

Research Article

A STUDY FUNCTIONAL OUTCOME OF CALCANEAL FRACTURES TREATED BY PERCUTANEOUS CC SCREWS

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Abstract: **Introduction:** Displaced intra-articular calcaneal fractures are complex injuries that frequently result from high-energy trauma and are associated with prolonged disability and impaired functional outcomes. Although open reduction and internal fixation remain the conventional treatment, wound-related complications have encouraged the use of minimally invasive techniques such as percutaneous cannulated cancellous (CC) screw fixation. **Aim:** To evaluate the functional outcome and postoperative complications of displaced intra-articular calcaneal fractures treated with percutaneous cannulated cancellous screw fixation. **Materials and Methods:** This prospective hospital-based observational study was conducted in the Department of Orthopaedics, Andhra Medical College, King George Hospital, Visakhapatnam, between July 2023 and December 2024. Twenty-five adult patients with closed displaced intra-articular calcaneal fractures (Sanders type II and III) underwent closed reduction and percutaneous CC screw fixation under fluoroscopic guidance. Patients were evaluated clinically and radiologically during follow-up. Functional outcome was assessed at three months using the American Orthopaedic Foot and Ankle Society (AOFAS) Hindfoot Score. Postoperative complications and fracture union were also recorded. **Results:** The study included 20 (80%) males and 5 (20%) females, with a mean age of 32.8 years. Falls from height accounted for 72% of injuries, while 28% resulted from road traffic accidents. Sanders type II fractures constituted 64% of cases and Sanders type III fractures 36%. The mean interval to surgery was 9 days, and the average time to radiological union was 14 weeks. Based on the AOFAS Hindfoot Score, 20 patients (80%) achieved good outcomes, 4 (16%) had fair outcomes, and 1 (4%) had a poor outcome. The mean AOFAS scores for the good, fair, and poor groups were 84, 70, and 48, respectively. Postoperative complications were infrequent, with one superficial wound infection, two cases of wound dehiscence, and two cases of subtalar arthritis, all of which were managed successfully with conservative treatment. **Conclusion:** Percutaneous cannulated cancellous screw fixation is a safe and effective minimally invasive technique for selected displaced intra-articular calcaneal fractures. It provides satisfactory fracture union, excellent functional outcomes in the majority of patients, and a low incidence of wound-related complications. Careful patient selection, meticulous reduction, and appropriate postoperative rehabilitation are essential for achieving favourable clinical outcomes.

Keywords: Calcaneal fracture; Percutaneous fixation; Cannulated cancellous screw; AOFAS hindfoot score; Intra-articular fracture.

INTRODUCTION

Calcaneal fractures are the most common fractures of the tarsal bones and account for approximately 2% of all skeletal fractures and nearly 60–75% of all tarsal injuries. The majority are intra-articular fractures resulting from high-energy axial loading, most commonly following a fall from height or road traffic accidents. These injuries predominantly affect young working adults and are associated with substantial socioeconomic burden because of prolonged disability, delayed return to work, chronic pain, and impaired quality of life. Owing to the complex three-dimensional anatomy of the calcaneus and its intimate relationship with the subtalar joint, restoration of normal hindfoot biomechanics remains a significant surgical challenge.[1,2]

Displaced intra-articular calcaneal fractures frequently produce collapse of the posterior facet, widening of the heel, reduction in Böhler's angle, increase in Gissane's angle, and loss of calcaneal height. Failure to restore these anatomical parameters may result in subtalar arthritis, chronic heel pain, altered gait mechanics, peroneal tendon impingement, and long-term functional impairment. Accurate assessment using computed tomography (CT), particularly the Sanders classification, has therefore become the standard for evaluating fracture morphology and planning surgical intervention.[3,4]

The optimal management of displaced intra-articular calcaneal fractures continues to be debated. Conservative treatment avoids surgical complications but is often associated with malunion, persistent deformity, chronic pain, and decreased functional outcomes in displaced fractures. Conversely, open reduction and internal

fixation (ORIF) through the extensile lateral approach provides direct visualization and anatomical reduction but has been associated with wound edge necrosis, infection, sural nerve injury, and delayed soft-tissue healing because of the tenuous vascularity of the lateral hindfoot.[5,6]

To minimize these soft-tissue complications, minimally invasive techniques have gained considerable popularity during the past two decades. Percutaneous reduction with cannulated cancellous (CC) screw fixation preserves soft-tissue integrity while allowing restoration of calcaneal morphology under fluoroscopic guidance. The technique combines indirect reduction maneuvers with stable internal fixation, thereby reducing operative morbidity, shortening hospital stay, facilitating earlier rehabilitation, and decreasing wound-related complications without compromising fracture stability in appropriately selected patients.[7,8]

Several clinical studies have demonstrated encouraging outcomes with minimally invasive fixation techniques. Restoration of Böhler's angle, congruity of the posterior facet, and maintenance of calcaneal height have been shown to correlate strongly with improved functional outcomes and lower rates of subtalar arthritis. Furthermore, percutaneous fixation has been reported to achieve comparable functional scores to traditional ORIF while substantially reducing wound complications and the need for secondary procedures. Nevertheless, patient selection, fracture pattern, timing of surgery, and surgeon experience continue to influence clinical outcomes.[9]

Functional outcome following calcaneal fracture treatment is commonly evaluated using the American Orthopaedic Foot and Ankle Society (AOFAS) Hindfoot Score, which assesses pain, function, walking ability, gait, range of motion, stability, and alignment. Together with radiological assessment and complication analysis, the AOFAS score provides a comprehensive evaluation of treatment success and patient recovery.[10]

In view of the growing interest in minimally invasive management, the present prospective study was undertaken to evaluate the functional outcome of calcaneal fractures treated with percutaneous cannulated cancellous screw fixation. The study aimed to assess postoperative functional recovery using the AOFAS Hindfoot Score while documenting radiological restoration and procedure-related complications, thereby determining the effectiveness and safety of this minimally invasive surgical technique in the management of calcaneal fractures.

MATERIALS AND METHODS

Study design and setting

A prospective hospital-based observational study was conducted in the Department of Orthopaedics, Andhra Medical College, King George Hospital,

Visakhapatnam, India, between July 2023 and December 2024. The study included 25 consecutive adult patients with displaced intra-articular calcaneal fractures who underwent percutaneous cannulated cancellous (CC) screw fixation. Ethical approval was obtained from the institutional ethics committee, and written informed consent was obtained from all participants before enrolment.

Patient selection

Patients aged more than 18 years presenting within three weeks of injury with unilateral or bilateral closed intra-articular calcaneal fractures were included in the study. Fractures were confirmed radiographically and classified using computed tomography according to the Sanders classification. (FIGURE 1)

Patients with extra-articular fractures, open or infected fractures, skeletal immaturity, delayed presentation (>3 weeks), severe medical comorbidities precluding surgery, or refusal to participate were excluded from the study.

Preoperative evaluation

All patients underwent detailed clinical examination and routine preoperative investigations including complete blood count, renal and liver function tests, serum electrolytes, bleeding and clotting profile, chest radiography, electrocardiography, and viral serology. Standard radiographs of the calcaneum (axial and lateral views) along with computed tomography were obtained to assess fracture morphology and facilitate operative planning. Initial management consisted of limb elevation, ice application, compression, and immobilization until soft tissue swelling subsided. Surgery was scheduled after the appearance of the wrinkle sign, generally between 8 and 14 days after injury. (FIGURE 2)

Surgical technique

All procedures were performed under spinal anaesthesia with the patient positioned in the lateral decubitus position on a radiolucent operating table. A pneumatic tourniquet was applied, and prophylactic intravenous antibiotics were administered before skin incision.

Closed reduction was achieved under fluoroscopic guidance using a transverse Steinmann pin inserted into the calcaneal tuberosity. Reduction was performed according to the modified Essex-Lopresti technique, restoring calcaneal height, width, alignment, and posterior facet congruity. Temporary fixation with Kirschner wires was followed by definitive fixation using 4-mm and/or 6.5-mm cannulated cancellous screws introduced through stab incisions. Reduction was confirmed intraoperatively using lateral, axial, and Broden's fluoroscopic views before final fixation. Depending on fracture configuration, three to six screws were used to obtain stable fixation. (FIGURE 3)

Postoperative protocol

A below-knee plaster splint was applied immediately after surgery. Limb elevation and intravenous antibiotics were continued for five postoperative days. The splint was removed on the fifth postoperative day, and ankle range-of-motion exercises were initiated during the second postoperative week. Sutures were removed between two and three weeks following surgery. Patients remained non-weight-bearing until radiological evidence of union was achieved, after which gradual progression to full weight-bearing was permitted. Clinical follow-up was performed at 2–3 weeks, 3 months, and 6 months.

Outcome assessment

Functional outcome was evaluated using the American Orthopaedic Foot and Ankle Society (AOFAS) Hindfoot Score. The scoring system assesses pain (40 points), function (50 points), and alignment (10 points), providing a maximum score of 100. Outcomes were categorized as good (>75), fair (50–74), or poor (<50). The primary endpoint of the study was the AOFAS Hindfoot Score at three months after surgery, while postoperative complications were documented throughout the follow-up period.

Statistical analysis

Data were entered into Microsoft Excel and analysed using descriptive statistics. Continuous variables were expressed as mean and range, whereas categorical variables were presented as frequencies and percentages.



FIGURE 1: X RAY IMAGE SHOWING FRACTURE CALCANEUM

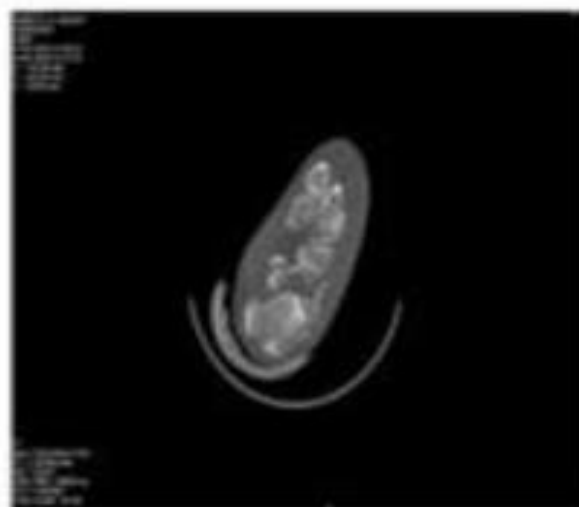


FIGURE 2: CT IMAGE SHOWING TYPE III FRACTURE



FIGURE 3: INTRAOPERATIVE IMAGES VIA C-ARM

RESULTS

Table 1. Demographic characteristics of the study population (n = 25)

Variable	Number	Percentage
Male	20	80.0
Female	5	20.0

Narrative

Twenty-five patients with intra-articular calcaneal fractures were included in the study. The majority were males (80%), while females accounted for 20% of the study population, indicating a marked male predominance among patients sustaining these high-energy injuries.

Table 2. Mode of injury

Mode of injury	Number	Percentage
Fall from height	18	72.0
Road traffic accident	7	28.0

Narrative

Falls from height constituted the predominant mechanism of injury, accounting for nearly three-fourths (72%) of all fractures. Road traffic accidents were responsible for the remaining 28% of cases, confirming that axial loading following falls remains the principal cause of intra-articular calcaneal fractures in this cohort.

Table 3. Distribution according to Sanders classification

Sanders type	Number	Percentage
Type II	16	64.0
Type III	9	36.0

Narrative

Based on computed tomography, Sanders type II fractures represented the majority (64%) of injuries, whereas Sanders type III fractures accounted for 36% of cases. No Sanders type IV fractures were included in the study, reflecting the selected patient population managed using percutaneous screw fixation.

The mean age of patients included in the study was **32.8 years** (range: **19–60 years**). Left-sided injuries were more common than right-sided injuries, accounting for **60%** and **40%** of cases, respectively. The average interval from injury to definitive surgery was **9 days**, with procedures performed between **5 and 13 days** after trauma. Radiological union was achieved at a mean duration of **14 weeks**. Functional outcome was assessed using the AOFAS Hindfoot Score at the end of three months following surgery.

Table 4. Baseline clinical characteristics of the study population (n = 25)

Variable	Value
Mean age (years)	32.8
Age range (years)	19–60
Left-sided fractures	15 (60%)
Right-sided fractures	10 (40%)
Mean day of surgery	9 days
Range of surgery	5–13 days
Mean radiological union	14 weeks

Narrative

The study population consisted predominantly of young adults with a mean age of 32.8 years. Left-sided injuries were more frequent than right-sided injuries. Definitive fixation was generally performed after subsidence of soft-tissue swelling, with surgery undertaken at a mean of 9 days following injury. Radiological union was achieved at an average of 14 weeks, demonstrating satisfactory fracture healing following percutaneous cannulated cancellous screw fixation.

Table 5. Functional outcome according to AOFAS Hindfoot Score

Outcome	Number	Percentage
Good (>75)	20	80.0
Fair (50–74)	4	16.0
Poor (<50)	1	4.0
Total	25	100

Narrative

Functional assessment at the final follow-up demonstrated encouraging clinical outcomes. Twenty patients (80%) achieved a good functional result, while four patients (16%) had fair outcomes. Only one patient (4%) had a poor result. The mean AOFAS scores within these categories were 84, 70, and 48 for the good, fair, and poor outcome groups, respectively, indicating that most patients experienced substantial improvement in pain, function, and alignment following surgery.

Table 6. Postoperative complications

Complication	Number	Percentage
Superficial wound infection	1	4.0
Wound dehiscence*	2	8.0
Subtalar arthritis	2	8.0

*One patient with wound dehiscence had associated superficial wound infection.

Narrative

Postoperative complications were infrequent. One patient developed a superficial wound infection that responded to antibiotic therapy and regular wound care. Two patients experienced wound dehiscence, one of which was associated with superficial infection. Subtalar arthritis developed in two patients despite acceptable fracture reduction, primarily because of extensive articular surface damage sustained at the time of injury. These patients were managed conservatively with non-steroidal anti-inflammatory drugs and physiotherapy.

DISCUSSION

Calcaneal fractures remain among the most challenging injuries encountered by orthopaedic surgeons because of their complex anatomy, frequent intra-articular involvement, and high incidence of long-term functional disability. The principal objective of treatment is restoration of the posterior facet, calcaneal height, width, length, and alignment while minimizing soft tissue complications. Over the past two decades, minimally invasive fixation techniques have gained increasing acceptance because they preserve the soft tissue envelope without compromising fracture reduction in carefully selected patients.[11,12]

The present prospective study evaluated the functional outcome of 25 patients with displaced intra-articular calcaneal fractures managed using percutaneous cannulated cancellous screw fixation. The findings demonstrated that this technique produced satisfactory fracture union, excellent functional recovery, and a relatively low complication rate. At three months, 80% of patients achieved a good AOFAS hindfoot score, while only one patient had a poor functional outcome. These findings support the effectiveness of minimally invasive fixation in appropriately selected Sanders type II and III fractures.

The demographic profile observed in the present study was consistent with existing literature. The mean age was 32.8 years, and males constituted 80% of the study population. Young adult males are more commonly affected because calcaneal fractures are predominantly occupational injuries occurring after falls from height or high-energy trauma. Similar demographic trends have been reported by Buckley et al. and Schepers et al., who observed that calcaneal fractures predominantly affect economically productive individuals and therefore have considerable socioeconomic implications owing to prolonged rehabilitation and delayed return to work.[11,13]

Falls from height accounted for 72% of injuries in the present study, whereas road traffic accidents constituted 28%. This finding corresponds well with previously

published studies, where axial loading after falls from height remains the commonest mechanism of injury. The biomechanics of axial compression explain the predominance of intra-articular fracture patterns and emphasize the importance of restoring the posterior subtalar joint to achieve satisfactory long-term outcomes.[12,14]

Computed tomography demonstrated that Sanders type II fractures represented 64% of the study population, while the remaining patients had Sanders type III injuries. No Sanders type IV fractures were included because highly comminuted fractures often require alternative fixation strategies or primary subtalar arthrodesis. Sanders classification continues to provide valuable prognostic information and remains the most widely accepted system for preoperative planning of displaced intra-articular calcaneal fractures.[14]

Timing of surgery plays an important role in minimizing wound complications. In the present study, surgery was performed at a mean of nine days after injury, once soft tissue swelling had subsided and the wrinkle sign became evident. Delayed fixation after improvement of soft tissue condition has consistently been recommended to reduce postoperative wound complications. The relatively low incidence of superficial wound infection observed in the present study may partly be attributed to adherence to this principle.[15]

Radiological union occurred at a mean of 14 weeks, which is comparable with reports from other contemporary series employing minimally invasive fixation. Stable fixation with cannulated cancellous screws permits adequate fracture compression while preserving periosteal blood supply and minimizing surgical dissection. Consequently, fracture healing is generally satisfactory without increasing the risk of delayed union or non-union.[16]

Functional recovery following calcaneal fracture surgery depends largely on restoration of subtalar congruity and preservation of hindfoot mechanics. The present study

demonstrated that 20 of 25 patients (80%) achieved good AOFAS outcomes, with a mean score of 84. Four patients achieved fair results, whereas only one patient had a poor outcome. These findings compare favourably with previous studies evaluating percutaneous fixation. Schepers et al. reported consistently good functional outcomes with minimally invasive techniques while observing significantly fewer wound complications compared with extensile lateral approaches. Likewise, Kline et al. demonstrated comparable functional outcomes between minimally invasive fixation and conventional open reduction, with substantially reduced soft tissue morbidity in the minimally invasive group.[13,17]

One of the principal advantages of percutaneous fixation is preservation of the lateral soft tissue envelope. Traditional extensile lateral approaches have been associated with wound complications ranging from 15% to 30%, including wound necrosis, infection, sural nerve injury, and delayed healing. In contrast, only one patient developed superficial wound infection in the present study, which resolved with antibiotics and regular wound care. Although two patients developed wound dehiscence, these complications were managed conservatively without requiring implant removal. The low incidence of soft tissue complications observed in the present series further supports the safety profile of minimally invasive surgery.[15,17]

Subtalar arthritis developed in two patients despite satisfactory fracture reduction. This observation highlights that postoperative arthritis depends not only on surgical reduction but also on the severity of the initial cartilage injury sustained at the time of trauma. Extensive destruction of the posterior facet may predispose patients to degenerative changes despite anatomical restoration. Similar findings have been reported by Potter and Nunley, who demonstrated that initial fracture severity remains one of the strongest predictors of long-term functional outcome after operative management.[18]

The present study has several strengths. It employed a prospective design with standardized operative technique, CT-based fracture classification, uniform postoperative rehabilitation, and validated functional assessment using the AOFAS Hindfoot Score. These methodological characteristics improve the reliability of the reported clinical outcomes.

However, certain limitations should be acknowledged. The study included a relatively small sample size from a single tertiary care centre, which may limit the generalizability of the findings. The follow-up duration was relatively short, with functional assessment performed at three months. Longer follow-up would better evaluate subtalar arthritis, implant-related complications, and long-term functional recovery. Additionally, the absence of a comparative group treated

by open reduction and plate fixation precludes direct comparison between treatment modalities.

Overall, the findings of the present study indicate that percutaneous cannulated cancellous screw fixation provides stable fracture fixation, satisfactory radiological union, excellent functional recovery, and a low incidence of wound-related complications in selected displaced intra-articular calcaneal fractures. Careful patient selection, meticulous reduction under fluoroscopic guidance, and adherence to soft tissue principles remain essential for achieving favourable outcomes.

CONCLUSION

Percutaneous cannulated cancellous screw fixation is an effective minimally invasive treatment option for selected displaced intra-articular calcaneal fractures. In the present study, the majority of patients achieved good functional outcomes with timely fracture union and a low rate of postoperative complications. Delayed surgery until soft tissue swelling subsided, accurate fluoroscopic reduction, and stable screw fixation contributed to favourable clinical results. Although subtalar arthritis occurred in a small proportion of patients, most complications were managed successfully without major surgical intervention. This technique offers the advantages of minimal soft tissue disruption, satisfactory functional recovery, and reduced wound morbidity, making it a valuable alternative to extensile open approaches in appropriately selected Sanders type II and III calcaneal fractures. Further multicentric studies with larger sample sizes and longer follow-up are warranted to validate these findings and evaluate long-term functional and radiological outcomes.

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