1.3 to 7% infection rates with extended lateral approach^[6-12]. Medial approaches carry the risk of neurovascular injury along with inadequate exposure. Chances of wound necrosis increase to 27% when

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Combined medial and lateral approaches are used [12]. Due to soft tissue problems associated with open reduction of calcaneal fractures, the focus has shifted on to minimally invasive methods.

We prospectively analysed the functional and radiological outcome of intraarticular fractures of calcaneum treated by the minimally invasive fixation techniques for one year.

Materials and Methods

We prospectively analysed forty patients, 18-50 yrs, with displaced intra articular fractures (Sanders type 2&3) of calcaneum presented to our casualty following history of fall from height or road traffic accident (Table 1&2).

All cases with Polytrauma, open fractures, smoking history, Uncontrolled diabetes, Sander I & IV types, delayed presentation of more than three weeks and deemed unfit for anaesthesia were excluded from the study. Most number of these cases resulted from fall from height.

All the patients were evaluated with X-ray of the calcaneum-axial, lateral and AP views along with CT scan with 3D. In this study, we followed the Sander's classification to classify the fractures. All patients were treated by limb elevation, ice application and crepe bandage to reduce the edema. Except for a few, due to gross edema, most of the patients were operated within 10-14 days of injury following wrinkle sign appearance.

The datas of all the patients treated with minimally invasive fixation of calcaneal fractures were collected prospectively with mean follow-up of one year. The study was approved by the institutional ethics committee.

Surgical technique

Following the administration of pre-operative antibiotics, patients were given regional peripheral nerve blocks (sciatic with femoral and lateral cutaneous nerve of thigh) / spinal anesthesia. All procedures were performed under thigh tourniquet. Minimally invasive fixation using sinus tarsi approach with screws, percutaneous screws or Essex Lopresti techniques under C Arm control were performed depending on the fracture anatomy.

2.1 Sinus tarsi approach

A 2-cm to 4-cm incision is made over the sinus tarsi following a line from the tip of the fibula to the base of the fourth metatarsal. Dissection is carefully carried down to the posterior facet as the extensor digitorum brevis is retracted cephalad and the peroneals retracted posteriorly to avoid damage. There is often fibrous debris and fat within the sinus tarsi that needs to be removed with a small rongeur in order to properly visualize the articular cartilage. A C-arm is brought in from the ipsilateral side to facilitate acquisition of multiple lateral and axial heel radiographs. The depressed posterior facet is directly visualized and a knife is used to sharply demarcate the exposed borders of the fracture fragment. A small periosteal elevator is then placed under the posterior facet fragment to elevate it up into an anatomic position. The Steinman pin and elevator are used together to lever the posterior fragment into place. Once the posterior fragment is anatomically reduced, a 1.4mm K-wire is inserted into the fragment and across the subtalar joint into the subchondral bone of the talus to hold the fragment in a reduced position. The screw position is confirmed under C Arm. A 6.5 mm or 4.0mm cannulated screw is inserted from lateral to medial just beneath the Gissane's angle towards the sustentaculum tali to support the posterior facet. A percutaneous Schanz pin is also

placed in the calcaneal tuberosity to restore axial height and length and correct any varus of the heel. The Steinman pin is then removed and a guide pin for a 6.5-mm partially threaded cannulated screw is inserted posteriorly directed into the anterior aspect of the calcaneus. No pre-drilling is required, and the stab incision for the guide pin must be slightly enlarged to accommodate the size of the screw head. This guide pin serves as an axial support to maintain calcaneal height and alignment, supports the posterior facet and is used later on for screw insertion. The central bony void in the neutral triangle region of the calcaneus is left alone. A small freer can used to directly palpate the subtalar joint to ensure articular congruity Final lateral, axial and Broden's heel radiographs are taken, and the subcutaneous tissues and skin are closed in a layered fashion.

2.2 Essex Lopresti and percutaneous screws technique

This is done for the extra-articular fractures in Essex- Lopresti classification and Sanders type IIc intra-articular fractures. We give a stab incision and pass a 3.5-mm Steinman pin from superolateral to the Achilles tendon, directed toward the anteroinferior margin, along the long axis of bone; this pin/wire goes into the tongue fragment of the calcaneum. Another 3.5-mm Steinman pin can be inserted at the posterior aspect of the calcaneum. The position of these is confirmed by image intensifier. Fracture reduction is performed by manipulating these two pins (principles used by Essex-Lopresti for his original maneuver) (Figs 2A to C). Simultaneous disimpaction and elevation of the posterior fragments is achieved. If the tongue fragment is small or bone is osteoporotic instead of 3.5-mm Steinman pins, 2.5-mm K-wires can be used. The above procedure is useful in tongue-type fractures, particularly Sanders type IIc, when the posterior facet is intact and is not comminuted. However, it can also be used in other fracture subtypes along with additional maneuvers. If heel widening is present, indicating mediolateral displacement of fragments, an additional reduction clamp is placed with ball-tipped tongs on either side of heel, and gently compressing the fragments. Routine transfixation of subtalar and calcaneocuboid joints is not required when the anterior process is intact and gives good purchase for K-wires. If calcaneocuboid joint is involved by fractures extending distally, then K-wires need to be advanced into cuboid and even cross the subtalar joint into the talus for additional stability. These K wires are then exchanged for percutaneous screws.

Patients are placed in well-padded posterior splint and made non-weight bearing with strict elevation. Sutures are removed 2 weeks after surgery with transition into a non-weight with below knee slab. Range of motion exercises are started at 2 weeks to help reduce stiffness and peroneal tenosynovitis. Slab is removed after 4 weeks. Progressive weight-bearing and physical therapy is started 10 weeks to 12 weeks after surgery. Full weight-bearing in a regular shoe is allowed 12 weeks to 16 weeks after surgery with repeat lateral and axial heel radiographs to evaluate maintenance of fragment reduction and hardware position along with fracture consolidation. Patients are release to full activity including running and jumping 8-12 months after surgery pending clinical exam and fracture healing on radiographs.

Postoperative assessment was done at 3 weeks, 6 weeks, 3 months, 6 months and one year end. Each time ankle lateral and heel axial views were taken to assess the Bohlers and Gissane angle as well AAFAS scores were recorded. AFASS is graded as, Good- >7; Fair- 50-74 Poor-<50.

Statistics

Statistical analysis was performed with Statistical Package for Social Sciences [SPSS] for Windows Version 22.0. (Armonk, NY: IBM Corp.). Chi square test was used to compare the outcome of various categories of treatment employed in minimally invasive surgeries. Student paired t-test is used to compare the mean of pre op and post op Bohlers and Gissanes angle. The level of significance was set at $p < 0.05$

Results

Out of 40 patients with Calcaneal fractures, which were operated through minimally invasive technique, we achieved bony union in all patients. Two patients had infections in which one patient had superficial infection which was managed through antibiotics and another patient had deep infection, went for screw removal after radiological evidence of fracture union. Two patients were having screw head pain in which one patient went for screw removal.

Out of 23 patients done by sinus tarsi approach, 21 patients had restored Bohlers angle and Gissanes angle significantly, out of 11 cases done by percutaneous screw fixation all of the cases maintained Bohlers and Gissanes angle, all 6 cases done by Essex lopresti maintained Bohlers and Gissanes angle. Of the 23 cases done with Sinus tarsi approach, 2 had infections. No infection was seen cases done by Essex lopresti and percutaneous screw fixation. (Table 3). The results of this study were analysed using AFASS SCORE for functional outcome and radiological outcome were calculated by measuring the Bohlers and Gissanes angle. (Table 4, 6). Total mean of Bohlers angle, pre operatively was 15.28 and post operatively 25.35 with p value of < 0.01 which is statistically significant. Total mean of Gissanes angle pre operatively was 145.80 and post operatively 131.78 with the p value of < 0.01 which is statistically significant. (Table 5, 7).

Other complications like heel pad problems, peroneal tendinitis, compartment syndrome, reflex sympathetic dystrophy were not seen in any of the patients.

Table 1: Age and Gender distribution among study patients

Variables	Category	n%	
Age	18-20 yrs	108.%	
	21-30 yrs	5	13.%
	31-40 yrs	17	43.%
	41-50 yrs	15	38.%
Gender	Males	39	98.%
	Females	1	3.%

Table 2: Distribution of Study Patients based on Mode of Injury

Mode of Injury	n	%
RTA	4	10%
Fall from Height	36	90%

Table 3: Distribution of Study patients based on the Minimal Invasive Surgery

Surgeries	n	%
STA + SF	23	58.%
ELA + SF	6	15.%
PCSF	11	28.%

Table 4: Distribution of AFASS & Post-Op Complications among study Patients

Variables	Category	n	%
AFASS	Good	30	75.%
	Fair	9	23.%
	Poor	1	3.%
Complications	Nil	38	95.%
	Infection	2	5.%

Table 5: Distribution of Bohler's Angle & Gissane's Angle during Post Minimal Invasive Surgery in study patients

Variables	Category	N	%
Bohler's Angle	Decreased	2	5%
	Maintained	38	95%
Gissane's Angle	Increased	2	5%
	Maintained	38	95%

Table 6: Comparison of Bohler's Angle, Gissane's Angle, AFASS & Post-Op Complications between different Post Minimal Invasive Surgeries using Chi square Test

Variables	Category	STA + SF		ELT + SF		PCSF		χ ² Value	P-Value
		N	%	n	%	N	%		
Bohler's Angle	Decreased	2	8.7%	0	0.0%	0	0.0%	1.556	0.46
	Maintained	21	91.3%	6	100.0%	11	100.0%		
Gissane's Angle	Increased	2	8.7%	0	0.0%	0	0.0%	1.556	0.46
	Maintained	21	91.3%	6	100.0%	11	100.0%		
AFASS	Good	16	69.6%	5	83.3%	9	81.8%	1.267	0.87
	Fair	6	26.1%	1	16.7%	2	18.2%		
	Poor	1	4.3%	0	0.0%	0	0.0%		
Post-Op Complications	Nil	21	91.3%	6	100.0%	11	100.0%	1.556	0.46
	Infection	2	8.7%	0	0.0%	0	0.0%		

Table 7: Comparison of mean bohler's and gissane's angle between pre and post-operative period using student paired t test

Variables	Time	N	Mean	SD	Mean Diff	T	P-Value
Bohler's Angle	Pre Op	39	15.28	2.21	-10.07	-23.581	$< 0.001^*$
	Post Op	39	25.35	2.25			
Gissane's Angle	Pre Op	39	145.80	4.75	14.02	17.686	$< 0.001^*$
	Post Op	39	131.78	2.49			

* - Statistically Significant

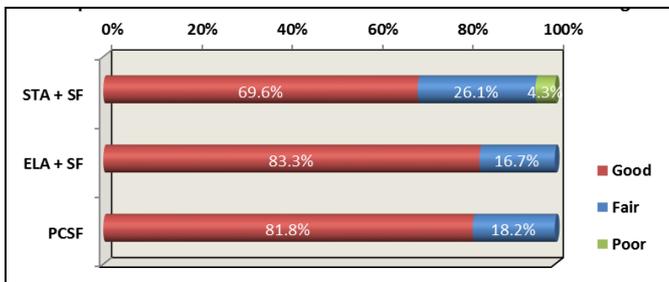


Fig 1: comparison of AFASWS between different post minimal invasive surgeries

Discussion

Majority of the calcaneum fractures were treated conservatively in the past. Due to complications like malunion, subtalar arthritis and well understanding of the anatomy of calcaneum and blood supply to surrounding flap, conservative treatment was changed into open reduction and internal fixation of calcaneum through lateral extensile approach. Again the lateral extensile approach faced a high incidence of postoperative infection, so to overcome this minimally invasive techniques like sinus tarsi approach has gained its importance. Currently sinus tarsi approach is being used extensively for Sanders type 2&3. Percutaneous reduction and screw fixation of calcaneum aims at reducing the risk of wound complication and postoperative scarring as compared with open reduction via extended approaches. The method of closed reduction with percutaneous pin leverage has found reappraisal for less severe fracture patterns, like Sanders type IIC fractures, with the posterior facet being displaced as a whole. When applying this method to Sanders type IIA and IIB fractures, anatomic reduction of the posterior facet should be controlled with intra-operative subtalar arthroscopy^[13] or fluoroscopy because subtalar joint congruity is highly predictive of the functional outcome^[14].

In our study 40 patients with calcaneal fractures were operated through minimally invasive techniques and followed up at 3 weeks, 6 weeks, 3 months, 6 months. Of the 23 cases treated with sinus tarsi approach with screw fixation, 21 Patients maintained Bohlers angle and Gissanes angle while 2 cases were unable to maintain it. This was assessed by AFASS (American association of foot and ankle society score). 16 Patients were good, 6 patients were fair, and 1 was poor. 2 patients developed post op infection. Our findings tallies well with study by Christaian Kikuchi^[15] *et al*, where limited sinus tarsi approach was used to treat intra-articular calcaneum fracture. They studied in 22 cases with statistically significant restoration of Bohlers angle in majority. Similar findings were obtained by Jin park *et al*.^[16] in 2017, who used sinus tarsi approach in treatment of displaced intra-articular calcaneum fractures. 47 cases followed up for a mean of 1 yr post op with AFASS score of 94(80-100). The functional outcome correlated well with degree of reduction of posterior facet joint and the amount of Bohlers angle restoration. Bony union achieved in every case mean union time 3.2 months (3-4 months).

With our PCSF (percutaneous screw fixation) out of 11 patients all patients maintained Bohlers and Gissane's angle. AFASS showed 9 patients were good, 2 were fair and none of them were having post op infections. When comparing these patients to study by Rammelt *et al* in 2009, out of 18 patients treated with open reduction and internal fixation via an extended lateral approach for Type II calcaneal fractures, the AFASS scores were comparable (94 vs. 88.2) and the calcaneal shape had been restored in both groups^[17]. The

patients from the percutaneous treatment group had significantly less time off from work and better range of motion at the subtalar joint and less complications at follow-up. With the Essex Lopresti method 6 cases were done and followed up. All cases showed restoration of Bohlers and Gissane's angle similar to results by Cetin Isik *et al*^[18] where 19 cases were treated with Essex Lopresti method with good restoration of Bohlers and Gissane's angle.

Of the total 40 cases done by us using the minimally invasive techniques and assessed by AFASS, 30 cases were good, 9 cases were fair and 1 with poor outcome which is similar to study by Shengl Xia *et al*^[19] in 2013. They studied 40 cases treated with minimally invasive approach with restoration of postoperative Bohlers angle and Gissanes angle. Their AFASS results were shown good in 32 cases, fair in 6 cases, fair, poor in 2 cases tallying with our results. Our values are also comparable to study by Chul Hyun Park *et al*.^[20] in 2017 who followed up 20 Sanders type 2 cases for one year. There was significant improvement in the postoperative Bohlers angle and Gissane's angle with AFASS scoring of 25% excellent, 50% good and 25% fair outcome.

The short comings of our study include small sample size and short follow up period. Hence we are not able to comment regarding the development of arthritis following out treatment modality. Similarly, we have assessed the results of minimally invasive techniques using 3 different approaches, so there is a possibility of technique bias in the outcome.

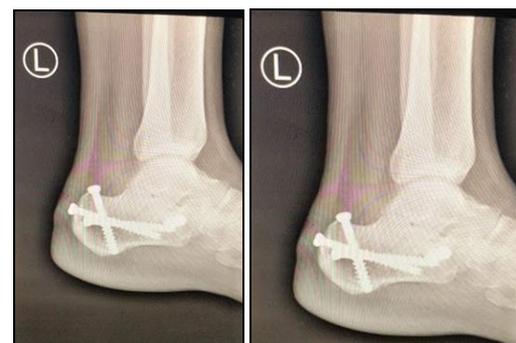
Conclusion

Minimally invasive technique for the treatment of intra articular fractures (Sanders type 2&3) gives good clinical and radiological outcome on short term period. Our study emphasises the need to restore the Bohler's and Gissane's angle in Sanders type 2 &3 cases to near normal to achieve good functional outcome following minimal invasive treatment of calcaneal fractures. The complications for Essex Lopresti technique and percutaneous screw fixation techniques are less compared to sinus tarsi approach in our study.

Case 1: (sinus tarsi approach –STA SF)



Preoper xrays and immediate post op x rays



At one year Gissane's and Bohler's angle maintained



Functional outcome

Case 2: (Percut screw tech - PCSF)



Preoper xrays and one year follow up



Functional outcome

Case 3: (Essex lopresti approach screw fixation –ELA SF)



Preoper xrays and immediate post op with Steinman Pin in situ



At one year follow up

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