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Dr. Paresh V Patil
Professor, Department of Orthopaedic, Krishna Institute of Medical Sciences, Karad, Maharashtra, India

Dr. Mithilesh A Nikam
Junior Resident, Department of Orthopaedic, Krishna Institute of Medical Sciences, Karad, Maharashtra, India

Dr. Priyambada Kumar
Junior Resident, Department of Orthopaedic, Krishna Institute of Medical Sciences, Karad, Maharashtra, India

Corresponding Author:
Dr. Mithilesh A Nikam
Junior Resident, Department of Orthopaedic, Krishna Institute of Medical Sciences, Karad, Maharashtra, India

Percutaneous cannulated cancellous screw fixation v/s open reduction and internal fixation with plating for intra-articular calcaneal fractures

Dr. Paresh V Patil, Dr. Mithilesh A Nikam and Dr. Priyambada Kumar

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Abstract
Introduction: The calcaneus is the largest tarsal bone and the most commonly fractured. Calcaneal fractures account for about 2% of all fractures, with 75 percent of these being intra-articular. Anatomic restoration in intra-articular calcaneal fractures was not always associated with a positive outcome in terms of quality of life, hence the best treatment option is still up for debate. Open reduction and internal fixation (ORIF) is considered an exemplary modality for treating calcaneal fractures. Soft tissue complications after ORIF procedures, on the other hand, have been reported to be as high as 30%. Scholars have advocated external fixation, percutaneous cannulated cancellous screw fixation, and Schanz pin assisted reduction and fixation as minimally invasive methods to reduce postoperative problems. In the present study, we aim to study the outcome of intra-articular calcaneum fractures treated with percutaneous cannulated cancellous screws V/S open reduction internal fixation with calcaneum plates.
Materials and Methods: 22 patients with intra-articular calcaneum fracture (with displacement > 2mm) were recruited for the study after taking informed written consent. Patients were divided randomly into 2 groups; Group A were treated with minimally invasive percutaneous cannulated cancellous (CC) screw fixation. While patients in Group B were treated with open reduction internal fixation (ORIF) with plating. The study was a randomized controlled trial conducted at Krishna Institute of Medical Sciences, Karad during the period of May-2020 to May-2021. Pre-operative and post-operative Bohler's angles were calculated using PACS, functional outcome was assessed at 6 months post-operatively using AOFAS score and post operative pain was assessed using VAS score.
Results: The present study indicated no significant difference in the post-operative maintenance of Bohler's angle when operated by either of the techniques. But, functional outcome in terms of AOFAS score when assessed at the end of 6 months indicated an excellent and good outcome in patients operated with cannulated cancellous screws as compared to patients operated with ORIF with calcaneum plating. Post operative complications were reported significantly high in group of patients operated with ORIF with plating as compared to percutaneous CC screw group patients.
Conclusion: Percutaneous minimally invasive fixation using cannulated cancellous screws are better choice than ORIF with calcaneum plating due to lesser post operative pain and soft tissue complications, better functional outcome in terms of AOFAS score and lesser implant related soft tissue complications.

Keywords: cannulated cancellous screws, calcaneum plating, minimally invasive, Sander's classification, AOFAS, VAS, Bohler's angle

Introduction
The calcaneus is the largest and most frequently fractured tarsal bone [1]. It is a major weight bearing osseous pillar of the foot. Approximately 2% of all fractures are accounted by calcaneal fractures; 75% of them being intra-articular [2, 3]. With a preponderance for the male sex, most of these fractures occur in young adults, secondary to high-energy injuries such as fall from height or RTA.15% of these injuries are compound, with 5–10% of them resulting in a bilateral involvement [4, 5].
With conservative treatment alone, the calcaneus heals eventually, but remains deformed. This leads to an incongruent subtalar joint, which on weight bearing gives rise to a painful and arthritic joint surface [6]. Traditionally, displaced intra-articular calcaneal fractures were treated conservatively as predictable operative reduction and fixation were not feasible [7].

As fracture care improved over time, operative reduction became popular. However, Anatomic restoration did not necessarily associate with a fruitful outcome in terms of quality of life and hence, the optimal treatment modality still remains a matter of debate. Although modern operative interventions have improved the functional outcome in many patients, a consensus on the ideal treatment modality or postoperative management seems to be lacking till date [8].

Open reduction and internal fixation (ORIF) is considered an exemplary modality for treating calcaneal fractures [8]. It enables clear visualization, and allow direct reduction of fracture fragments, to better restore the anatomical position of the subtalar joint. However, the incidence of soft tissue complications after ORIF procedures; such as wound infection, suture line dehiscence, skin necrosis; have been reported to be as high as 30% [9]. These complications seem to be the major culprit behind the procedure's poor prognosis. To reduce postoperative complications, scholars have proposed various minimally invasive alternatives such as external fixation, percutaneous fixation, Schanz pin assisted reduction and fixation, and arthroscopically assisted operation [10-12]. These techniques effectively reduce complications related to soft-tissue damage and hence lower the incidence of wound-related post-operative complications, while still allowing a satisfactory fracture reduction [13-15].

In the present study, we aim to study the outcome of intra-articular calcaneum fractures treated with percutaneous cannulated cancellous screws V/S open reduction internal fixation with calcaneum plates.

Materials and Methods

The study was a randomized controlled trial conducted at Krishna Institute of Medical Sciences, KARAD during the period of May-2020 to May-2021. 22 patients with intra-articular calcaneum fracture (with displacement > 2mm) were recruited for the study after taking informed written consent. Patients were divided randomly into 2 groups; patients in Group A were treated with minimally invasive percutaneous cannulated cancellous (CC) screw fixation. While patients in Group B were treated with open reduction internal fixation (ORIF) with plating. All patients were evaluated pre-operatively using plain radiographs of the calcaneum in lateral and axial views, and computed tomography (CT) scans. According to the CT scan results, the pattern of injury was classified according to Sanders classification [18], and the radiological parameters of the calcaneus were measured. Pre-operative and post-operative Bohler's angles [17] were calculated using PACS, functional outcome was assessed at 6 months post-operatively using AOFAS score [16] and post operative pain was assessed using VAS score. The study was approved by the Institutional Ethical and Research Committee. All patients signed a written and informed consent before enrolling in the study.

Inclusion Criteria

1. Patients above 18 years of age
2. Patients of either sex
3. Unilateral intra-articular calcaneum fracture with >2mm displacement with Sanders Type II/III/IV fracture pattern according to CT scan
4. Closed fractures
5. Nondiabetic patients

Exclusion Criteria

1. Compound fractures
2. Pathological fractures
3. Other Fractures of ipsilateral lower limb
4. Patients with previous history of ipsilateral calcaneum fracture

Operative Technique

All patients were given single dose of intra-venous antibiotic (Inj. Ceftriaxone 1.5gm) 30 min prior to surgery.

Percutaneous CC screw fixation

Patients in Group A underwent percutaneous reduction with CC screw fixation. A 3.5-mm Steinmann pin was inserted over the calcaneal tubercle transversely, traversing from the medial to lateral side, and was used to apply traction. The pin was pulled along the axis of the calcaneus, primarily to restore it's height and length. Another 3.5-mm Steinmann pin was then introduced along the postero-superior portion of the calcaneus, through the fracture fragment, along its axis in order to reduce the posterior facet. It was ensured that the tip of the pin was placed on the major fracture fragment and not beyond the fracture line. The surgeon performed repeated percutaneous leverage by using these pins inserted sagittally, to achieve acceptable reduction of the fracture fragments. The reduction was confirmed under guidance of the C-arm image intensifier. A guide pin was then inserted adjacent to the lateral edge of the Achilles tendon from the postero-superior portion of the calcaneal tubercle, and advanced up to the distal part of the fracture. Another guide needle was inserted percutaneously from a point approximately 0.5 cm lower to the insertion point of the Achilles tendon, and was advanced across the fracture line up to the anterior part of the calcaneus. After satisfactory positioning of the guide pin as confirmed radiologically, 6.5-mm diameter partially threaded CC screws were inserted over the guide pins to achieve the axial support fixation of the calcaneus. (Figure 1)

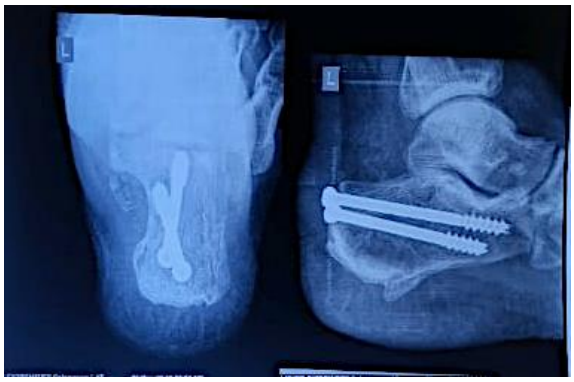

Fig 1: Post operative radiograph showing percutaneous fixation with cannulated cancellous (CC) screws

Open reduction internal fixation with plating

L shaped skin incision was taken, with it's vertical arm running midway between the posterior border of fibula and the tendoachillis, while it's horizontal arm placed along the line of base of 5th metatarsal. A thick flap was elevated, including the subcutaneous tissue along the line of skin incision. Once the lateral wall of the calcaneus and the subtalar joints were exposed, the full-thickness flap was retracted out of the surgical field with three 2.0-mm Kirschner wires (1 each in the fibula, talar neck, and the navicular respectively). A Steinmann pin was utilised for applying axial traction and reducing the displaced articular surface to restore the calcaneal shape. Once satisfactory reduction was achieved, an especially designed malleable lateral calcaneal plate was used for rigid fixation. A Romovac drain

was then inserted into the incision, and the incision was closed in layers, followed by compression bandaging (Figure 2)

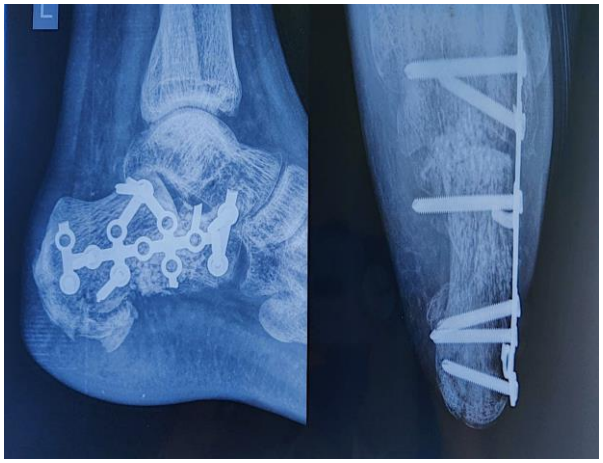

Fig 2: Post operative radiograph showing open reduction internal fixation with laterally placed calcaneum plate

Post Operative Protocol

- Intra-venous triple antibiotics regimen was adopted for 3 days followed by oral antibiotic for 3 days.
- Sutures were removed after 12 days and below knee cast applied if local skin condition permitted.
- Patients were kept non weight bearing with a posterior slab till suture removal, after which a below knee cast was done by post operative day 11 if the local skin condition permitted.
- Radiographs were taken on post operative day 1. At 6 weeks X-rays were done after removing below knee cast. Gradual weight bearing was started at 12-16 weeks post operatively to full weight bearing in accordance with union assed radiologically and clinically.
- Patients were followed up at 6 weeks, 3 months and 6 months post operatively.

Statistical Analysis

There was no bias of sex, age, mechanism of injury while choosing the samples. All data was entered the Microsoft Excel spreadsheet and variables were analysed using SPSS software. Continuous data with a normal distribution were expressed as mean±standard deviation. Preoperative and postoperative calcaneal anatomical parameters were compared by a unpaired t-test. A p-value <0.05 indicated a statistically significant difference.

Observations and Results

Patients ranging from 18-50 years of age were included in the present study. 16 males and 6 females were enrolled in the study. Right side showed predominant involvement in our study. Most common mode of trauma was fall from height. The demographic data in the present study is depicted in Table 1, Table 2, Table 3 and Table 4.

Table 1: Age distribution

Age (Years)	No. of Patients
<20 years	1
20-30 years	10
31-40 years	7
41-50 years	4
>50 years	0
Total	22

Table 2: Gender distribution

Gender	N	Percentage
Male	16	72.73%
Female	6	27.27%

Table 3: Side distribution

Side	N	Percentage
Right	15	68.18%
Left	7	31.82%

Table 4: Mode of trauma

Mode Of Trauma	N	Percentage
Fall From Height	18	81.81%
Rta	4	18.19%

Table 5 depicts the pre-operative Bohler angle calculated in all patients. The Bohler's angle was calculated using PACS radiological system. Table 6 depicts the post-operative Bohler angles in Group A and Group B respectively.

Table 5: Pre-operative Bohler angle

Pre-Operative Bohler Angle	N	Percentage
<20	15	68.18%
21-25	4	18.18%
26-30	2	9.09%
31-35	-	-
>36	1	4.55%

Table 6: Post-operative Bohler angle in both groups

Post-Operative Bohler Angle	Group A (N)	Group B (N)
<20	-	-
21-25	2 (9.09%)	3 (13.63%)
26-30	17 (77.27%)	15 (68.19%)
31-35	2 (9.09%)	2 (9.09%)
>36	1 (4.55%)	2 (9.09%)

Table 7 depicts the average VAS score in patients of both groups immediately post-operatively and at each follow up.

Table 7: Average VAS score in each group

Post-Operative Follow Up	Vas Score In Group A (Mean+/-Sd)	Vas Score In Group B (Mean+/-Sd)
24 Hours Post Operatively	6.2+/-0.8	8.4+/-0.6
6 Weeks	2.1+/-0.7	4.8+/-0.5
3 Months	1.8+/-0.4	3.2+/-0.6
6 Months	1.2+/-0.3	2.9+/-0.4

Table 8 shows the functional outcome in terms of AOFAS score at 6 months post-operatively in both groups.

Table 8: Functional outcome (AOFAS score) at 6 months post operatively

AOFAS Score At 6 Months Post Operatively	Group A	Group B
Excellent (90-100)	14 (63.64%)	2 (9.09%)
Good (80-89)	7 (31.81%)	10 (45.46%)
Falr (65-79)	1 (4.55%)	6 (27.27%)
POOR (<65)	0	4 (18.18%)

Table 9 enlists the complications faced in patients of both groups. Two patients (One in percutaneous CC screw group and one in calcaneum plating group) showed evidence of superficial infection in our study. They were treated uneventfully with serial dressing and course of antibiotics. One patient in plating group showed evidence of deep infection. Local debridement led to hardware exposure. Vacuum assisted dressing had to be done for the patient. Skin necrosis around the suture line was seen in two patients in the plating group. Episode of peroneal tendonitis was reported in one patient in plating group, which was treated conservatively.

Table 9: Post-operative complications

Complications	N (Group A)	N (Group B)
Superficial Lnfectlon	1 (4.55%)	1 (4.55%)
Deep Infection	0	1 (4.55%)
Skln NECROSIS	0	2 (9.09%)
Peroneal Tendonitis	0	1 (4.55%)
Sural Nerve Injury	0	0

Fig 3: Skin necrosis observed in a patient operated with calcaneum plating on post operative day 7

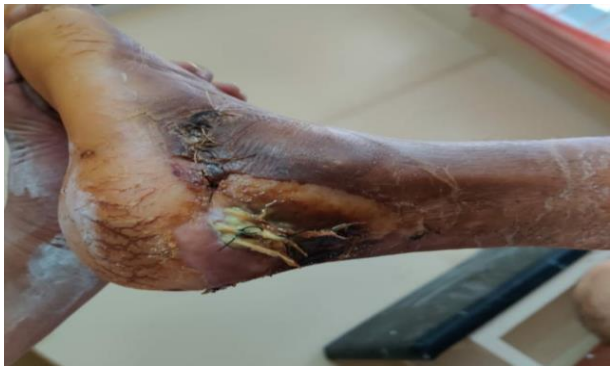

Fig 4A: Deep infection with slough reported in a patient at post operative day 10

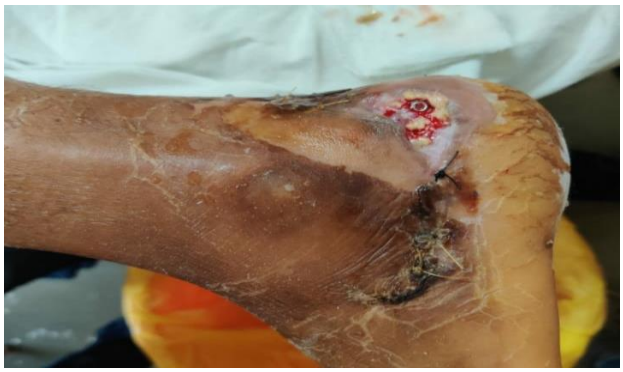

Fig 4B: Local debridement led to exposure of the hardware in the same patient

The calcaneus is the largest and most common fractured tarsal bone. Calcaneal fractures account for about 2% of all fractures, and 70% of them are intra-articular. Most of these fractures occur in young adults (males> females), secondary to high-energy trauma mostly due to fall from height or road traffic accidents. Calcaneum fractures were historically managed conservatively and that was considered the gold standard of treatment [19, 20]. However, over the years, various methods of internal fixation started showing excellent results [21, 22].

The present study aims to assess the efficacy of percutaneous cannulated cancellous screws v/s open reduction internal fixation with calcaneal plating in terms of maintenance of Bohler angle post-operatively, post operative pain as judged by VAS score, functional outcome in terms of AOFAS score and post operative complications.

In this study, majority of the patients belonged to the age group of 20-30 years. Maximum number of patients were males with predominantly right sided calcaneus fracture. Most common mode of trauma was fall from height. This was in accordance with the study conducted by Ming Li *et al* (2020) [23] which also showed a male preponderance, with dominant right side involvement, and the most common mode of trauma being fall from height.

The present study indicated no significant difference in the post-operative maintenance of Bohler's angle when operated by either of the techniques ($p>0.005$). This was similar to the findings of Pareek *et al* (2021) who concluded that the difference between post-operative bohler's angle in both groups was not significant.

Functional outcome in terms of AOFAS score when assessed at the end of 6 months indicated an excellent and good outcome in 63.64% and 31.81% patients respectively when operated with cannulated cancellous screws. No poor outcomes were reported in this group. In patients operated with calcaneum plates, only 9.09% patients showed an excellent outcome. Good, fair and poor outcomes were seen in 45.46%, 27.27% and 18.18% patients in Group B respectively.

Tornetta *et al*. [24] reported 46 patients with calcaneal fractures treated by percutaneous internal fixation and found that 85% of patients obtained good results. In a study conducted by Pareek *et al*, all of the patients treated by percutaneous cc screw fixation for calcaneum fractures in this study yielded either excellent or good results whereas those treated by plating yielded variable results.

Due to the dense tissue around the calcaneus, the inflammatory reaction and swelling of the tissue commonly cause severe pain, especially during the first 3 postoperative days [25]. Mean VAS score at the end of 6 months was significantly lower in patients operated with CC screws as compared to those operated with calcaneum plates ($p<0.005$).

In the present study, 3 patients (1 in Group A and 2 in Group B) developed superficial infection which was treated with serial dressing and oral antibiotics. 1 patient treated with plating developed deep infection, which was treated with debridement, followed by VAC dressing. 2 patients treated with calcium plating showed evidence of skin necrosis. 1 patient treated with calcaneum plating reported incidence of peroneal tendonitis due to mechanical irritation caused by the implant. No cases with sural nerve injury were reported in the present study. Prolonged operative time and extensive exposure of incisions can significantly increase the incidence of infection complications [26, 27].

Agren *et al*. [28] also indicated that the reduction of soft-tissue complications was a beneficial factor for postoperative

functional recovery. In a study conducted by Ming Li et. Al it was showed that the complication rate of patients treated with calcaneum plates was high, at 10.8%, while that in patients treated with percutaneous CC screws was only at 3.2%. The incidence of complications from the incision for percutaneous reduction and hollow screw fixation was significantly reduced, which may be related to the smaller incision and shorter operative time.

Conclusion

Although a study with a larger sample size is warranted for a definitive conclusion, it is safe to conclude that percutaneous minimally invasive fixation using cannulated cancellous screws are better choice than calcaneum plating due to lesser soft tissue complications such as infections, skin necrosis and hardware exposure. The quality of fracture reduction in terms of maintainence of the Bohler's angle does not show significant difference by the two techniques. However it is safe to say that due to better functional outcome in terms of AOFAS score, lesser post0operative pain and lesser implant related soft tissue complications, percutaneous reduction and CC screw fixation is a safe and effective treatment choice for intra-articular calcaneal fractures as compared to plating. The author declares no conflicts of interest.

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