

Functional Outcome Evaluation of Surgically Controlled Intra-Articular Calcaneum Fractures using Plate Fixation

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Abstract

Aim: To evaluate the functional result of surgically controlled intra-articular calcaneum fractures using plate fixation.

Material and Methods: This study was conducted in the Department of Orthopaedics, Jannayak Karpoori Thakur Medical College and Hospital, Madhepura, Bihar, India for 18 months. A total of 25 patients with intra-articular calcaneal fractures meeting the inclusion and exclusion criteria were chosen for the study. Patients aged between 18-60yrs, Intra-articular fracture of calcaneum (Sander's classification), Ability to understand the content of the subject information/informed consent form and to be willing to participate in the clinical investigation were included in this study.

Results: The majority of the patients in the study were males, with 92% of the study population. In this study, 56% of the patients had right side involvement and 44% of the patients had left side involvement. The most common mode of injury in the study group was falling from height followed by RTA. The most common fracture type in our study was Sander's type II, followed by type IV. Type III was the least common. In all the patients included in the study, surgery was delayed until the appearance of wrinkles on the skin to avoid the complication of wound dehiscence and for appropriate wound closure. The number of days from the injury to surgery varied from 4 to 14 days with an average of 7.8 days. The average time period for the radiological union was 13.64 weeks in the study population. About 72% of patients had a Bohler's angle between 10°-20° and in 28% of patients, it was <10° in the pre-operative period, with a mean Bohler's angle of 11.75°. Whereas in the post-operative period, 48% of patients had a Bohler's angle between 20°-30° and 52% had it between 30°-40°, with a mean post-operative Bohler's angle of 29.67°. The difference between pre-operative and post-operative mean Bohler's angle was statistically significant with a p value <0.01. The difference between pre-operative and post-operative mean Gissane's angle was statistically significant with a p value <0.01.

Conclusion: we conclude that: Good quality radiographs like lateral and axial view and pre-operative CT scan is necessary in understanding the displacement of major fragments and help to classify the fracture pattern according to Sander's classification, which is vital in pre-operative planning and assessment of the prognosis of fracture. The timing of the surgery is a crucial determinant for the treatment outcome and is to be done once the wrinkle sign is positive.

Keywords: Calcaneal fractures, intra-articular, high energy fractures, soft tissue, operative techniques

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Introduction

Intra-articular calcaneal fractures are complex injuries that significantly impact the function of the hindfoot. These fractures often result from high-energy trauma such as falls from a height or motor vehicle accidents and are characterized by disruptions within the calcaneus that extend into the subtalar joint. These injuries can lead to substantial

morbidity, including chronic pain, decreased mobility, and long-term disability if not properly managed. [1,2] The surgical management of displaced intra-articular calcaneal fractures has evolved over the years, with plate fixation being one of the most widely adopted techniques. The goal of surgical intervention is to restore the anatomy of the

calcaneus, realign the subtalar joint, and ensure early mobilization to enhance functional recovery. Plate fixation, often performed through an extensile lateral approach, allows for direct visualization and precise reduction of the fracture fragments, providing stable fixation and facilitating postoperative rehabilitation. [3-5] Several studies have investigated the functional outcomes following plate fixation for intra-articular calcaneal fractures, reporting varying degrees of success. A 2022 meta-analysis by Zhang et al. highlighted that patients undergoing plate fixation experienced significant improvements in pain relief, functional scores, and overall satisfaction compared to non-surgical management. Additionally, the study underscored the importance of achieving anatomical reduction and stable fixation to optimize outcomes. [6] Recent advances in surgical techniques and postoperative protocols have further improved the prognosis for these patients. For instance, a study by Schepers et al. (2021) demonstrated that minimally invasive techniques coupled with modern fixation devices could reduce the risk of complications such as wound infections and soft tissue irritation, thereby enhancing recovery and functional outcomes. [7] Despite these advancements, the management of intra-articular calcaneal fractures remains challenging due to the high variability in fracture patterns and patient-specific factors. The choice of surgical technique and fixation method must be individualized, taking into account the patient's overall health, the extent of the fracture, and the surgeon's expertise. [8-12] Moreover, long-term follow-up studies have emphasized the importance of comprehensive rehabilitation programs in achieving optimal functional outcomes. Postoperative rehabilitation, including physical therapy and weight-bearing exercises, plays a crucial role in restoring mobility and preventing complications such as joint stiffness and atrophy.

Material and Methods

This study was conducted in the department of Orthopaedics, Jannayak Karpoori Thakur Medical College and Hospital, Madhepura, Bihar, India for 18 months. A total of 25 patients with intra-articular calcaneal fractures meeting the inclusion and exclusion criteria were chosen for the study. Patients aged between 18-60yrs, Intra-articular fracture of calcaneum (Sanders classification), Ability to understand the content of the subject information/informed consent form and to be willing to participate in the clinical investigation were included in this study. Patients with extra-articular fracture, Open fracture (Gustillo-Anderson type 2 and 3), Patients medically not fit for surgery, Paraplegia/paraparesis as they interfere with the assessment of the functional outcome of the surgery, Old ankle fractures, Fracture in osteoporotic bone, Fracture of the long bone in the ipsilateral limb,

Chronic local infection and Sanders type I calcaneal fracture were excluded from the study.

Methodology

After admitting the patients with intra-articular calcaneal fractures satisfying the inclusion criteria, relevant investigations were done and fitness for surgery was taken. Appropriate measures were taken to reduce the swelling, such as below knee slab with cotton padding, limb elevation, and ice pack application. Pre-operative x-rays-lateral and axial view of the calcaneum and CT scan of calcaneum were obtained and pre-operative planning was done. Pre-operative Bohler's and Gissane's angles were measured using radiographs and fractures were classified using Sander's classification with the help of a CT-scan. After obtaining informed consent, the patients were taken up for surgery once the swelling was reduced and the wrinkle sign was positive. After the patient is anaesthetised, the patient is placed in the lateral decubitus position over a radiolucent table with the operative side up. The lower extremities are positioned in a scissor-like configuration. Protective padding is placed beneath the contralateral limb to protect the peroneal nerve and a pillow is placed between the legs. A pneumatic thigh tourniquet is used, and the limb is exsanguinated with an Esmarch bandage to provide a dry operative field. The limb is painted and draped till mid calf region and the fracture is approached with a lateral extensile incision starting 2cm above the tip of the lateral malleolus and just lateral to the Achilles tendon and taking it up to the base of the 5th metatarsal in an L shaped fashion. The knife is taken "straight to bone" at this level, taking care not to bevel the skin. Once the initial incision is made, the corner of the flap is now raised as a subperiosteal, full-thickness flap. One K-wire (1.5mm) is passed in the fibula, talar neck and cuboid each to retract the flap using the "no-touch" technique. Fracture reduction and correction of calcaneus varus, height and width were done under direct vision and with the help of fluoroscopy. K wires were used for the temporary stabilization of fracture fragments. Application of locking calcaneal compression plate and locking screws is done. Intraoperative radiographic evaluation with image intensifier with lateral, axial and Anteroposterior view. Wound wash was given with normal saline. Wound closed with non-absorbable suture (Ethilon) using Allgower-Donati technique. Bulky cotton dressing is done. Patients were given below- knee slab and limb elevation in the post-op period, till wound healing and suture removal, which was usually done on the 14th day. Ankle range of movements were started at 2nd post-op week. Patients were followed up regularly in OPD at 6wk, 12wk, 24wk and 1yr and clinical and radiological assessments were done. Weight-bearing was allowed after 3 months depending upon the

fracture union. Radiological assessment was done by measuring bohler's and gissane's angles, union rate. Functional outcome was measured using American Orthopedics Foot and Ankle Society (AOFAS) score. A score of 90-100 is taken as an excellent outcome, 75-89 as good, 55-74 as fair and a score less than 50 is considered a poor outcome.

Results

A retrospective study was undertaken of 25 patients

with intra- articular calcaneal fractures (Sander's type II, III and IV) treated by calcaneal locking compression plate and screws. Results were analyzed in terms of functional outcome of a postoperative range of movement after the union, time for fracture union, early and late postoperative complications.

Table 1: Distribution of age of patients

Age (years)	Frequency	Percentage (%)
18-30	11	44
31-40	9	36
41-50	3	12
51-60	2	8
Total	25	100

In our study, patients between the ages group 18yr and 60yr with a mean age of 33.36yr were included.

Table 2: Gender distribution in the study population

Gender	Frequency	Percentage (%)
Male	23	92
Female	2	8

The majority of the patients in the study were males, with 92% of the study population.

Table 3: Distribution of sides involved in patients studied

Side	No. of patients	Percentage (%)
Right	14	56
Left	11	44
Total	25	100

In this study, 56% of the patients had right side involvement and 44% of the patients had left side involvement.

Table 4: Distribution of mode of injury in the study group

Mode of injury	No. of patients	Percentage (%)
Fall from height	20	80
RTA	5	20

The most common mode of injury in the study group was falling from height followed by RTA.

Table 5: Distribution types of Sander's classification of fracture in the study population

Sander's type	No. of patients	Percentage (%)
Type II	10	40
Type III	7	28
Type IV	8	32
Total	25	100

The most common fracture type in our study was Sander's type II, followed by type IV. Type III was the least common.

Table 6: Time interval between injury to surgery

Time interval	Frequency	Percentage (%)
1-5 days	6	24
6-10 days	14	56
11-14 days	5	20

In all the patients included in the study, surgery was delayed until the appearance of wrinkles on the skin to avoid the complication of wound dehiscence and for appropriate wound closure. The number of days from the injury to surgery varied from 4 to 14 days with an average of 7.8 days.

Table 7: Distribution of period in weeks for complete radiologic union in patients studied

Time in weeks	No. of patients	Percentage (%)
10-13 wks	14	56
14-16 wks	7	28
17-19 wks	4	16
Total	25	100

The average time period for the radiological union was 13.64 weeks in the study population.

Table 8: Distribution of pre and post-operative Bohler's angle in the study population

Bohler's angle	Pre-operative (%)	Post-operative (%)
<10°	7 (28%)	00
10°-20°	18 (72%)	00
20°-30°	00	12(48%)
30°-40°	00	13(52%)
Mean	11.75 ⁰	29.67 ⁰
Total	25 (100%)	25(100%)

About 72% of patients had a Bohler's angle between 10°-20° and in 28% of patients, it was <10° in the pre-operative period, with a mean Bohler's angle of 11.75⁰. Whereas in the post-operative period, 48%

of patients had a Bohler's angle between 20°-30° and 52% had it between 30°-40°, with a mean post-operative Bohler's angle of 29.67⁰.

Table 9: Comparison between mean pre-operative and post-operative Bohler's angle

Parameter	Pre-op (mean ±SD)	Post-op (mean ±SD)	P – value
Bohler's angle	11.75 ⁰ ± 2.59	29.67 ⁰ ± 4.57	P < 0.01

The difference between pre-operative and post-operative mean Bohler's angle was statistically significant with a p value <0.01. (paired t test)

Table 10: Distribution of pre and post operative Gissane's angle in the study population

Gissane's angle	Pre-operative (%)	Post-operative (%)
110°-120°	00 (28%)	18(52%)
120°-130°	4(16%)	7(28%)
130°-145°	18(52%)	00
>145°	3(12%)	00
Mean	137.06 ⁰	116.7 ⁰
Total	25 (100%)	25(100%)

Table 11: Comparison between mean pre-operative and post-operative Gissane's angle

Parameter	Pre-op (mean ±SD)	Post-op (mean ±SD)	P – value
Gissane's angle	137.06 ⁰ ± 6.08	116.7 ⁰ ± 4.75	P < 0.01

The difference between pre-operative and post-operative mean Gissane's angle was statistically significant with a p value <0.01. (Paired t test).

Table 12: Functional outcome using AOFAS score

Result	Frequency	Percentage (%)
Excellent	4	16
Good	16	64
Fair	4	16
Poor	1	4
Total	25	100

Table 13: Distribution of complications in the study population

Complication	Frequency	Percentage (%)
Ankle and foot stiffness	2	8
Deep infection	1	4
Superficial wound infection	2	8
Implant prominence	2	8
No complications	18	72
Total	25	100

Discussion

Our study consists of 25 cases of displaced intra-articular calcaneal fractures operated at the Department of Orthopaedics, Jannayak Karpoori Thakur Medical College and Hospital, Madhepura, Bihar, India. Functional outcome was assessed using the AOFAS scoring system and radiological outcome was evaluated by Bohler's and Gissane's angles and rate of fracture union. Out of 25 cases there were 23 males (92%) and 2 females (8%). The mean age of the patients was 33.6 years with ages ranging from 18 years to 60 years. In our study, the mean age of the patients was 33.6 years which was comparable to previous studies done by M.J.Mitchell et al. [4] and Farell et al. [5] who also demonstrated that the fracture was more in the younger age group and the majority of the patients were male. The mode of injury was falling from height in 20 cases and 5 cases had a history of RTA. In our study most common mode of injury was falling from height (80%), followed by RTA (20%). This result was comparable with the results of a study done by M.J.Mitchell et al. [4] (fall from height 71.5%).

Our study delayed the operative management until the wrinkle sign was positive to prevent wound complications. We operated within the first two weeks of injury, as open reduction internal fixation with more than 3 weeks of delay is not recommended. [6] The mean time duration between injury and surgery in our study was 7.8 days.

The treatment of choice for intraarticular calcaneum fractures remains controversial. Surgical treatment was associated with a significant incidence of wound complications, particularly sepsis. [7] However, the conservative treatment also has its share of complications, such as subtalar joint pain, heel varus and peroneal tendon impingement. [8] Sanders et al. confirmed that the learning curve for operative treatment of this fracture is steep. Sanders observed that the clinical results are a surgeon-dependent learning curve and requires 35 to 50 cases or about 2 years' experience. [9, 10]

Pendse et al. [11] concluded that open reduction and internal fixation with a plate in intra-articular calcaneus fractures to restore anatomical articular congruency, early mobilization and primary option for subtalar arthrodesis if needed. Schepers et al.

[12] observed that ORIF was the mainstay among all modalities of treatments.

A medial, lateral or combined approach can be used to perform calcaneal fracture surgery [13-16]. In our study, a lateralexensile exposure popularized by Benirschke and Sangeorzan was used in all the cases. [17] Important points for success with this approach include careful flap elevation and "no-touch" technique using K-wires, mobilization, and anatomic restoration of the posterior facet; adequate mobilization and reduction of the tuberosity fragment through the primary fracture line; and stabilization with plate and screws. Plates allowing locking of the screws to the plate have become popular for this fracture. We used locking calcaneal plates in all our cases. The "blow out" of the lateral wall, when present, could be well reduced and held in place with this plate. The contoured plate was fixed, extending from the anterior process into the most posterior aspect of the tuberosity.

If a large defect remains after the procedure, which often is the case, most surgeons recommend using an autogenous iliac crest bone graft; however, if internal fixation is secure and the fracture is stable, the defect may be accepted. A.K. Singh et al. in his study, concluded that Bohler's angle showed improved restoration and the patients returned to full weight-bearing earlier when bone grafting was used in the treatment of intra-articular calcaneal fracture. [18] However, studies by Rammelt et al., [19] and Zhongguo et al., [20] suggested that it is not necessary to implant a bone graft for DIACFs.

Surgical treatment of displaced intra-articular calcaneal fractures enables anatomical reduction, and restores the shape, height and alignment. It also aims to reduce the subtalar and calcaneocuboid joints in order to achieve a reduced lateral wall and peroneal tendons. [21] Paley D et al. stated that Bohler's angle is an indirect measurement of both calcaneal height and the arch angle. [22] The Bohler's angle [23], is considered as normal within measurements ranging from 20° to 40°. In this study, the post-operative mean Bohler angle was 29.67 degree.

In our study, the time for fracture union showed that the mean time for union among patients was 13.64 ± 2.56 weeks. Biz [24] et al. reported radiological consolidation of calcaneal fractures in an average

period of around 3 months (12 weeks), which agreed to the findings of our study. In a study on functional outcomes of different modalities of fixation in intra-articular calcaneus fractures by Rajesh V Chawda [25] et al., it was observed that the radiological union appears between 2-3 months. This finding was comparable to the present study.

In this study, outcomes were measured with AOFAS Score. Out of 25 patients 4 patients (16%) had excellent (90–100 points), 16 patients (64%) had well (75–89 points), 4 patients

(16%) had fair (50–74 points) and 1 patient (4%) had poor outcome (<50 points). Biz et al.²⁴ who also measured outcomes with AOFAS score and he found excellent results in 11 (12.6%) patients, good results in 46 (52.9%) patients, fair results in 26 (29.9%) patients, while 4 (4.6%) patients were graded as failures. We also compared our outcomes of AOFAS Score with Voelckel et al. [26] who found excellent results in 24 (32%) patients, good in 28 (37%) patients, fair in 14 (18%) patients and poor results in 10 (13%) patients. We also compared our outcomes with other series of Gusic et al. [27] and Mohammed et al. [28]

The main drawback of ORIF of calcaneal fractures is the complications usually associated with its surgical treatment. In this study, out of 25 patients, two patients had ankle and foot stiffness, two patients had implant prominence and two patients had superficial wound infection and 1 patient had deep wound infection. The patients developed ankle and foot stiffness as a result of noncompliance for physiotherapy. As per culture and sensitivity, deep wound infection was treated with implant removal, wound debridement, and antibiotic cover. Superficial wound infection was treated with regular dressings and appropriate antibiotics. Patients with implant prominence were treated with implant removal after the fracture was united at the final follow up.

Conclusion

We conclude that: Good quality radiographs like lateral and axial view and pre-operative CT scan is necessary in understanding the displacement of major fragments and help to classify the fracture pattern according to Sanders's classification, which is vital in pre-operative planning and assessment of the prognosis of fracture. The timing of the surgery is a crucial determinant for the treatment outcome and is to be done once the wrinkle sign is positive. If for other reasons operation is done after three weeks, it causes not only soft tissue healing problems and high infection rate but also intra-operative difficulty in fracture reduction, as the fracture would have started consolidating. Surgeon's expertise in soft tissue handling, anatomical alignment of fracture fragments, maintaining the height of the calcaneum,

Bohler's and Gissane's angle, Judicious use of bone graft in large void spaces before placing the plate, and proper intra-operative planning and post-operative care are the main factors which can lead to a successful outcome and minimize the postoperative complications.

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