International Journal of Orthopaedics Sciences

E-ISSN: 2395-1958
P-ISSN: 2706-6630
IJOS 2020; 6(2): 452-458

www.orthopaper.com
Received: 25-01-2020
Accepted: 27-02-2020

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Early comparative analysis of functional outcome between open reduction and internal fixation and conservative treatment for closed, displaced, intra-articular fractures of the calcaneum, a randomised study

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DOI: https://doi.org/10.22271/ortho.2020.v6.i2g.2080

Abstract
Background: Calcaneum fracture contributes to significant morbidity to the patients. Therefore debate continues regarding choice of its management, between open reduction internal fixation and closed treatment. The aim of this study was to compare the outcomes of open reduction and rigid internal fixation of displaced calcaneal fractures using locking plate with that of non-operative treatment.
Materials and Methods: Thirty patients with thirty-two displaced intra-articular calcaneal fractures were selected during July 2016 to June 2017 with taking inclusive and exclusive criteria into account and randomly allocated to surgical and non surgical groups. First group of patients was treated with open reduction and internal fixation using reconstruction plate and screws through lateral extensile approach. Patients in second group were treated with closed reduction and cast immobilization using *Omoto technique*. The observations in both the groups were analyzed and compared.
Results: The significant difference between the outcomes of surgical treatment and nonsurgical method were noted. The fracture got united between 12 -16 weeks and no case of non-union has reported. Few patients had reported with wound related complications and were managed with antibiotics and regular antiseptic dressings. The functional assessment of patients during follow ups has suggested that 87.5% patients of operated group has good to excellent outcome while 87.5% patients of conservatively managed patients has good to fair outcome.
Conclusion: Open reduction and internal fixation of close displaced calcaneal fractures in absence of severe osteoporosis, comminution, and co-existing morbidity may be the preferred method of treatment.

Keywords: Calcaneum fracture, intra-articular, internal fixation, bone plates, close reduction, omoto technique

Introduction
Calcaneal fractures were first described by Malgaigne in 1843. It is the commonest fractured tarsal bone (60% of all tarsal bones) and in 5-10% cases both calcaneum are fractured[1]. It accounts approximately 2% of all fractures and 10% patients of calcaneum fracture has open injuries [2-4]. Nearly 10% of calcaneum fractures are associated with injuries of spine, pelvis and hip [2, 3]. It is more common in male specially in industrial workers and age group of 21-45 years [2, 3].

Material and Methods
A prospective randomized study was carried out on 30 patients with 32 displaced intra-articular calcaneum fracture(s) attending the Emergency and OPD of Orthopedics at Silchar Medical College and Hospital, Silchar, Assam from 1st July 2016 to 30th June 2017. Patients were divided into two groups operative (15 cases) and conservative (15 cases) according to randomization sequence. Patients in Group A were managed with ORIF while those in Group B were managed with closed reduction by 'Omoto technique' and below knee POP cast application. Immediate post-op/post-cast check x-rays were taken in both axial and lateral views. The correction of the deformity was checked and any displacements were noted.

Information on gender, age, mechanism of injury, side, fracture classification with associated injuries, etc. was recorded for these patients.

Table 1: Inclusion and exclusion criteria's taken in the present study

Inclusion Criteria	Exclusion Criteria
• Patients who gave consent for study • Age > 18 years • Fracture less than 3 weeks old • Fracture with displacement >2mm • Fracture with Sander's type II, III & IV classification	• Patients who did not give consent for study • History of drug or alcohol abuse • Patient unlikely to cooperate or attend all schedule visits • Patients with previous calcaneum pathology (infection; tumor; fracture) • Open calcaneum fracture • Extra- articular calcaneum fractures • Sander's Type I calcaneum fractures • Associated neurovascular injury

Surgical Procedure: Standard lateral extensile approach to the calcaneum was used. Fracture was reduced, articular congruity was confirmed using c-arm imaging followed by fixation with calcaneal plate and locking cancellous screws. Wound was closed with application of drain.

Post-operative care: Limb was immobilized in below knee splint with the advice for active toes movements and elevation. Analgesics were given as per requirement. Antibiotics (intravenous/ oral) were administered every 12 hourly till stitches were removed. Antiseptic wound dressing was done every alternate day. Early ROM exercise was encouraged.

Closed reduction Technique (*Omoto technique*) [5]: Patient was placed prone under sedation. One assistant supported the thigh while surgeon stands on the foot end of the patient and applied medial and lateral pressure of the heel. Then the surgeon gave a longitudinal traction in the line of leg. Heel varus or valgus was corrected and tuberosity was manipulated. Finally below knee POP cast was applied in standard neutral position of 90^0 angles between the foot and the tibia.

Rehabilitation: Post-cast pain and swelling were managed using anti-inflammatory analgesics and limb elevation along with advice to perform active toe movements from day one. Cast was removed after 2 months and physiotherapy started. Partial weight bearing was started after 12 weeks and full weight bearing was allowed after 14-16 weeks in all conservatively treated cases.
In all operated cases partial weight bearing was started after 8-10 weeks and full weight bearing was allowed only after union and subsidence of pain at about 12 weeks.

Follow-ups: Patients were followed up at 3, 6, 9, 12 week time and then every 3 months.

Parameters for evaluation: The fracture was considered united when clinically there was no tenderness and subjective complaints (if any) were noted at every follow up.

- **Radiographic Assessment:** to assess consolidation or post reduction collapse and to note any displacement. The fracture was considered united when the fracture line was not visible and establishment of trabecular continuity between the two fragments on axial and lateral x-rays. All radiological parameters of outcome (Bohler's angle, Gissane angle, height, width etc.) were noted at every follow up.
- **Functional Assessment**: The results were assessed using American Orthopaedic Foot Ankle Society (AOFAS) Ankle-Hindfoot Score [5]. This takes the following items into consideration: intensity of pain; function, including restraint of activities and the need for support with an orthosis; maximum walking distance measured by blocks; abnormality of gait; sagittal mobility (flexion and extension); hindfoot mobility (inversion and eversion); the antero-posterior and varus-valgus stability of the ankle and hindfoot and the alignment of the foot and ankle. The scores for each item were added together, providing a total between 0 and 100.

Statistical Analysis: Statistical testing of data was done with statistical package of social science system version 22.0. Continuous variables were presented as mean±SD. Categorical variables are presented as absolute numbers and percentage. Paired t test was used for comparison of preoperative v/s post-operative and pre casting v/s post casting measurements while unpaired t- test was used for post-operative v/s post- manipulation measurements. *p-values* were calculated and differences between the two groups were considered significant if the *p-value* was less than 0.05. Pearson correlation coefficient was calculated for determining the correlation between radiological and functional outcome.

Results

All 30 patients were followed up successfully during the study period. Of these 26 patients were male and 4 patients were female (M:F= 6.5:1). In this study, the youngest patient was 19 years of age and the oldest was 75 years of age. The mean age at presentation was 30.7 ± 11.06 years. The maximum numbers of cases were between 21 to 30 years of age (33.33%). 2 patients had fracture on bilateral sides. The commonest mode of injury was fall from height in 90% cases, followed by RTA accounting for 10% of patients. There were total of 8 fractures of Sander's Type II (25%), 18(56.25%) fractures of Sander's Type III and 6(18.75%) of Sander's Type IV fracture. There were 2 (6.67%) cases with associated spinal injury one at L1 vertebra and other at D12 vertebra. There was one case (3.33%) of fracture left superior and inferior pubic rami of pelvis. Both the cases of spinal injury were not associated with neurological deficit and were managed conservatively. The average time interval between trauma and surgery was 11.25 ± 1.78 days (range 9 to 14 days), while between trauma and cast application was 11.31 ±1.69 days (range 9 to 14 days). We had either operated or applied cast to all the cases after the wrinkle sign was positive.

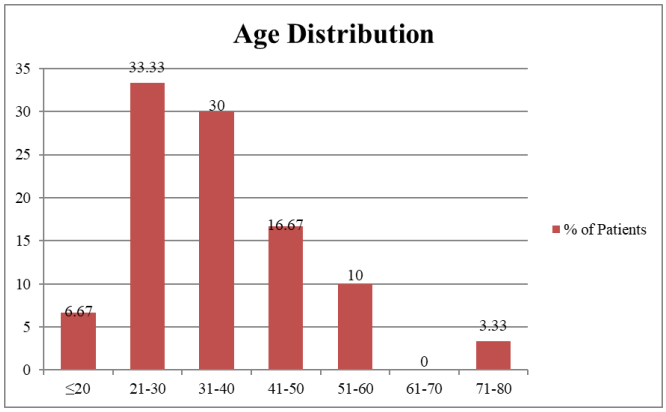


Fig 1: Age Distribution of Patients

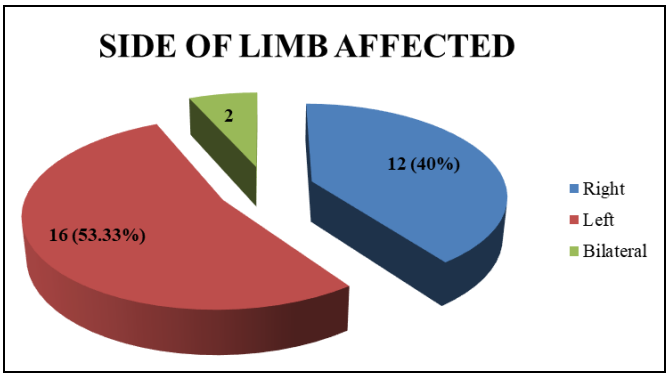


Fig 2: Side of limb affected

Table 2: Duration of surgeries with their types as per Sander's Classification

Type Of Fracture (Sander's Classification)	Duration Of Surgery (In Minutes)
TYPE II	81.25±6.25
TYPE III	85.56±7.16
TYPE IV	91.67± 5.57

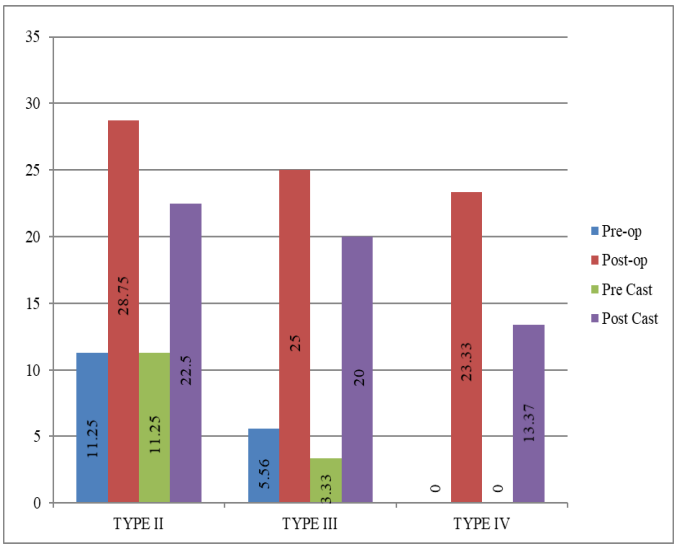


Fig 3: Mean Bohler's Angle (In Degree) with different Sander's Type Fracture

We had achieved an increase in Bohler's angle in both the groups post intervention. The Bohler's angle improved from $5.94^0 \pm 4.32^0$ to $21.25^0 \pm 4.84^0$ in operative group and from $5.0^0 \pm 5.63^0$ to $19.38^0 \pm 2.78^0$ in manipulation group. The increase was significantly more after plate osteosynthesis than post-manipulation ($p<0.05$).

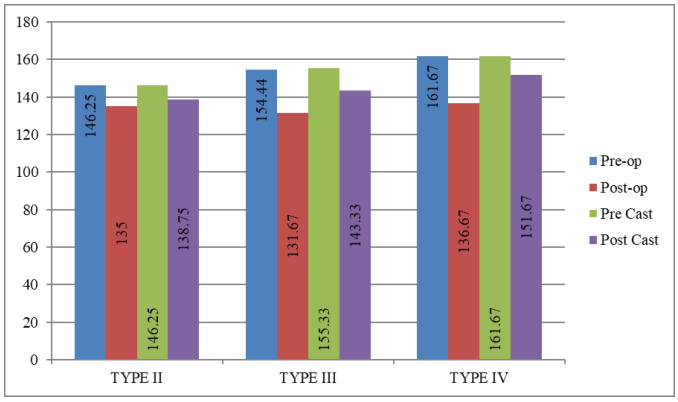


Fig 4: Mean Gissane's Angle (In Degree) with different Sander's Type Fracture

Both the methods used had resulted into decrease in Gissane's angle. The Gissane's angle changed from $153.75^0 \pm 5.78^0$ to $133.44^0 \pm 3.82^0$ in operative group and from $153.13^0 \pm 6.43^0$ to $143.75^0 \pm 4.36^0$ in manipulation group post intervention. The Gissane's angle was decreased significantly after plate osteosynthesis than after manipulation ($p<0.05$).

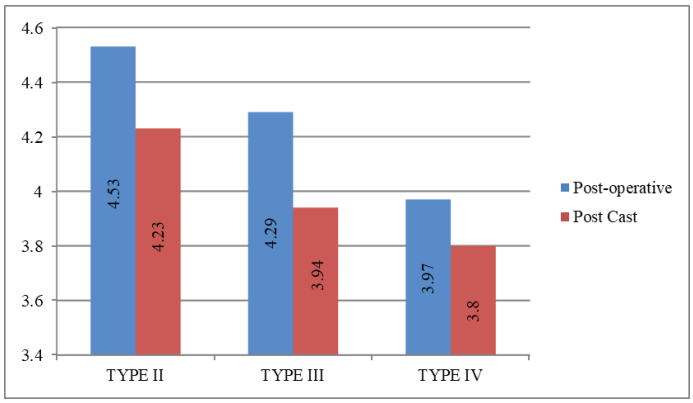


Fig 5: Correlation between Post-Operative and Post-Conservative Calcaneal Height with Sander's Types

The total calcaneal height in operative group improved from preoperative value of 3.64±0.22cm to postoperative value of 4.29 ±0.18cm. The total calcaneal height improved from 3.60±0.23 cm to 3.99 ±0.15 cm in conservative group. The calcaneal height was increased significantly after plate osteosynthesis than after manipulation ($p<0.05$).

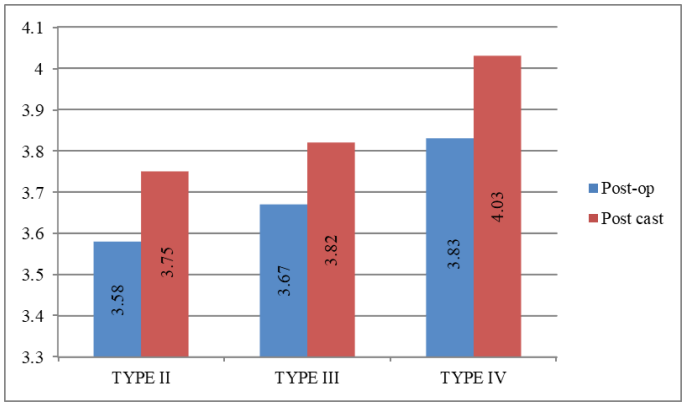


Fig 6: Correlation between Post-Operative and Post-Conservative Calcaneal Width with Sanders Type

The calcaneal width improved from its preoperative value of 4.21±0.19 cm to postoperative value of 3.68±0.09 cm in surgically managed group. The calcaneal width changed from

4.21±0.13 cm to 3.84±0.10 cm in conservative group. The decrease in calcaneal width was significantly more after plate osteosynthesis than after manipulation (p<0.05).

The average time of union in operated cases was 13.75 ±1.44 weeks (range = 12 to 16 weeks) while in conservatively managed cases was 13.13 ±1.13 weeks (range = 12 to 16 weeks). Maximum number of fractures united between 12 to 14 weeks (93.75%) in both the groups. No case of nonunion was encountered in either group. The result was not statistically significant.

Functional Evaluation by American Orthopaedic Foot Ankle Society (Aofas) Ankle-Hindfoot Score [6]

The functional outcome was assessed using AOFAS score at last follow up or minimum after 3 months.

Table 3: Functional outcome using AOFAS Ankle-Hindfoot Score

Outcome	Aofas Score
Excellent	90 to 100
Good	80 to 89
Fair	70 to 79
Bad	below 69

Table 4: AOFAS Ankle-Hindfoot Score in different Sander's Type in both groups

Aofas Score		Sander's Classification		Total
	Type II	Type III	Type IV	
Operative Group	95±1	88.67±2.46	77.33±5.56	88.5±5.81
Conservative Group	84.25±1.25	77.11±4.96	70.0±5.33	77.56 ±5.80

On statistical analysis of post-operative and post-conservative AOFAS score, the result was statistically significant (p<0.05). The AOFAS score was increased significantly after plate osteosynthesis than after conservative management.

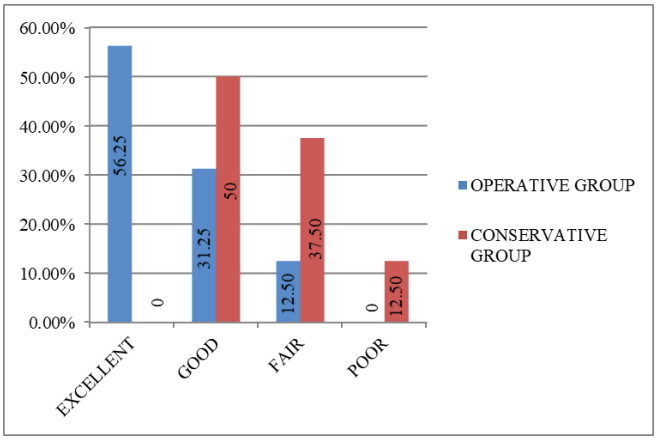


Fig 7: Correlation between AOFAS Score for Operative And Conservative Group

Complication: Superficial wound defect at the corner of skin incision site was observed in 2 cases of Sander's Type III fracture and 1 case of Sander's Type IV fracture (18.75%), managed with extended antibiotics and regular antiseptic dressings. Only 1(6.25%) case with Sander's Type III fracture presented with severe defect of the soft tissue. There was wound edge necrosis with wound gaping and slough formation. Wound debridement and secondary suturing was done to manage the defect. The wound healed with extended intravenous antibiotics and regular antiseptic dressing. No case presented with severe soft tissue complication for which plate removal was required. Only one case presented with varus malunion (<10^0) of the calcaneum but at last follow up the functional outcome was good. There was no case of post-operative loss of reduction, screw loosening or implant failure.

Among conservatively managed group 2 cases (12.5%) had reported with superficial skin necrosis which was healed by removal of cast, application of below knee slab with oral antibiotics and regular antiseptic dressings. Below knee cast was applied after wound healing. Four case presented with varus malunion (<10^0) of the calcaneum and at last follow up, two of them presented with good functional outcome but two had poor functional outcome. Five patients developed heel pad problems.

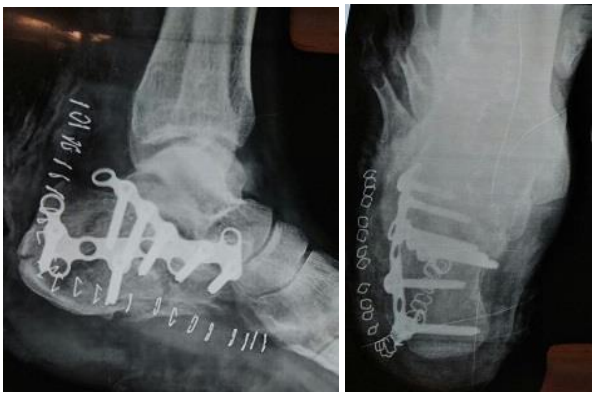
No case presented with other complications like compartment syndrome, blisters, peroneal tendinitis, sural nerve hypoesthesia, tarsal tunnel syndrome, tendon dislocation and reflex sympathetic dystrophy in either group.

Fig 8: Post-operative infected wound on 3rd week

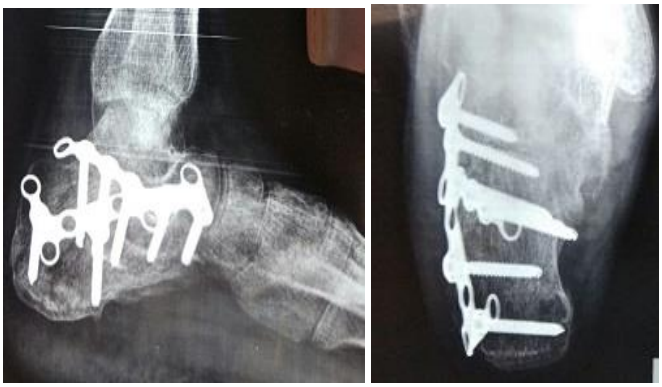
Case Images

Operative Patient (25 year Male with Sander's Type III fracture)

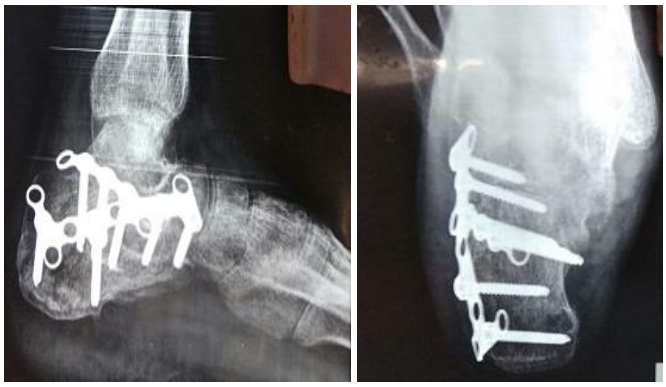
Pre-op X-ray



Immediate post-op x-ray



3 wks follow-up



3 months follow-up

9 months follow-up

Clinical photographs after 6 months of follow-up

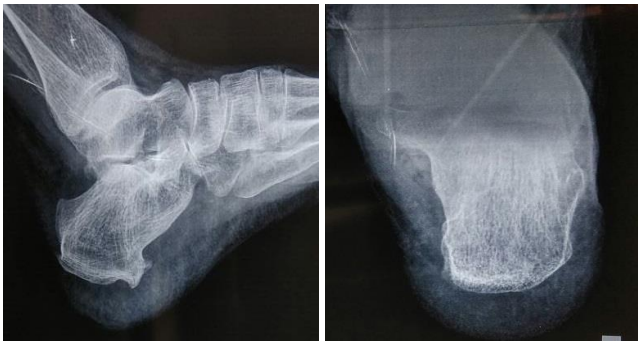
Conservative Patient (75 years Female with Sander's Type III fracture)

Pre-manipulation x-ray

Immediate post-manipulation x-ray

3 weeks follow-up

3 months follow-up



6 months follow-up

Clinical photographs after 6 months follow-up

Discussion

Fracture of the calcaneus are serious injuries, commonly affect young and active individuals, and are often associated with long term sequelae, permanent disability, a considerable reduction in quality of life, and high socio-economic costs. The majority of published series on operative treatment of calcaneal fractures have employed a lateral approach through which reduction of the calcaneal body and restoration of calcaneal height, length, and width was consistently reproducible, irrespective of the extent of comminution [7-29]. In the last decade, open reduction and internal plate fixation of displaced intra-articular calcaneal fractures has become a standard surgical method with low complication rate and better quality of life after the surgery. By implanting locking compression plates, the osteosynthesis becomes more stable, enables earlier weight bearing, and bone grafting is rarely necessary [30-33].

There has been lot of studies done to evaluate the effectiveness of surgical management of calcaneum fracture and to compare its effectiveness with conservative management. O'Farrell *et al.* [34] has shown that patients managed by surgery had a significantly more stable calcaneal height and width than the patients with conservative treatment. Cheng Long *et al.* [35] had found in their study that the mean time for calcaneum fracture to unite was 3.2 months which is comparable to the result of our study. Vaclav Rak *et al.* [36] confirmed correlation between the Böhler´s angle size and patient satisfaction. O'Farrell *et al.* [34] shows that non-surgically treated patients had a significantly higher mean Gissane's angle than those surgically treated.

Buckley *et al.* [37] and Hart *et al.* [22] and a lot of other authors, has confirmed the role of Böhler´s angle size as a predictive factor for subsequent late complications. The studies done by O'Farrell *et al.* [34], Buckley *et al.* [37], Ibrahim *et al.* [38] and Thordarson *et al.* [9] shows that soft tissue complications are more in operated cases and other complications like varus mal-union, heal pad problems, restriction of sub-talar joint movements are more in conservative cases.

All these observations are similar and comparable with our study.

Conclusion

Open reduction and internal fixation with locking calcaneal plate gives a good functional outcome, even when bone grafts are not used manifested by restoring anatomical reconstruction of height, width, Bohler's and Gissane's angles of the calcaneum, and allowing early mobilization in comparison to conservative treatment. However larger study with longer duration of study is needed for evaluation.

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