

## Effect of Bone Grafting in Short and Long Term Outcomes of Displaced Intra-Articular Calcaneal Fractures: A Prospective Comparative Study

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### ABSTRACT

**AIM:** This prospective comparative study was done to evaluate effect of autologous bone grafting in outcomes and complications of displaced intra-articular calcaneal fractures.

**MATERIAL AND METHODS:** Seventy-two patients with displaced intra-articular calcaneal fractures were treated with open reduction and internal fixation with plate. Osteosynthesis of 36 patients were supplemented with bone graft and other 36 patients did not receive bone graft. All patients were followed for 2 years and clinico-radiological assessment was done using the Maryland foot score and plain radiography as-well-as CT scan. Bohler's angle, the crucial angle of Gissane, calcaneal height and width in the preoperative, immediate postoperative period and at the 2-year follow-up were compared.

**RESULTS:** There was no significant difference found in terms of clinical results as assessed by Maryland foot score between both the groups ( $p > 0.05$ ). No significant difference was found between both the groups in terms of loss of Bohler's angle, the average change in the crucial angle, calcaneal height and width ( $p > 0.05$ ). No significant difference was found between the groups regarding complications like infection rate, skin necrosis, wound dehiscence, postoperative osteoarthritis and subtalar fusion ( $p > 0.05$ ).

**CONCLUSION:** There was no significant difference between both the groups regarding functional outcomes and complications.

### INTRODUCTION

The calcaneus is the most frequently fractured of the tarsal bones, and represents 1% to 2% of all fractures<sup>[1,2]</sup>. Calcaneus fractures can be broadly classified into intra-articular and extra-articular types. Intra-articular fractures are more common, representing 60-75% of all calcaneal fractures, with a wide spectrum of fragment patterns<sup>[2,3]</sup>. The mechanism of injury is usually through axial loading of the calcaneus, causing a blowout of the lateral wall of the calcaneus downward and fracture through the posterior facet with various degrees of comminution bohler angle<sup>[3,4]</sup>. Displaced intra-articular fractures carry a high morbidity representing a significant therapeutic challenge, and despite their frequency, no clear consensus exists on treatment protocol for this class of fractures<sup>[5,6,7,8]</sup>. Plate osteosynthesis of the intra-articular fractures is a standard treatment method. Lenormant first described the use of bone graft to fill the space created after open reduction of calcaneal fracture in 1928. Cancellous core of calcaneus, the thalamus<sup>[9]</sup>, is usually compressed during calcaneal fracture. It has been a common practice during open reduction and internal fixation for fracture of the calcaneus to supplement the fixation with bone graft, most commonly using an autograft from the iliac crest<sup>[10,11,12]</sup>. Other options available to supplement osteosynthesis includes allogeneous cancellous bone graft and synthetic bone substitutes. Morbidity at the donor site from iliac crest autograft is well known and the benefits of using a bone graft

in displaced intra-articular calcaneal fractures is still controversial<sup>[13]</sup>. Earlier studies has shown that bone grafting in intra-articular calcaneal fractures could increase stimulation of fracture healing for early full weight bearing and add mechanical strength to avoid significant late collapse and post-traumatic subtalar arthrosis<sup>[14,15]</sup>. It has been shown also that autologous bone grafting increases the infection rate, blood loss and postoperative pain<sup>[16,17]</sup> along with the donor site morbidity and complications of harvesting autograft<sup>[18,19]</sup>.

We were interested in determining if the use of autologous bone grafting would work best for management of displaced intra-articular calcaneal fractures. We hypothesized that supplementing osteosynthesis with autologous bone grafting would provide better outcomes and early rehabilitation in management of patients of displaced intra-articular calcaneal fractures. Our primary aim was to measure patient satisfaction in terms of outcome scores following calcaneal fracture fixation, and our secondary aim was to determine the range of motion at subtalar joint, infection rate, incidence of subtalar arthrosis and other radiographic parameters (Calcaneal height and corresponding angles). We undertook a prospective comparative study to compare outcomes and complications in patients who had undergone osteosynthesis with bone grafting to those who had undergone only osteosynthesis in management of displaced intra-articular calcaneal fractures.

## MATERIAL AND METHODS

We performed a prospective comparative study of the cases with displaced intra-articular calcaneal fractures treated by open reduction and internal fixation (ORIF), with and without bone graft and compared the outcomes and complications of the two groups. This study was authorized by the local ethical committee and was performed after approval of institutional review board. Informed consent was taken from all the patients. A power analysis, with a power of 90% to detect Maryland foot score difference of 10 as being significant at the 5% level, determined that a sample size of sixty four patients was needed. It was anticipated initially that 10% to 15% of the patients would drop out or not fully meet the criteria for long-term follow-up and that sample size of 72 patients. Each group required at least 36 participants. From January 20011 to January 2013, 84 patients with displaced intra-articular calcaneal fractures were admitted. Out of these cases, 72 patients with unilateral, isolated, closed, displaced intra-articular calcaneal fracture in patients of more than 18 years old age were included in this study according to inclusion criterias. We used Sanders' classification<sup>[20]</sup> developed on the basis of coronal and axial CT scan sections for calcaneal fractures. Sanders computed tomography (CT) scan classification is based on articular fracture lines of the posterior articular calcaneal facet (A, lateral; B, central; C, medial), and the severity of the fracture (Sanders types I–IV) depends on the number of lines and their courses.

**Inclusion criterias:** (1) Age more than 18 years; (2) Closed, unilateral Sanders displaced intra-articular calcaneal fractures;(3) Posterior articular facet step off more than 2 mm.

All the patients included in this study were randomly allocated to two groups using sealed envelop method, group A having 36 patients treated by ORIF with autologous bone graft and group B having another 36 patients treated by ORIF without autologous bone graft. All the cases were operated upon by a single surgeon. The average age in group A was 36.2 (range, 19–74) years and in the group B was 40.8 (range, 18–75) years. Average body mass index (BMI) in group A was  $28.6 \pm 6.0$  (range 21.26 to 42.14) kg/m<sup>2</sup> and in group B was  $29.4 \pm 5.8$  (range 20.18 to 44.28) and there was no

significant difference found ( $p = 0.28$ ). Twelve patients in group A and 14 patients in group B were smokers. Seven cases in group A and 9 cases in group B were diabetic patients. Gender proportions in the two groups were similar ( $p = 0.44$ ). All the patients in both the group were followed for minimum duration of 2 years.

The majority of calcaneus fractures are high-energy injuries so all the cases were treated initially with ice and elevation until soft tissue swelling subsided and skin wrinkles were apparent (Figure. 1A and 1B). All the patients were operated from the sixth to tenth day after injury (range 4–18 days, average 8.0 days). All the operations were performed under spinal anaesthesia with the patient placed in lateral decubitus position, using the extended L-shaped lateral approach. The posterior facet, angle of Gissane, Bohler's angle, calcaneal height, width and length were meticulously restored (Figure 1B, 1C, 2A, 2B and 2C) and the reduction was temporarily maintained with Kirschner wires. Locking calcaneal plate (Synthes) was used in all the cases for internal fixation (Figure 1C, 1D, 2C and 2D). In the patients receiving bone graft, cancellous autograft was taken from the ipsilateral iliac crest and filled in the bony defect, present just below the posterior facet at the area of the neutral triangle (Figure 1C and 1D) and then the lateral cortical wall of the calcaneus was reduced and internal fixation with plate was completed. The wound was closed over a drain that was removed the following day.

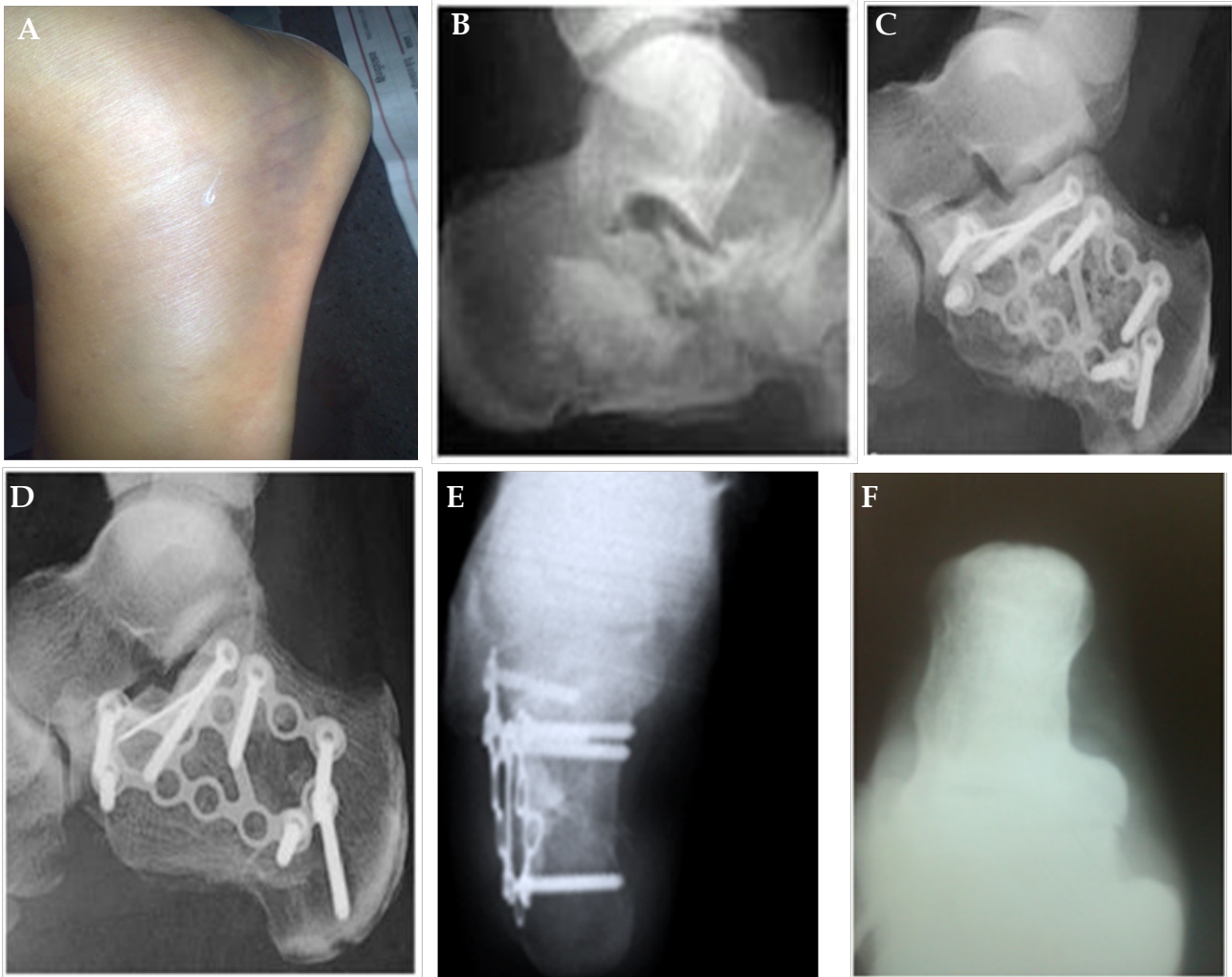
Active and passive range of motion exercises were carried out at the first day after surgery. Postoperatively, non-weight-bearing walking was started on the third postoperative day. Patients were allowed to bear weight partially (25% weight) on affected side, 6 weeks after the surgery. Clinical and radiological assessment was done at every follow-up visit. The preoperative, immediate postoperative and two year follow-up visit x-rays were compared to assess changes in Bohler's angle, the crucial angle, height and width of the calcaneus.

Time to full weight-bearing, range of motion and outcome scores were recorded for all the patients. Posterior facet incongruity and subtalar joint fusion were assessed radiologically. For the evaluation of subtalar joint reduction, Sanders criteria<sup>[20]</sup> and, for posttraumatic posterior facet degenerative changes, Allmachers Arthrosis Rating Scale<sup>[21]</sup> was used in this study. Clinical outcome was assessed by the Maryland foot score<sup>[20]</sup>. The Maryland Foot Score is a disability index that derives a score from 0 to 100 points (excellent, 90 to 100; good, 75 to 89; fair, 50 to 74; failure, less than 50). It evaluates subjective and objective elements such as pain (maximum score 45), function (maximum score 40, subdivided into gait, stability, use of walking aids, limp, type of shoes required, walking distance), cosmesis (maximum score 10), and movement of the ankle, subtalar, midfoot and metatarsophalangeal joints (maximum score 5). Range of motion of the subtalar joint was measured according to the method of Morrey and Wiedeman<sup>[22]</sup>.

Absolute values of the differences were used for statistical analysis. Statistical significance was taken as 0.05. The t test for equality was used to test for significance of difference.

## RESULTS

The average overall duration of follow-up was  $2 \pm 0.3$  years (range, 1.4–2.7 years). The patients of group A had an average hospital stay of  $20.20 \pm 3.2$  days (range, 15–25 days) and the group B patients had an average hospital stay of  $19.02 \pm 4.8$  days (range, 14–24 days). There was no significant difference between two groups ( $p = 0.68$ ). All patients were able to wear normal footwear; no orthotic devices were required.

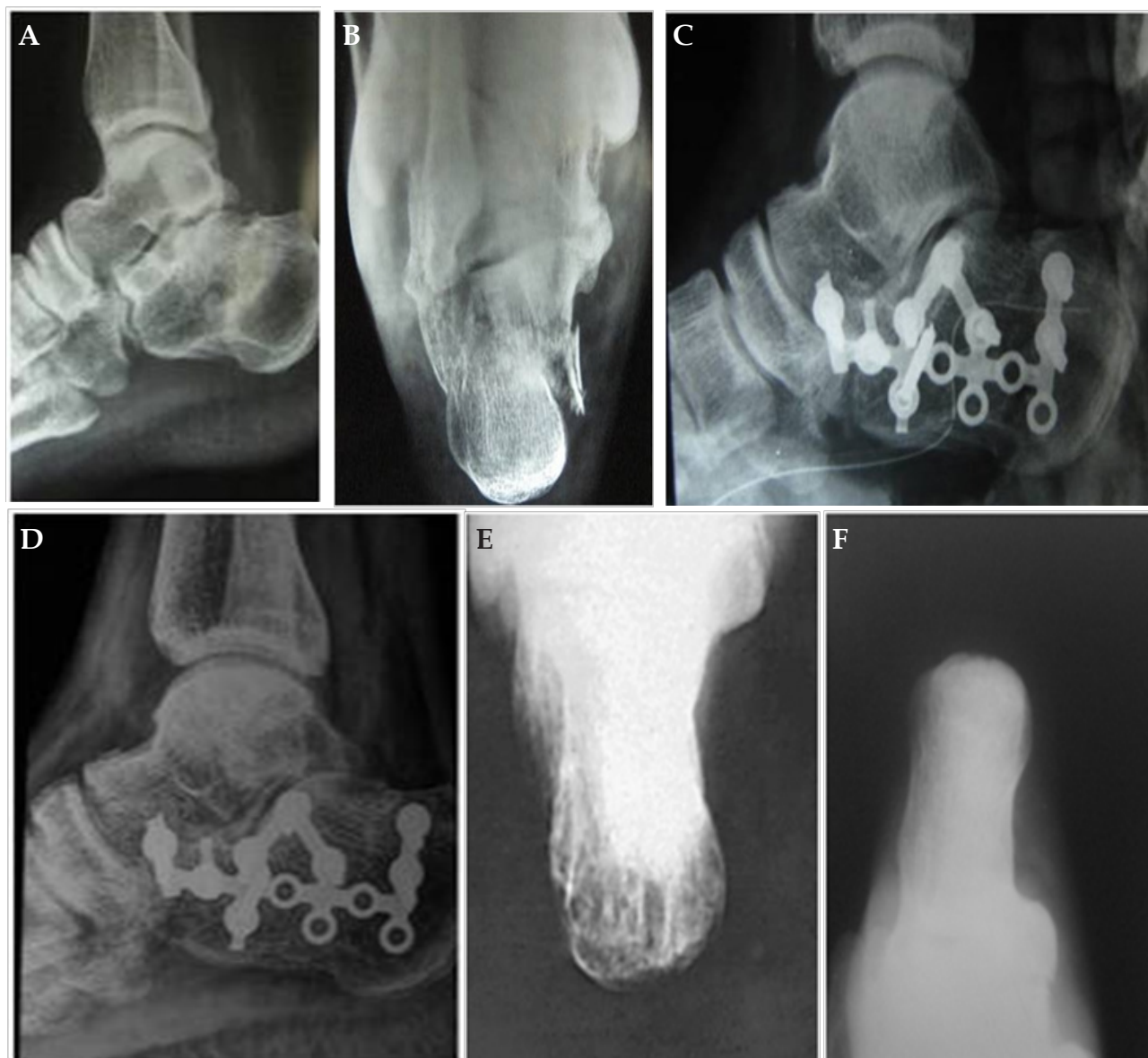


**Figure 1** A: Clinical picture of a 32 years female patient with displaced intra-articular fracture showing gross swelling of hind foot.  
 B: Preoperative X ray lateral view showing displaced intraarticular calcaneal fracture.  
 C: Post-operative x-ray lateral view showing plate osteosynthesis with autologous bone grafting.  
 D: Two years follow-up x-ray showing united fracture.  
 E: Two years follow-up x-ray axial view of fractured calcaneum showing united fracture.  
 F: X-ray axial view of calcaneum of normal side.

The mean time to full weight-bearing in bone graft group A ( $5.2 \pm 1.2$  months; range, 3-7 months) was insignificantly lower ( $p = 0.09$ ) as compared to the non-graft group B ( $6.3 \pm 1.6$  months; range, 3.5-18 months). In group A, there were 20 cases who were manual labourer by occupation and in these cases, mean time to full-weight-bearing was  $6.0 \pm 1.4$  months (range 3.5-7 months). In group B, there were 18 cases who were manual labourer by occupation and in these cases, mean time to full-weight-bearing was  $6.4 \pm 1.8$  months (range 4-8 months). There were insignificant difference ( $P=0.34$ ) found in terms of mean time to full-weight-bearing in manual labourers between both the groups. There was insignificant difference ( $P=0.28$ ) found between both the groups in terms of mean time to full weight-bearing in patients with non-demanding job (group A, mean  $4.8 \pm 1.3$  months, range 3-6.9 months and group B, mean  $5.2 \pm 1.5$  months, range 4-9.1 months). Immediate post-operative and 2 year follow-up Bohler's angle was significantly higher in the group A ( $p = 0.042$ ). The Bohler's angle loss after 2 year was insignificantly lower in the bone graft group A ( $3.5^\circ \pm 1.4^\circ$ ; range,  $2^\circ$ - $6^\circ$ ) as compared to the non-graft group B ( $4.2^\circ \pm 2.1^\circ$ ; range,  $3^\circ$ - $7^\circ$ ); ( $p = 0.14$ ). The overall subtalar joint reduction was found to be satisfactory. No significant difference was found

between the two groups on comparing the good reduction rate. Comparison of the immediate postoperative and the 2 year follow-up radiological results showed the change in Bohler's angle, crucial angle, width and the height of the calcaneus (Table 2). The average change in crucial angle was  $3.8^\circ \pm 1.8^\circ$  (range,  $2^\circ$ - $6^\circ$ ) for the group A and  $3.6^\circ \pm 2.1^\circ$  (range,  $1^\circ$ - $6^\circ$ ) for the group B. The difference was not statistically significant ( $p = 0.48$ ). The average change in calcaneal height was  $2.8 \pm 1.4$  mm (range, 1-4 mm) for the group A and  $2.5 \pm 1.2$  mm (range, 1-4 mm) for the group B. This difference was statistically not significant ( $p = 0.68$ ). The average change in calcaneal width for the group A ( $2.01 \pm 0.34$  mm; range, 1.5-2.5 mm) was insignificantly higher ( $p = 0.42$ ) than patients of group B ( $1.98 \pm 0.22$  mm; range, 1.75-2.25 mm) (Table 2).

Mean Maryland foot score was lower (76.4; range, 66-88 points) in the group B than in group A (81.6; range, 74-92 points) but this difference was not significant ( $p = 0.82$ ). In the studies of group A, the result was excellent in 30% of the patients, good in 36%, fair in 25%, and poor in 8% of the patients. In the non-graft Group B, the outcomes were excellent in 27%, good in 33%, fair in 27%, and poor in 11% cases. No significant difference was found on comparing both groups ( $p = 0.09$ ) (Table 3).



**Figure 2** A: Preoperative x-ray lateral view showing displaced intra-articular calcaneal fracture in a 29 years old male patient.  
 B: Axial view of calcaneum showing displaced intra-articular calcaneal fracture in same patient.  
 C: Immediate postoperative x-ray lateral view showing plate osteosynthesis without bone graft.  
 D: X-ray at 2 years follow-up showing united fracture.  
 E: Two years follow-up x-ray axial view of fractured calcaneum (plate removed) showing united fracture and congruent medial wall.  
 F: X-ray axial view of calcaneum of normal side.

Table 1 Demographic Profile of Study (N=72 cases of displaced intra-articular calcaneal fractures).			
Patient characteristics	Open Reduction and Internal Fixation with bone graft (Group A)	Open Reduction and Internal Fixation without bone graft (Group B)	P value
Sex			
Male: Female	24 : 12	26 : 10	0.44
Side			
Right: Left	22 : 14	20 : 16	0.62
Mean age (years)	36.2	40.8	0.58
Fracture type (Sander's Classification System)			
Type II	20	18	
Type II A	6	7	0.42
Type II B	10	8	
Type II C	4	3	
Type III	9	12	
Type III AC	4	6	0.68
Type III AB	3	4	
Type III BC	2	2	
Type IV	7	6	0.46

**Table 2** Comparison of preoperative and postoperative radiological parameters of displaced calcaneal fractures treated with plate osteosynthesis with bone graft (group A, N=36 cases) and without bonegraft (group B, n=36 cases).

Radiological parameters	Group A(Average value $\pm$ standard deviation)	Group B(Average value $\pm$ standard deviation)	P vlue
<b>Mean Bohler's Angle (in degree)</b>			
After injury	7.6 $\pm$ 8.2	8.2 $\pm$ 7.8	0.46
Immed.Post op	29.2 $\pm$ 6.6	22.1 $\pm$ 5.8	0.048
After 2 yr followup	25.8 $\pm$ 6.1	17.2 $\pm$ 7.2	0.042
Bohler Angle loss	4.1 $\pm$ 1.4	4.7 $\pm$ 1.7	0.14
<b>Mean Gissane Angle (in degree)</b>			
After injury	134.8 $\pm$ 11.4	132.4 $\pm$ 10.2	0.48
Immed.Post op	120.4 $\pm$ 8.4	118.8 $\pm$ 9.8	0.58
After 2 yr followup	124.2 $\pm$ 7.6	122.4 $\pm$ 9.2	0.54
Angle change	3.8 $\pm$ 1.8	3.6 $\pm$ 2.1	0.48
<b>Mean Calcaneal Height(mm)</b>			
After injury	35.2 $\pm$ 6.4	37.6 $\pm$ 6.6	0.52
Immed. Post op	42.8 $\pm$ 3.1	42.6 $\pm$ 4.2	0.62
After 2 yr followup	40.0 $\pm$ 3.6	40.1 $\pm$ 3.8	0.52
Height loss	2.8 $\pm$ 1.4	2.5 $\pm$ 1.2	0.68
<b>Width of the calcaneus (mm)</b>			
After injury	56.4 $\pm$ 5.9	57.8 $\pm$ 6.1	0.50
Immed. Post op	47.3 $\pm$ 5.4	48.2 $\pm$ 6.0	0.45
After 2 yr followup	49.1 $\pm$ 5.6	50.1 $\pm$ 5.9	0.41
Change in width	2.01 $\pm$ 0.34	1.98 $\pm$ 0.22	0.42

**Table 3** Comparison of Maryland Foot Score of displaced calcaneal fractures treated with plate osteosynthesis with bone graft (group A, N=36 cases) and without bonegraft (group B, n=36 cases).

Sander's Fracture Type	Group A					Group B				
	Excellent	Good	Fair	Poor	Total	Excellent	Good	Fair	Poor	Total
Type II	6	8	5	1	20	5	7	5	1	18
Type III	3	4	2	0	9	4	3	4	1	12
Type IV	2	1	2	2	7	1	2	1	2	6
	11 (30.56%)	13 (36.1%)	9 (25.0%)	3 (8.33%)		10 (27.8%)	12 (33.3%)	10 (27.8%)	4 (11.1%)	

In this study, incidence of infection was 6.94%. The infection rate in group A (8.33%) was higher as compared to group B (5.66%) but no statistical significant difference was found ( $p = 0.22$ ). Three patients (4.16%) had superficial wound dehiscence. There were no donor site wound complications. Subtalar arthrosis developed in 5 patients of group A (13.8%) and in 7 patients of group B (19.4%) and there was no significant difference found between both the groups ( $p = 0.08$ ). The incidence of postoperative subtalar fusion was insignificantly higher in group B (5.56%) as compared to group A (2.77%).

## DISCUSSION

Displaced intraarticular calcaneal fractures pose a challenge to orthopaedic surgeons and the most appropriate management remains controversial. The results of open reduction and internal fixation after intra-articular calcaneal fractures have varied, with good and excellent results ranging from 33% to 85%<sup>[11,23,24,25,26]</sup>. The need for bone grafting in the surgical management of calcaneal fractures is still controversial. Some authors have supported role of bone grafting in earlier studies<sup>[11,12,14,27]</sup> while many authors do not prefer to supplement osteosynthesis with bone graft<sup>[28,29,30]</sup>. A nationwide survey in the Netherlands reported that the definite use of bone grafts in the ORIF group was 20%, a total of 42% used grafting when deemed necessary, and 38% did not use bone grafts at all<sup>[31]</sup>. Letournel demonstrated that rigid plate fixation with lag screws adequately supported the articular surface and therefore bone grafting was unnecessary<sup>[25]</sup>. Sanders et al<sup>[20]</sup> and Stephenson et al<sup>[30]</sup> in their studies reported good results without the use of bone graft. Lowery et al. reviewed treatment of calcaneal fractures extensively and did not recommend the use of bone graft<sup>[32]</sup>. Longino et al. had compared cases of displaced intraarticular fractures with locking plate osteosynthesis with and without bone grafting and did not find any significant difference<sup>[33]</sup>. Zwipp et al<sup>[34]</sup> also achieved good results

without the use of bone graft.

Benirschke *et al*<sup>[35]</sup> recommended supplemental bone grafting to fill large defects, which otherwise remained after rigid plate fixation. Leung et al recommended open reduction with rigid internal fixation with primary bone grafting as the preferred treatment method for calcaneal fracture<sup>[11,12]</sup>.

Huang *et al*<sup>[28]</sup> did not use bone graft in their series and there was no late collapse, but they emphasized that it is critical to keep the patients strictly nonweightbearing for at least 10 weeks to prevent any possible loss of joint reduction. In our study, both groups had similar clinical and radiological outcomes. Higher Infection rate was reported for the intraarticular calcaneal fractures treated with bone grafts in many studies<sup>[16]</sup>. In our study, no significant difference was found between the patients with bone grafts and without bone grafts on comparing the infection rates. It was observed in many studies that restoration of Bohler's angle was associated with a better outcome<sup>[13,36,37,38]</sup>. The mean postoperative Bohler's angle was significantly higher and the mean loss of reduction of the angle was insignificantly lower in the bone graft group. Biomechanical and clinical studies have shown that even a minor stepoff of 1 to 2 mm in the posterior facet leads to a significant load shift within the subtalar joint with the possible development of post-traumatic arthritis<sup>[39]</sup>. In our study, the subtalar joint reduction achieved during surgery was maintained during long-term follow-up in both groups.

The efficacy outcomes in the two groups showed no significant difference. For the reported scores, the patients in bone graft group reached a lower mean Maryland foot score. Sanders et al<sup>[20]</sup>, using both subjective and objective criteria, reported 67% good and excellent results for their Type II, Type III and Type IV fractures. Similarly, Zwipp et al<sup>[34]</sup>, using their own classification system and rating scale, reported 61% good and excellent results in 123 operatively treated fractures. The Maryland foot score, which evaluates both subjective and objective elements was used in our

study. However, 92% good and excellent results were observed in our study.

Bone grafts have been commonly used in calcaneal fracture surgeries for the filling of bone cavities. However, the use of autograft is associated with morbidity, including the risk of infection, bleeding, and increased postoperative pain and there is a limit to the amount of bone that can be harvested<sup>[28,36]</sup>. Another form of bone graft, allograft is a major form of bone graft substitute used clinically. Human demineralized bone matrix, calcium sulfate, calcium phosphate cement and nanocrystalline hydroxyapatite have been used as reasonable alternatives to autograft in calcaneal fractures<sup>[40,41]</sup>.

The primary limitation of our study was that it was a small prospective comparative study including small number of patients and done at a single-center. Larger randomized controlled trials are needed to further evaluate usefulness of bone grafting in displaced intraarticular calcaneal fractures.

This study concludes that bone grafting leads to better anatomical restoration of calcaneal anatomy and earlier return to full weight-bearing. Though intermediate and long-term efficacy outcomes in both the groups were similar, it can be suggested that bone grafting should be added to plate osteosynthesis of intra-articular calcaneal fractures with large fracture void and cancellous bone collapse.

## CONCLUSION

Despite its rarity, a tumor involving the subscapularis should be considered for any young patients presenting with an isolated loss of external rotation of the glenohumeral joint. A high index of suspicion based on clinical examination and MRI study may contribute to earlier diagnosis of these tumors.

## CONFLICT OF INTEREST

None.

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