

# Analysis between Open Method and Closed Method of Reduction in Intra-articular Joint Depression Type of Calcaneal Fractures

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## ABSTRACT

**Background:** Calcaneus is the largest tarsal bone, comprising four articular surfaces: the posterior, middle, and frontal facets connecting to the talus, and the distal articular surface of the cuboid. Intra-articular calcaneal fractures, making up 75% of calcaneal fractures, often result from high-energy trauma and can significantly impact health outcomes. These fractures are classified using the Sanders and Essex-Lopresti systems.

**Methods:** This prospective study evaluates outcomes of joint depression intra-articular calcaneal fractures treated using operative techniques over three years. Twenty patients with 24 fractures underwent either open reduction internal fixation (ORIF) or closed reduction with the ESSEX-LOPRESTI technique. Vital signs, radiological evaluations, and CT scans were conducted pre-operatively. Bohler's angle, Gissane's angle, and heel width were measured. The American Orthopaedic Foot & Ankle Society (AOFAS) score assessed functional outcomes post-operatively. Statistical analysis compared pre- and post-operative results.

**Results:** The study divided 24 intra-articular calcaneal fracture cases equally between ORIF and closed reduction. Hospital stays varied, with 50% staying 0-5 days. Immobilization ranged from 1½ to 3 months, with 58% needing 2 months. Post-treatment, 80% returned to their previous occupations. ORIF showed better outcomes, with 58% achieving normal ROM and 20% scoring excellent on AOFAS, compared to no excellent scores in closed reduction. ORIF had fewer complications, with lower malunion and infection rates.

**Conclusion:** The study has concluded that ORIF provides better functional outcomes and fewer complications than closed reduction for treating intra-articular calcaneal fractures.

**Key-words:** Calcaneus, Fracture, Open method, Closed method, Intra-articular

## How to cite this article

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## INTRODUCTION

The calcaneus is considered the largest tarsal bone that consists of four articular surfaces: i) the posterior, ii) middle, and iii) frontal facets that connect to the talus, iv) and distal articular surface of the cuboid <sup>[1]</sup>.

Intra-articular calcaneal fractures possess a principal fracture line passing through the calcaneus' posterior facet, resulting in the formation of anteromedial and lateral fragments.

The deltoid and interosseous talocalcaneal ligaments firmly anchor the anteromedial fragment, sometimes referred to as the constant fragment, to the talus. Among the tarsal bones, calcaneal fractures are the most prevalent, constituting up 1–2 percent of all fractures [2,3]. Calcaneal fractures are categorized into extra-articular and intra-articular. Of these injuries, 25% are extra-articular fractures, which typically include avulsions of the sustentaculum tali, the anterior process that forms the bifurcate ligament, or the calcaneal tuberosity attached to the Achilles tendon. Intra-articular fractures make up 75% of calcaneal fractures, where the talus compresses the calcaneus at the angle of Gissane, leading to the fracture [4]. Most often, high-energy trauma through falls or car crashes causes such damages, leading to axial loading. The impact of these fractures on health outcomes is significant, often comparable to those of myocardial infarction and chronic kidney disease [5].

Intra-articular calcaneal fractures are typically classified by the Sanders and Essex-Lopresti systems. The Sanders system categorizes fractures based on CT scans of the posterior facet, ranging from nondisplaced (Type I) to highly comminuted (Type IV), with further subclassifications due to the location of fracture lines and is important for treatment and prognosis. The Essex-Lopresti classification divides fractures based on the mechanism of injury into two types: joint depression (Type A) and tongue type (Type B). This system aids in understanding the nature and management of the fractures [6].

The main goal of the American Orthopedic Foot and Ankle Society is to regain the natural posture and shape of the calcaneus, including heel height and length, posterior facet realignment, and the foot's mechanical axis [7]. Management involves choosing between ORIF and Closed Reduction with Percutaneous Fixation (CRPF) for treating intra-articular calcaneal fractures. ORIF involves making a surgical incision and using wires and screws for precise fracture reduction, but it carries higher complication risks. CRPF is less invasive, using small incisions or none with percutaneous pins or screws, leading to quicker recovery and fewer complications, though it may be less effective for severe fractures. The choice between these methods depends on the fracture's complexity, patient health, and surgical expertise [8].

There is a debate between the open and closed methods of reduction and this study contributes to this research gap and tries to investigate the efficacy and outcomes of the open method and closed methods of reduction in intra-articular joint depression type of calcaneal fractures.

## MATERIALS AND METHODS

**Research Design-** This prospective study investigates the outcomes of joint depression variety of intra-articular fractures of the calcaneum treated using various operative techniques over the past three years at our institute. The study includes 24 cases of calcaneal fractures in 20 patients, with 4 patients presenting bilateral injuries. Two primary treatment methods were employed: ORIF in 12 cases, and closed reduction using the ESSEX-LOPRESTI technique with ST pin elevation in the remaining 12 cases.

Upon admission, all patients had their vital signs assessed, and a thorough examination was conducted to identify any associated injuries. Radiological evaluations included lateral and axial views of the calcaneum, along with X-rays of the spine and pelvis to rule out additional injuries. CT scans were performed for a subset of patients as needed and where economically feasible. were used to assess the final functional outcome. Descriptive statistics were used to summarize patient demographics and injury characteristics. Paired t-tests were employed to compare pre-operative and post-operative measurements. A p-value of less than 0.05 was considered statistically significant. Patients were managed pre-operatively with strict limb elevation and a below-knee slab to reduce edema. Measurements of Bohler's angle, Gissane's angle, and heel width (using a vernier caliper) were taken for all patients. Fractures were classified using the ESSEX-LOPRESTI classification, and additional CT scan classification was employed where applicable. All patients received an injectable antibiotic 30 minutes before surgery.

**Closed Reduction Group and ORIF-** In the closed reduction group, the ESSEX-LOPRESTI technique involved axial calcaneal ST pin insertion and depression elevation, followed by immobilization in a below-knee plaster cast. Among the 12 cases treated this way, 11 used K-wires alone for fixation, while one case used a combination of K-wires and a percutaneous screw.

For the ORIF group, a lateral universal approach to the calcaneum was used. Various types of calcaneal plates (simple reconstruction plate, 'Y' reconstruction plate, H plate, and anatomical calcaneal plate) were employed in 9 cases, while K-wires and cancellous screws were used in the remaining 3 cases.

**Post-Operative Care-** Post-operatively, all patients received strict limb elevation. Injectable antibiotics were administered for three days in the ORIF group and a single dose for the closed reduction group. Stitch removal was scheduled between 15 to 21 days post-operation for ORIF patients. Ankle mobilization was encouraged after the reduction of edema. Follow-up evaluations were conducted at one, two, three-, and six-months post-surgery, including physical examination, radiological assessment (Bohler's angle, Gissane's angle), and patient satisfaction scores. Immobilization duration varied from 1.5 to 3 months, with non-weight-bearing periods ranging from 2 to 4 months, depending on radiological signs of union. The final functional outcome was assessed using the AOFAS score and disability score, with regular follow-up ensuring comprehensive evaluation and comparison to pre-operative findings.

### Inclusion and Exclusion Criteria

#### Inclusion Criteria

- Adult patients between 18 to 65 years of age with joint depression variety of intra-articular calcaneum fractures.
- Patients who were weight-bearing on the same limb before the fracture.
- Fresh fractures.

#### Exclusion Criteria

- Extra-articular calcaneum fractures.
- Open fractures.
- Pathological fractures.
- Patients with other associated fractures in the same lower limb.
- Patients with neurological deficits.
- Medically unfit patients.

**Statistical Analysis-** The study used SPSS 27 for effective analysis. Statistical analysis was performed using appropriate statistical tools to compare pre-operative and post-operative outcomes. Parameters such as

Bohler's angle, Gissane's angle, and heel width were measured pre-operatively and at each follow-up visit. The American Orthopaedic Foot & Ankle Society score and disability score.

### RESULTS

Table 1 shows the baseline characteristics of the patients in this study which presents a diverse age distribution. The majority of patients fall into two age groups: 18-30 years and 31-42 years, each comprising 40% of the total patient population (8 patients each). Patients aged 43-54 years represent 15% (3 patients), while those aged 55-65 years make up the remaining 5% (1 patient). The study population predominantly consists of males, with 85% (17 patients) being male and 15% (3 patients) female. Additionally, 20% (4 patients) had bilateral (B/L) injuries, while 80% (16 patients) had unilateral (U/L) injuries. Occupation-wise, 55% (11 patients) were laborers, 30% (6 patients) were drivers, 10% (2 patients) were housewives, and 5% (1 patient) fell into the 'others' category. The mode of injury was predominantly falling from a height, accounting for 70% (14 patients), followed by road traffic accidents (RTA) at 25% (5 patients), and other causes at 5% (1 patient). Regarding the interval between injury and treatment, 63% (15 cases) were treated within 0-5 days, 33% (8 cases) within 5-10 days, and 4% (1 case) after more than 10 days.

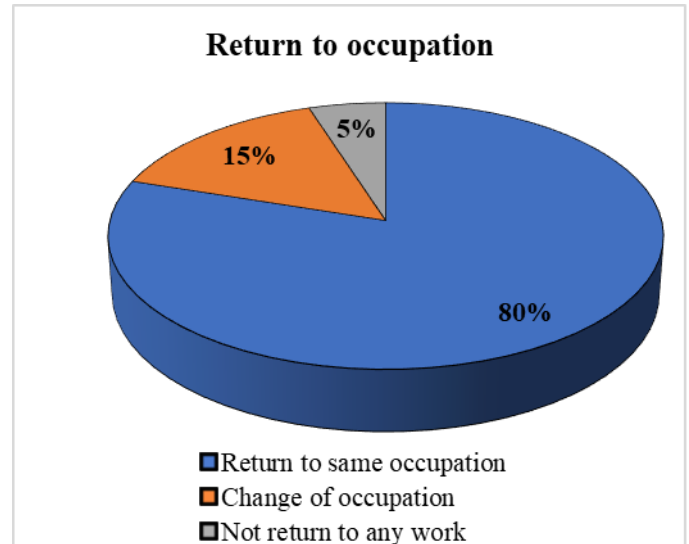
**Table 1:** Baseline characteristics of the patients in this study

| Age in Years | No. of Patients | Percentage (%) |
|--------------|-----------------|----------------|
| 18-30        | 8               | 40             |
| 31-42        | 8               | 40             |
| 43-54        | 3               | 15             |
| 55-65        | 1               | 5              |
| Sex          | No. of Patients | Percentage (%) |
| Male         | 17              | 85             |
| Female       | 3               | 15             |
| Sex          | No. of Patients | Percentage (%) |
| Male         | 17              | 85             |
| Female       | 3               | 15             |
| Side         | No. of Patients | Percentage (%) |
| B/L          | 4               | 20             |
| U/L          | 16              | 80             |

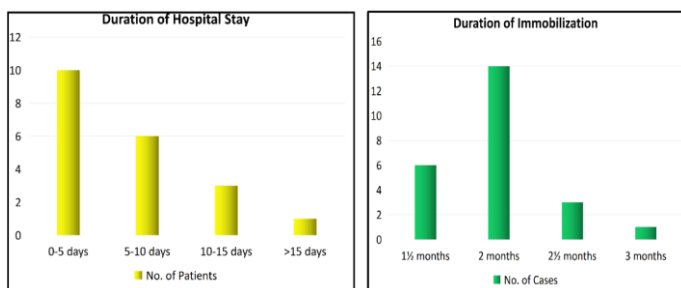
| Occupation              | No. of Patients | Percentage (%) |
|-------------------------|-----------------|----------------|
| Laborers                | 11              | 55             |
| Drivers                 | 6               | 30             |
| House wife              | 2               | 10             |
| Others                  | 1               | 5              |
| Mode of Injury          | No. of Patients | Percentage (%) |
| Fall from height        | 14              | 70             |
| RTA                     | 5               | 25             |
| Others                  | 1               | 5              |
| No. of days of interval | No. of Cases    | Percentage (%) |
| 0-5 days                | 15              | 63             |
| 5-10 days               | 8               | 33             |
| >10 days                | 1               | 4              |

The study evenly split its 24 cases of intra-articular calcaneum fractures between two treatment methods: ORIF and closed reduction. Each method was applied to 12 cases, accounting for 50% of the total cases each. Fig. 1 shows the number of patients with duration of hospital stay and immobilization. The duration of hospital stays varied among the patients. Half of the patients (50%) were hospitalized for 0-5 days. Another 30% stayed for 5-10 days, 15% for 10-15 days, and only 5% had a hospital stay of more than 15 days. The duration of immobilization also varied among the 24 cases. Most patients (58%) required 2 months of immobilization. Another 25% needed 1½ months, 13% required 2½ months, and only 4% needed 3 months of immobilization. This variation depended on the individual patient's recovery and radiological signs of union.

calcaneum, 80% (16 patients) successfully returned to their previous occupations. Meanwhile, 15% (3 patients) had to change their occupation due to the injury or its treatment. Only 5% (1 patient) were unable to return to any work post-treatment.



**Fig. 2:** Percentage of patients and their status of returning to their respective occupation post-intervention



**Fig. 1:** Duration of hospital stay and immobilization among the patients in this study

The return to occupation (Fig. 2) indicates that out of 20 patients treated for intra-articular fractures of the

Table 2 evaluated the outcomes of two treatment methods for intra-articular fractures of the calcaneum: ORIF and closed reduction. In terms of the ROM of the ankle joint, 58% of cases treated with ORIF had normal ROM, compared to 25% in the closed reduction group. Minimally restricted ROM was observed in 42% of ORIF cases and 67% of closed reduction cases. Only one case (8%) in the closed reduction group exhibited significantly restricted ROM, while no ORIF cases had significant restrictions. Complications were assessed, revealing that malunion at the final follow-up was present in 8% of ORIF cases and 33% of closed reduction cases. In contrast, 92% of ORIF cases and 67% of closed reduction cases had no malunion. Infection at the first follow-up was present in 17% of ORIF cases, with no infections reported in the closed reduction group. According to AOFAS score, 20% of patients treated with ORIF achieved an excellent score (90-100), whereas none of the closed reduction cases reached this level. Both treatment groups had 70% of cases classified as good (score 75-89). Fair results (score 50-74) were observed in 10% of ORIF cases and 20% of closed reduction cases. A poor result (score <49) was recorded in 10% of the closed reduction cases, while no ORIF cases fell into this category.

**Table 2:** Outcome assessments of two groups of the study

| ROM of Ankle joint               |                                 |                |   |                |
|----------------------------------|---------------------------------|----------------|---|----------------|
| ROM                              | No. of cases treated with ORIF  | Percentage (%) | No. of cases treated with closed reduction  | Percentage (%) |
| Normal                           | 7                               | 58             | 3   | 25             |
| Minimally Restricted             | 5                               | 42             | 8   | 67             |
| Significantly Restricted         | 0                               | -              | 1   | 8              |
| Total                            | 12                              | 100            | 12  | 100            |
| Complications                    |                                 |                |   |                |
|                                  | No. of Cases treated by ORIF    | Percentage     | No. of Cases treated by Closed Reduction    | Percentage     |
| Malunion at Final Follow up      |                                 |                |   |                |
| Present                          | 1                               | 8              | 4   | 33             |
| Absent                           | 11                              | 92             | 8   | 67             |
| Total                            | 12                              | 100            | 12  | 100            |
| Infection at First follow up     |                                 |                |   |                |
| Present                          | 2                               | 17             | 0   | -              |
| Absent                           | 10                              | 83             | 12  | 100            |
| Total                            | 12                              | 100            | 12  | 100            |
| Results according to AOFAS score |                                 |                |   |                |
| Result                           | No. of Patients treated by ORIF | Percentage     | No. of Patients treated by Closed reduction | Percentage     |
| Excellent (score 90-100)         | 2                               | 20             | 0   | -              |
| Good (score 75-89)               | 7                               | 70             | 7   | 70             |
| Fair (score 50-74)               | 1                               | 10             | 2   | 20             |
| Poor (score <49)                 | 0                               | -              | 1   | 10             |

## DISCUSSION

Various surgical approaches have been described, with the medial approach leading to poor outcomes due to incomplete reduction and high complications, while the lateral approach, despite limited access, risks injuring peroneal tendons and the sural nerve <sup>[9,10]</sup>. The dual medial and lateral strategies have high complications of wound necrosis, morbidity, and poor outcomes <sup>[9,11]</sup>. The sinus tarsi approach is often favoured for its direct exposure of the posterior facet. Kline *et al.* reported 6% wound complication with the sinus tarsi approach <sup>[12]</sup>, while Xia *et al.* observed reduced surgical timings and decreased rate of wound complications in comparison with the extended lateral approach <sup>[13]</sup>.

Nonoperative treatment is often recommended for undisplaced fractures, while surgery is an option for displaced intra-articular fractures. Regardless of the treatment method, patients may develop painful post-

traumatic subtalar arthritis, necessitating fusion. Surgical treatment aims to restore normal biomechanics to the hindfoot by achieving anatomic reduction of the calcaneus, ensuring congruent joints, reducing the lateral wall, restoring height and achieving proper talar declination, allowing patients to walk pain-free. Studies consistently show that the best outcomes are achieved with anatomic open reduction and internal fixation using an extensible lateral method <sup>[14]</sup>.

Despite these advantages, many surgeons prefer nonoperative treatment due to its familiarity and fewer complications. Closed reduction using dual-point distraction is a minimally invasive technique that reduces postoperative pain, shorter sickness absence periods, and shorter hospital stays. In a study by Batibay *et al.* both sickness absence periods and hospital stays were significantly shorter in the dual-point distraction group compared to the extended lateral approach group

( $p < 0.001$ )<sup>[15]</sup>. However, nonoperative methods can lead to symptomatic malunion, post-traumatic arthritis, and functional impairments. Thus, operative treatment generally results in better long-term outcomes in terms of function and recovery by initial open reduction and internal fixation with a locking calcaneal plate<sup>[16]</sup>.

Controversies exist regarding the use of primary bone grafting to prevent collapse. Some studies report no significant collapse without bone grafts<sup>[17,18]</sup>, while others recommend bone grafting or cement for stability and rapid rehabilitation<sup>[19,20]</sup>. In this study, both treatments have advantages and disadvantages. The best course of action is determined by the patient's health, age, and specific medical conditions, and should be determined by a medical expert.

## CONCLUSIONS

The study has concluded that ORIF provides better functional outcomes and fewer complications than closed reduction for treating intra-articular calcaneal fractures. The study concluded that ORIF and closed reduction were equally utilized for treating intra-articular calcaneal fractures. ORIF demonstrated superior outcomes with a higher percentage of patients achieving normal ankle ROM and excellent AOFAS scores, along with fewer complications like malunion and infections. Hospital stays and immobilization periods varied among patients, but most returned to their previous occupations post-treatment, underscoring ORIF's effectiveness in managing these fractures. Future studies should explore long-term outcomes of ORIF versus closed reduction and investigate advanced techniques and materials to further enhance recovery and reduce complications in treating intra-articular calcaneal fractures.

## CONTRIBUTION OF AUTHORS

**Research concept-** Avi Paras Rangwala, Anandkumar Sureshbhai Tailor

**Research design-** Avi Paras Rangwala, Anandkumar Sureshbhai Tailor

**Supervision-** Anandkumar Sureshbhai Tailor

**Materials-** Anandkumar Sureshbhai Tailor

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**Critical review-** Patel Kishan Manoj Kumar

**Article editing-** Avi Paras Rangwala

**Final approval-** Avi Paras Rangwala

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