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Evaluation of the outcome of displaced intraarticular calcaneal fractures treated with locking plate fixation: An observational study

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Abstract
Aim: The aim of the present study was to evaluate the functional and radiological outcome of intra-articular calcaneal fractures managed surgically with a plate in terms of bohler's and gissane's angle, rate of radiological union and AOFAS score.
Methods: The Prospective study was conducted for the period of two years and a total of 50 patients with intra-articular calcaneal fractures who met the inclusion criteria were admitted, underwent necessary examinations, and were assessed for surgical suitability. Swelling was reduced by using a below knee slab with cotton padding, elevating the leg, and using an ice pack. Pre-operative x-rays of the lateral and axial views of the calcaneum, together with a CT scan of the calcaneum, were taken for pre-operative planning. Bohler's and Gissane's angles were measured pre-operatively.
Results: Patients aged 18–60 with a mean age of 34.38 years were included in our research. The research included 88% male patients. This research found 64% right side engagement and 36% left side involvement. Falling from height caused the greatest injuries in the research group, followed by RTA. Our investigation found Sander's type II fractures most prevalent, followed by type IV. Type III was rarest. In all research participants, surgery was postponed until skin wrinkles appeared to prevent wound dehiscence and ensure proper wound closure. From injury until surgery, it took 4–14 days, averaging 7.8. Radiological union averaged 13.64 weeks in the research group. Difference between pre- and post-op mean Gissane's angle was significant ($p< 0.01$).
Conclusion: Proper pre-operative planning, scheduling of surgery, surgeon's skill during the operation, and post-operative care are crucial factors for achieving successful surgical treatment of intra-articular fractures with a locking plate, resulting in improved outcomes and fewer problems.

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

Introduction
The calcaneum is the tarsal bone most often damaged, comprising around 1-2% of all fractures in the human body. Around 75% of calcaneal fractures affect the subtalar joint and are often caused by falling from a height and landing straight on the heel [1, 2]. In 22% of cases, these instances are linked to further bone injuries. Displaced intra-articular fractures were first classified primarily on intraoperative observations, but eventually transitioned to a more precise classification using computed tomography, focusing on the quantity and placement of articular fragments [3, 4]. When evaluating calcaneal fractures using radiology, two important angles are seen on the lateral radiograph of the calcaneus: Bohler's angle and the angle of Gissane [5]. The mechanism of damage significantly influences the outcome of intra-articular calcaneal fractures [6].
Conservative treatment of intra-articular fractures might result in higher morbidity rates owing to articular surface incongruence, heel broadening, decreased talar dorsiflexion, loss of talocalcaneal lever arm, and peroneal tendon impingement [7]. Utilizing open reduction and internal fixation with plates is a superior choice for achieving a favorable functional result. Open reduction and internal fixation is the preferred therapy for Sanders type 2, 3, and 4 fractures, with optimal surgical timing and technique resulting in successful outcomes in over 90% of patients and minimizing morbidity [8]. Surgical intervention for intraarticular calcaneal fractures with bone grafts may improve Bohler's angle and allow patients to resume full weight

bearing sooner [9]. Plate fixation using a lateral method is suitable for promoting fracture healing and improving functional outcomes. It also helps in achieving anatomical alignment by correcting Bohler's and Gissane angles [10].

Intraarticular calcaneal fractures care is a topic of debate, with compelling reasons for both conservative and surgical approaches. Recent studies have varied opinions, with some indicating no difference between the two options and others claiming that surgery is a superior choice. There is much disagreement over the outcomes of nonoperative vs operative therapy. The absence of standardized findings has hindered the comparison of research assessing outcomes [11]. Over time, care techniques have significantly changed as our knowledge of the fracture has advanced. Cotton's historical assertion that "the man who breaks his calcaneus is done" [12].

This research aimed to assess the functional and radiological results of surgically treated intra articular calcaneal fractures using a plate, focusing on Boehler's and Gissane's angles, radiological union rate, and AOFAS score.

Materials and Methods

The Prospective study was conducted for the period of two years and a total of 50 patients with intra-articular calcaneal fractures meeting the inclusion and exclusion criteria were chosen for the study.

Inclusion Criteria

1. Patients aged between 18-60 yrs
2. Intra-articular fracture of calcaneum (Sanders classification)
3. Ability to understand the content of the subject information/informed consent form and to be willing to participate in the clinical investigation.
4. I have written informed consent.

Exclusion Criteria

1. Patients with extra-articular fracture
2. Open fracture (Gustillo-Anderson type 2 and 3)
3. Patients medically not fit for surgery
4. Paraplegia/paraparesis as they interfere with the assessment of the functional outcome of the surgery
5. Old ankle fractures.
6. Fracture in osteoporotic bone
7. Fracture of the long bone in the ipsilateral limb
8. Chronic local infection
9. Sanders type I calcaneal fracture

Methodology and procedure

Patients with intra-articular calcaneal fractures who met the inclusion criteria were admitted, underwent necessary examinations, and were assessed for surgical suitability. Swelling was reduced by using a below knee slab with cotton padding, elevating the leg, and using an ice pack. Pre-operative x-rays of the lateral and axial views of the calcaneum, together with a CT scan of the calcaneum, were taken for pre-operative planning. Bohler's and Gissane's angles were measured pre-operatively using radiographs, and fractures were categorized according to Sander's classification with the assistance of a CT-scan. After receiving informed permission from the patients and ethics committee approval, surgery was performed on the patients after the edema decreased and the wrinkle sign was present.

Once the patient is under anesthesia, they are positioned on their side with the side to be operated on facing up on a table that allows X-rays to pass through. The lower limbs are arranged in a scissor-like formation. Padding is put under the opposite limb to protect the peroneal nerve, and a cushion is inserted between the legs. A pneumatic thigh tourniquet is used to exsanguinate the limb using an Esmarch bandage to ensure a dry operating area. The limb is painted and covered until the middle of the calf area. The fracture is accessed by a lateral extensile incision that begins 2cm above the tip of the lateral malleolus, runs immediately beside the Achilles tendon, and extends up to the base of the 5th metatarsal in an L-shaped manner. The knife is brought directly to the bone at this depth, ensuring the skin is not beveled. After making the first cut, the corner of the flap is lifted as a subperiosteal, full-thickness flap. A single K-wire (1.5mm) is inserted into the fibula, talar neck, and cuboid individually to pull back the flap utilizing the "no-touch" approach.

Fracture reduction and correction of calcaneus varus were performed using direct visualization and fluoroscopy guidance to adjust height and breadth. Kirschner wires were used to temporarily stabilize the fracture pieces. Locking calcaneal compression plate and locking screws are applied. During surgery, radiographic assessment will be conducted using an image intensifier to provide lateral, axial, and anteroposterior views. Wound cleansing was administered with regular saline. The wound was sutured closed using non-absorbable Ethilon suture using the Allgower-Donati method. Cotton dressing that is bulky has been completed. Patients received a below-knee slab and limb elevation after surgery until the incision healed and sutures were removed, often on the 14th day. Ankle range of motion exercises started during the second week after the operation. Patients were periodically monitored in the outpatient department at 6 weeks, 12 weeks, 24 weeks, and 1 year, and clinical and radiological evaluations were conducted. Weight-bearing was permitted after 3 months based on the fracture's union.

Radiological examination was conducted by measuring Bohler's and Gissane's angles, as well as the union rate. Functional outcome was assessed using the American Orthopaedics Foot and Ankle Society (AOFAS) score. A score between 90 and 100 is regarded exceptional, 75 to 89 is acceptable, 55 to 74 is decent, and less than 50 is bad.

Results

Table 1: Patient details

Variables	N%
Gender	
Male	44 (88)
Female	6 (11)
Age groups	
18-30	21 (42)
31-40	16 (32)
41-50	8 (16)
51-60	5 (10)
Distribution of sides involved	
Right	32 (64)
Left	18 (36)
Mode of injury	
Fall from height	41 (82)
RTA	9 (18)

Patients in our research ranged in age from 18 to 60 years old, with an average age of 34.38 years. A whopping 88% of the people who participated in the research were men. A total of 64% of patients exhibited involvement on the right side and 36% on the left side in this investigation. The research group most often had injuries due to falls from great heights,

followed by road traffic accidents.

Table 2: Distribution types of Sander's classification of fracture in the study population, Time interval between injury to surgery and Distribution of period in weeks for complete radiologic union in patients studied

Sander's type	N%
Type II	21 (42)
Type III	12 (24)
Type IV	17 (34)
Time interval	
1-5 days	12 (24)
6-10 days	28 (56)
11-14 days	10 (20)
Time in weeks	
10-13 wks	28 (56)
14-16 wks	13 (26)
17-19 wks	9 (18)

Type II Sander fractures were the most prevalent in our sample, followed by type IV. By far, the rarest kind was kind III. Surgery was postponed in all research participants until wrinkles appeared on their skin. This was done to prevent wound dehiscence and ensure proper wound closure. On average, 7.8 days passed between the injury and surgery, yet this time frame ranged from 4 to 14 days. In the research group, the average duration of the radiological union was 13.64 weeks.

Table 3: Distribution of pre and post-operative Bohler's angle and gissane's angle in the study population

Bohler's angle	Pre-operative (%)	Post-operative (%)
<10º	14 (28)	0
10º-20º	36 (72)	0
20º-30º	0	23(46)
30º-40º	0	27 (54)
Mean	11.71 º	29.77 º
Gissane's angle		
110º-120º	0	27 (54)
120º-130º	8 (16)	23 (46)
130º-145º	27 (54)	0
>145º	15 (30)	0
Mean	138.08 º	115.5 º

The majority of patients (72%), with an average Bohler's angle of 11.71 degrees, had an angle between 10 and 20 degrees, while a smaller percentage (28%), had an angle less than 10 degrees, before the operation. In contrast, the mean post-operative bohler's angle was 29.77 degrees, with 46% of patients experiencing angles between 200 and 300 degrees and 54% experiencing angles between 300 and 400 degrees. A p value less than 0.01 indicates that there was a statistically significant difference between the mean Bohler's angle before and after the operation. A statistically significant change was seen with a p value <0.01 between the pre- and post-operative means of Gissane's angle.

Table 4: Functional outcome using AOFAS score

AOFAS score	N%
Excellent	8 (16)
Good	32 (64)
Fair	8 (16)
Poor	2 (4)

The majority of patients were rated as good, followed by excellent, and fair, according to the AOFAS score. As few as two patients had subpar AOFAS results.

Discussions

Despite how rare they are, calcaneal fractures account for around 2% of all fractures.13–15 High-energy axial trauma, most often caused by falls from great heights, is the most common cause [13-17]. Seventy percent of calcaneal fractures occur inside the joint itself. Not only are they the most difficult, but the results are also completely random [13]. The results of surgical and conservative treatments are not universally agreed upon [14].

Patients in our research ranged in age from 18 to 60 years old, with an average age of 34.38 years. Consistent with earlier research showing that fractures were more common in younger age groups and that men made up the majority of patients (88% of the study population), this study found that the majority of patients were male. A total of 64% of patients exhibited involvement on the right side and 36% on the left side in this investigation. We found that falls from heights accounted for 82% of all injuries, with road traffic accidents coming in second with 18%. The findings were similar previous research which also found a decline from height of 71.5% [18, 19].

In order to avoid problems related to wounds, our research postponed surgical care until the wrinkle indicator was positive. Because it is not suggested to postpone open reduction internal fixation for more than three weeks, we performed the procedure within the first two weeks after the accident [20]. Our research found that, on average, patients had to wait 7.8 days after injury before surgery. Controversy still surrounds the optimal method of treating intraarticular calcaneum fractures. Wound complications, especially infection, were common after surgical procedures [21]. Subtalar joint discomfort, heel varus, and peroneal tendon impingement are some of the consequences that might arise after conservative therapy [22]. The severe learning curve for operating on this kind of fracture was validated by Sanders *et al*. It takes 35–50 cases, or about two years of experience, according to Sanders, and the clinical outcomes are reliant on the surgeon's learning curve [23, 24].

The majority of patients (72%), with an average Bohler's angle of 11.71 degrees, had an angle between 10 and 20 degrees, while a smaller percentage (28%), had an angle less than 10 degrees, before the operation. In contrast, the mean post-operative bohler's angle was 29.77 degrees, with 46% of patients experiencing angles between 200 and 300 degrees and 54% experiencing angles between 300 and 400 degrees. A p value less than 0.01 indicates that there was a statistically significant difference between the mean Bohler's angle before and after the operation. A statistically significant change was seen with a p value <0.01 between the pre- and post-operative means of Gissane's angle. Most surgeons advise employing an autogenous iliac crest bone transplant if a significant defect is left after the treatment (Which happens often); however, if the fracture is stable and internal fixation is strong, the defect may be tolerated. The use of bone grafting in the treatment of intra-articular calcaneal fractures resulted in better repair and sooner complete weight-bearing for patients, according to research by A.K. Singh *et al*. [25] Nonetheless, a bone transplant may not be required for DIACFs, according to research by Rammelt *et al*. [26] and Zhongguo *et al*. [27] Anatomical reduction and restoration of form, height, and alignment are achieved by surgical treatment of displaced intra-articular calcaneal fractures. The reduction of the lateral wall and peroneal tendons is another goal, as is the reduction

of the subtalar and calcaneocuboid joints [28]. According to Paley D *et al*., Bohler's angle may be used as a proxy for both the arch angle and the calcaneal height [29]. In the range of 20° to 40°, the Bohler's angle [30] is thought to be typical. The average Bohler angle after surgery was 29.67 degrees in this research. The average time it took for patients to achieve fracture union in our research was 13.64±2.56 weeks. Consistent with our results, Biz *et al*. [31] documented radiographic consolidation of calcaneal fractures in an average of around three months (12 weeks). Radiological union often emerges between two and three months after intra-articular calcaneus fractures are stabilized, according to research by Rajesh V. Chawda *et al*. [32]

The majority of patients were rated as good, followed by excellent, and fair, according to the AOFAS score. As few as two patients had subpar AOFAS results. Results were rated as outstanding in 11 (12.6%) patients, acceptable in 46 (52.9%), fair in 26 (29.9%) and failed in 4 (4.6%) according to Biz *et al*. [30], who also used AOFAS scores to assess outcomes. Due to the patients' lack of cooperation with their physiotherapy, they experienced stiffness in their ankles and feet. Implant removal, wound debridement, and antibiotic cover were used to treat the deep wound infection, according to culture and sensitivity. The patient's superficial wound infection was managed with the use of suitable antibiotics and frequent dressing changes. Implant removal was performed on patients with implant prominence after fracture unification during the last follow-up.

Conclusion

Proper pre-operative planning, scheduling of surgery, surgeon's skill during the operation, and post-operative care are crucial factors for achieving successful surgical treatment of intra-articular fractures with a locking plate, resulting in improved outcomes and low problems. The initial displacement of Bohler's angle is a crucial factor in determining the treatment outcome. Studies suggest that patients with severely fragmented intra-articular fractures and significantly reduced Bohler's angle are at a higher risk of developing early subtalar arthritis and experiencing poor outcomes, irrespective of the treatment provided. It is advisable to do primary subtalar arthrodesis in Sander's type 4 intra-articular fractures to improve functional outcomes and prevent the need for further surgeries and their associated problems.

Conflict of Interest

Not available

Financial Support

Not available

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