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Research

Mini-open sinus tarsi approach with percutaneous screw fixation of displaced calcaneal fractures: A prospective study

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Abstract

Calcaneal fractures are the most common fractures of the foot in our body and represent 1-2% of all fractures. Among these fractures, >75% fractures are intra-articular fractures, which are frequently associated with prolonged disability if not treated. The goal of our study was to assess clinical and functional outcome and complications of Calcaneal fracture operated with k wire and screw fixation through sinus tarsi approach. ORIF of calcaneal fractures using an extended lateral approach results in soft tissue disruption and stiffness of subtalar joint.

A minimally invasive sinus tarsi approach used in calcaneal fractures for posterior facet of calcaneal exposure and percutaneous screw fixation of the calcaneal body through Sinus Tarsi Approach has been implemented. Methods: This study was conducted at Department of Orthopedics, RD Gardi Medical College Ujjain between Dec 2018 to Aug 2021 on 20 patients managed surgically by Mini-Open Sinus Tarsi Approach (18 Sanders type II and 2 type III). All patients both clinical and radiological evaluations. Results: The follow-up duration for all patients ranged from 12 to 24 months. The radiological evaluations show significant corrections of the Böhler angle, and Gissane angle from pre-operatively to 3 months post-operatively and the last follow-up.

However, there no significant differences in the variables between 3 months and the last follow-up postoperatively. Conclusion: Sinus tarsi approach provides good exposure to the talocalcaneal joint. ORIF of calcaneus

fractures through sinus tarsi approach allows good exposure with low risk of complications. It's less invasive method for treatment of calcaneal fractures. It permits good exposure of the fracture, and allows good reduction of articular surfaces. Most patients had good or excellent functional outcome results, through Sinus tarsi approach.

Keywords: Calcaneal Fractures; open reduction and internal fixation (ORIF), Mini- Open; Sinus Tarsi Approach

INTRODUCTION

Calcaneus fractures comprise 1%-2% of all fractures of the human body and 60% of all tarsal bones injuries [1]. Calcaneal fractures are occurring predominantly in young patients. Calcaneal fractures are typically High-energy axial traumas, such as fall from height or motor accidents, are the common causes for calcaneal fractures [2]. Calcaneus fractures are 2 types: extra-articular and intra-articular. 60% -75% of calcaneal fractures are Displaced Intra-Articular Calcaneal fractures (DIACFs). DIACFs can cause hind foot deformities and if its persist for long term can cause pain and stiffness of joint [3]. Anatomic reduction of the posterior facet of the subtalar joint is critical to successful outcomes, and efforts have been made to restore calcaneal geometry [4]. Treatments options, such as percutaneous pins, k wire fixation, open reduction, primary fusion and total excision, have been used for displaced intra-articular Calcaneal fractures in the past. However, many surgeons have recommended open reduction and internal fixation with conventional plate via an extensible lateral L-shaped approach for displaced intra-articular Calcaneal fractures [5]. However, several studies report high postoperative wound complications rate including wound dehiscence, flap necrosis, deep infection, hematoma, using extensible lateral L-shaped approach [5]. Various techniques have been suggested for fixation, such as the use of a screw and plate for percutaneous, semi- and mini open fixation. These techniques have not been evaluated for the quality of reduction and stability of internal fixation. Using smaller incision, sinus tarsi approach allows visualization of the articular reduction while limiting soft tissue dissection [6]. The aim of our study was (a) to assess the quality of reduction, (b) to assess stability of fixation and (c) to evaluate clinical outcome (Table 1).

Table 1. Clinical Outcome According to AOFAS Hind foot Score

AOFAS Scale	Mean \pm SD	Range
PAIN	34.7 \pm 7.0	20 – 40
FUNCTION	43.6 \pm 6.0	27 – 50
ALIGNMENT	8.4 \pm 2.9	0-10
TOTAL	86.7 \pm 15.9	57 – 100

MATERIALS AND METHODS

This study was conducted at Department of Orthopaedics, RD Gardi Medical College Ujjain between Dec 2018 to Aug 2021 on 20 patients managed surgically by Mini-Open Sinus Tarsi Approach (18 Sanders type II and 2 type III). The mean age was 34 years (range 18 years to 54 years). 14/20 patients were male and 06/20 were female. 06 patients had fracture of left side, 12 had right side and 2 sustained bilateral fractures. The most common mechanism of injury was fall from height seen in 13 patients and 7 had road traffic accident. The mean follow up period was 16 months (range 12 months-24 months). Mean union time was 10 weeks (range 8 weeks-12 weeks). The fractures were evaluated by standard radiographic views- axial, lateral, Antero-Posterior (AP) view of the foot, and ankle-mortise views. The fractures were further evaluated by Computerized Tomographic (CT) scans. Sanders classification was used to classify the fractures based on a CT scan (Figure 1).



Fig 1. Intra Op

OBSERVATIONS AND ANALYSIS

Preoperative Bohler angle ranged from 7.10 ± 23.19 degrees and postoperative 24.16 ± 8.12 Preoperative Gissane angle ranged from 38.8-105 degrees and postoperative gissane angle 105-138 degree. The preoperative and postoperative calcaneal anatomical parameters were compared by the paired t-test [7]. Comparisons were considered to be significant at $P<0.05$ (Figure 1-3).

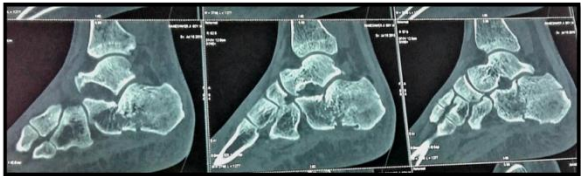


Fig 1. Pre OP 1



Fig 3. Pre OP 2

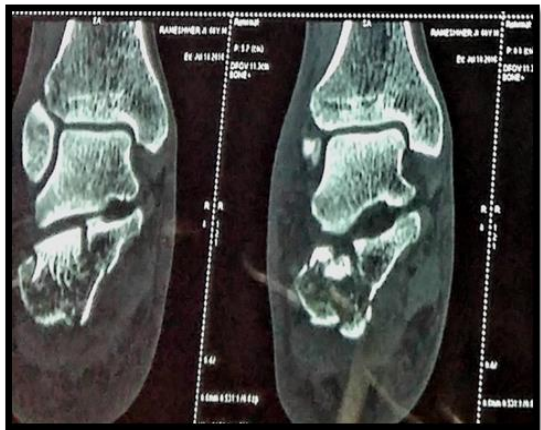


Fig 4. Pre OP 3

POSTOPERATIVE MANAGEMENT

Postoperatively Radiographs were taken to measure the Calcaneal anatomical parameters, including Böhler angle (6) and Gissane angle(7). The suction drain was removed 1 day postoperative day (Figure 4).



Fig 5. Post OP

Sutures were removed at 14 days. Progressive weight bearing was allowed at 8 weeks postoperative and full weight bearing was permitted at 12 weeks. Using the Maryland foot scoring system (100 points), clinical assessment of patients. An overall result of excellent (90-100), good (80-89), fair (70-79), and poor (<69) was assigned to each fracture (Table 2).

Table 2. Postoperative Maryland foot score.

Sanders type	Feet	Excellent (90–100)	Good (80–89)	Fair (70–79)	Poor (60–69)
II	8	7	2	0	0
III	8	3	3	1	0
IV	4	1	1	2	0
Total	20	11	6	3	0

OPERATIVE PROCEDURE

The surgery was done with the patient in a lateral decubitus position after administration of spinal anesthesia. Tourniquet was used in all cases after exsanguination. Approximately 5cm -7 cm long incision was made starting from 1 cm below the tip of lateral malleolus extending anteriorly in the line of the fourth metatarsal. Subcutaneous tissue was dissected (Figure 5).



Fig 6. Post OP-3 Month

Soft tissue care was taken to avoid injury of sural nerve. Sinus tarsi fat pad was mobilized, and the origin of

extensor digitorum brevis was elevated sharply and reflected dorsally and distally along with an inferior attachment of the extensor retinaculum. The peroneal sheath was sharply dissected and tendons were retracted inferiorly. Subtalar joint was exposed by capsulotomy and the posterior facet of calcaneum was identified [8].

In pure tongue depression type fractures, the facet was elevated using the Essex Lopresti maneuver, while in thalamic depression fractures, a periosteal elevator was passed below the depressed fragment to elevate the posterior facet. Alternatively, a novel technique used in which multiple drill holes are made with 3.2 mm drill bit over tuberosity just below Tendo Achilles (TA) insertion and a vertical slit was created to pass a Kirschner wire (k-wire) for use as a joystick, and the depressed thalamic fragment was elevated under fluoroscopy guidance [9]. Then the reduction was assessed in axial view.

If the medial wall was not reduced then a Schanz screw was passed from tuberosity anteriorly to exert valgus force and simultaneously a small bone spike was passed between the body and sustentaculum fragment and levered back to achieve reduction. We have found the Mixer forceps to be a useful tool in some cases which was passed medially to hook the sustentacular fragment and the fragment pulled laterally with a valgus force applied from the posteriorly placed Schanz pin. The reduction was held with a k-wire passed anteriorly from tuberosity toward the sustentaculum tali. Then the elevated facet fragment was temporarily fixed to a constant medial fragment with a 2 mm k-wire and the reduction was assessed under fluoroscopy. Another 1 mm k-wire was passed directed medially anteriorly, and cephalad to caudate, exiting medially through the anterior part of the sustentaculum. A 4 mm cannulated drill was passed over this wire and a cannulated screw of appropriate size was inserted over the wire. A “kickstand” screw is inserted to support the elevated facet. Two or three postero anterior screws were inserted to maintain the length of the calcaneus. Small 2.7 mm screws were used to fix anterolateral fragments when required. The reduction was assessed by passing a periosteal elevator in the subtalar space to feel for any incongruity or articular step. Further, the reduction was assessed visually and on

fluoroscopy by obtaining axial, lateral, and Broden’s views. Wound washed and closure was done in layers. The posterior splint was applied. The dressing was mostly done on 5th day. Sutures were removed on 12th day-14th day and the splint was discontinued. Mobilization was initiated at the visit for suture removal. Radiographic evaluation was done monthly for the first three months and then at 6 months and 9 months. Partial weight-bearing was initiated at 4 weeks-6 weeks and full weight-bearing from 8 weeks-10 weeks (Figure 6).



Fig 7. Post OP 6 Month

CLINICAL EVALUATION

AOFAS (American Orthopaedic Foot and Ankle Society) hindfoot score used for evaluation of function outcome [9].

Results were graded excellent for >90 points, good for >80, fair for >70, and poor when ≤70.41.

Range of motion (ROM) at the subtalar joint was assessed by comparing the injured foot to the contralateral side. Pain was assessed using a Visual Analog Scale (VAS), ranging from 0 (no pain) to 10 (maximum pain). A careful physical examination performed to identify any local sensitivity, such as scar irritation, sensory neurological deficit, and tenderness (Table 3).

Table 3. Preoperative and Postoperative

	BOHLER ANGLE	GISSANE ANGLE
	Range	Range
Pre op	7.10±22.15	38.8–105
Post op	24.16±8.12	105-138
P value	<0.01	<0.01

Statistical analysis all data were analyzed by SPSS 17.0 statistical software and expressed as mean ± standard deviation. The pre and postoperative calcaneal anatomical parameters were compared by the paired t test. Comparisons were considered significant when P<0.05

(Table 4).

Table 4. Patients Dermography

CHARACTERISTICS	n(%)
Age (mean) yrs	34
Sex	
Male	14
Female	6
Side	
Right	12
Left	6
Bilateral	2
Mechanism of injury	
Fall from height	13
RTA	7
Sanders classification	
Type II	8
Type III	8
Type IV	4

DISCUSSION

The treatment of calcaneal fractures is aimed at restoration of the posterior facet of the subtalar joint, restoration of the height of calcaneus (Bohler angle), reduction of the width of calcaneum, decompression of subfibular space available for peroneal tendons, realignment of tuberosity into a valgus position, and reduction of the calacaneo-cuboid joint if fractured. pursued in patients with a joint step-off of more than 2 mm or fracture gap of more than 3 mm.

Various alternative open approaches have been developed in treating DIACFs, including extensile lateral approach, medial approach, combined lateral and medial approach, limited posterolateral approach, and sinus tarsi approach [10]. Open reduction and internal fixation is currently considered the gold standard in the surgical treatment of displaced intra-articular fractures, several surgical techniques have been described of which the extended lateral approach most frequently applied. Advantages of the extensile lateral approach include wide exposure of the subtalar joint allowing more accurate reduction of the facet fragments, ability to decompress the lateral wall, exposure of the calcaneocuboid joint, and sufficient area laterally for plate fixation. However extensile approach is associated with increased risk of complications like delayed wound healing, wound dehiscence, infection etc. Soft tissue covering the lateral wall of the calcaneum is supplied by the lateral calcaneal artery which is thin and vulnerable, making the extensile lateral approach prone to

wound complications. Risk factors for complications in the wound after calcaneal open reduction and internal fixation include single-layered closure, high body mass index, extended time between injury and surgery, smoking, diabetes, and open fractures. Therefore less extensive approaches were described including the approaches described by Palmer, modified obtuse-angled approach, limited lateral approaches, postero-lateral approach modified lateral Palmer approach, etc Many studies have shown that the clinical results were similar between calcaneal fractures treated with an extensile approach and those treated with a minimally invasive approach.

However, incidence of wound infection and secondary surgeries complications significantly lower in minimally invasive approach.

Sinus tarsi approach permits good visualization of the fracture and allows anatomic reduction of articular surfaces,

In 2008, Hospodar et al studied 16 consecutive cases using minimally invasive sinus tarsi approach. No major wound complications were found in those cases.The posterior facet joint was successfully reduced to less than 2mm of displacement in 14 patients [11].

On the other hand, Nathaniel et al. report a higher incidence of deep infection in cases treated with sinus tarsi (17.6%). This was not the case in our experience, as we found only 1/34 cases developed deep infection. No specific factor could be attributed to the occurrence of this infection. Sural nerve injury has been reported as complications of sinus tarsi approach. We did not see any such case; the incidence of sural nerve injury increases if the incision extends posterior to the lateral malleolus, and we ensure adequate visualization of the nerve with careful retraction whenever possible. Abdelazeem et al used limited open sinus tarsi approach and fixation by screws only technique to manage 33 cases of DIACFs. Marked improvement in Böhler angle was noticed in all patients. The mean preoperative angle was 2.8°, and postoperatively it was 19.4°. In 2015, Yeo et al. reported successful improvement in Böhler angle from 17.0° to 26.5° using sinus tarsi approach. In Our Study Preoperative Bohler angle ranged from 7.10±23.19° and

postoperative 24.16 ± 8.12 , Preoperative Gissane angle ranged from 38.8° – 105° and postoperative gissane angle 105° – 138° . In this study, we achieved sufficient exposure of the posterior facet. There was a significant improvement in Böhler angle from 7.10° to 24.16° and Gissane angle from 38.8° to 105° . ($P < 0.01$) [11].

In our study, satisfactory reduction of the fracture was obtained through limited sinus tarsi approach in all 20 calcaneum cases. Incidence of complications was 1 (20 cases) (5%) which is quite less compared to the studies with extensile lateral approach. The results were good with average AOFAS score of $84(86.7 \pm 15.9)$.

In our study, 08 Sanders II, 08 Sanders III, and 4 Sanders IV calcaneal fractures were included in this study population. Most authors only included Sanders II and Sanders III fractures. There are very few studies that included Sanders IV fractures [12].

The reduction of the posterior facet was graded as nearly anatomical (less than 2 mm articular displacement) in 08 feet (40%) of type II fractures, 08 feet (40%) of type III fractures, and 4 feet (20%) of type IV fractures. Our outcome correlated with the Sanders classification. It has been reported that wound complications ranged from 0% to 5%. In all patients Böhler angle, Gissane's angles were corrected to normal value with valgus correction which was satisfactory. Good results correlate with restoration

of Böhler angle. There is significant correlation between preoperative Böhler angle and the injury severity of the fracture but postoperative Böhler angle parameters have a significant correlation with the functional recovery [13]. We found no difficulty in fracture reduction, and were able to restore both Böhler and Gissane angles to acceptable or better levels from the supportive evidence in the literature, and our experience of 20 cases, we would recommend considering the sinus tarsi approach to be the new gold standard for the treatment of DIACFs.

CONCLUSION

Complex calcaneal fractures were sufficiently exposed by a sinus tarsi approach for anatomic reduction and stable fixation. Sinus tarsi approach provides good exposure to the talocalcaneal joint. ORIF of calcaneus fractures through sinus tarsi approach allows good exposure with low risk of complications. Despite a limited number of patients, this study suggests that the quality of reduction and stability of internal fixation are satisfactory, supporting the continued use of this technique. Its less invasive method for treatment of calcaneal fractures. It permits good exposure of the fracture, and allows good reduction of articular surfaces. Most patients had good or excellent functional outcome results, through Sinus tarsi approach.

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