

## Correlation of Bohler's Angle with Functional Outcome on Displaced Intra-Articular Calcaneal Fractures

### Abstract

**Aims:** To determine whether restoration of Bohler's angle within normal range gives better outcome when compared to the outliers.

**Settings and Design:** Level 1 trauma centre, Prospective randomized controlled trial.

**Methods and Material:** 42 patients who had intra articular fracture of calcaneus were included in the study. They were operated by surgeons with expertise in foot surgery. Randomization was done and treatment done as open reduction and internal fixation with plate with or without strut bone graft. Bohler's angle was measured pre and post operatively and at each follow up visit till union of fracture.

**Statistical analysis used:** American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hind Foot Scale, paired t Test.

**Results:** When Bohler's angle was restored to within normal limits, fewer complications and statistically significant better results were observed in relation to treatment with internal fixation and bone grafting as compared to those treated without bone grafting.

**Conclusions:** Bohler's angle should be restored to as near normal as possible for achieving better functional outcome. Addition of strut bone grafts with internal fixation helps maintaining reduction of Bohler's angle in postoperative period.

**Keywords:** Intra-Articular Calcaneal Fracture, Bohler's Angle, Bone Grafting, Functional Outcome

**Key Message:** Autologous bone graft supplementation is beneficial in achieving and maintaining restoration of Bohler's angle

### Introduction

Calcaneum is the most common tarsal bone fractured. The commonest mechanism of injury is fall from height followed by motor vehicle accidents [1]. Calcaneal fractures, particularly the intra articular ones, are one of the most disabling fractures, with frequent occurrence during the wage-earning periods of life [2,3]. The treatment is difficult and rehabilitation can be time-consuming in intra articular calcaneal fractures, and still the outcome is highly unpredictable [4,5]. This makes calcaneal fractures a huge socio-economic burden to society. This made us search for a variable, the Bohler's angle, which we could relate with functional outcome in patients with intra articular calcaneal

### Research Article

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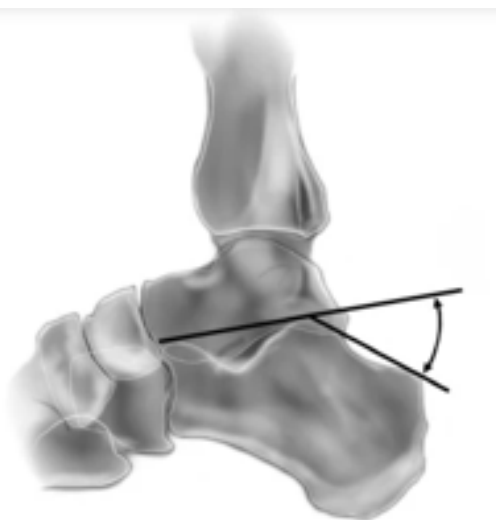
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fractures [6]. The tuber angle of Bohler's is indicated by a line drawn from the highest point of the anterior process of the calcaneus to the highest point of the posterior facet and a line drawn tangential to the superior edge of the tuberosity (Figure-1) [7]. The aim of this study is to determine whether restoration of Bohler's angle within normal ranges gives better outcome when compared to the outliers.



**Figure 1:** Diagram showing how to calculate Bohler's angle

### Materials and Methods

During the period of study all the patients with calcaneum fracture were admitted to the hospital. the inclusion and

exclusion criteria were as follows.

#### Inclusion Criteria [4]:

1. Age more than 18 years and less than 65 years
2. Flattening of the foot i.e. decreased Bohler's angle
3. Displaced intra articular fracture.
4. Absence of preoperative neuro vascular deficit.

#### Exclusion Criteria:

1. Age of less than 18 years and more than 65 years
2. Extra-articular fractures
3. Compound calcaneal fracture, more than Gr. II compounding
4. Un displaced intra articular fractures
5. Presence of preoperative neuro vascular deficit

We included a total of 42 patients in the study, 38 males (90.47%) and 04 females (9.52%) with an average age of 33.59 years (range 18-65 years). Out of these 42 patients four cases were bilateral. The most frequent cause of accident was a fall ( $n = 33$ ) (78.57%) from an average height of up to 3m. Traffic accidents were seen in 08 cases (19.04%) and assault in 01 case (2.38%). All the patients were investigated preoperatively with x-rays and computed tomography (CT) scanning [8] (Figure-2). The Bohler's angle was calculated on the lateral radiograph manually with the help of goniometer and a record was prepared for future references. CT images were evaluated to see intra articular comminution and hence formulate a plan of surgery [9,10]. According to the classification by Essex-Lopresti [11], predominantly joint depression type fractures occurred ( $n = 30$ ) (65.21%), with 16 cases (34.78%) of tongue type fractures. 05 cases (11.90%) were associated with additional injuries, 04 patients (9.52%) had suffered fractures of the spinal column without neurodeficit.

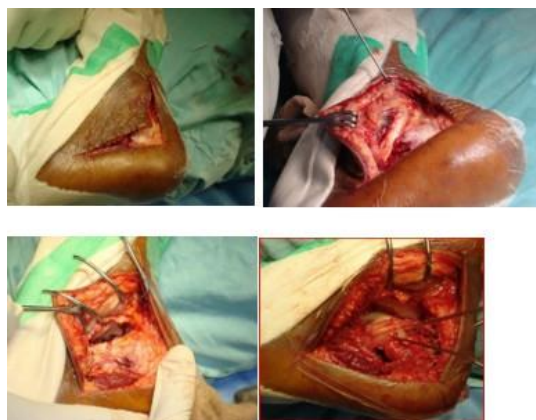


**Figure 2:** Preop-CT Image showing depressed articular fragment with change in Bohler's angle

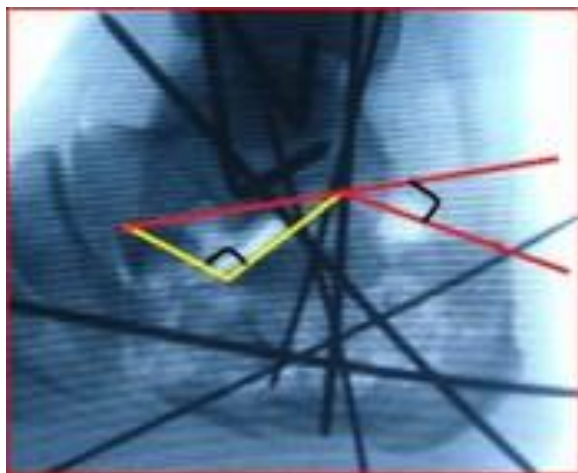
Surgical treatment of the fractures took place once soft tissue conditions allowed. The average duration from admission to surgery was 8 days (range 5-14 days). The patients were randomly assigned to two groups one GROUP 'A' with bone grafting and the other GROUP 'B' without bone grafting.

#### Surgical Technique [12]:

Patients were operated under spinal/ general anaesthesia. Pneumatic tourniquet was used in all patients. Patients were positioned in lateral decubitus position on a radiolucent operating table. An extended lateral approach was performed [5] (Figure-3). The approach was developed as a full-thickness flap. The lateral cortical fragment (bulge fragment) was then hinged away. Subsequently, a good view into the subtalar joint was obtained. The soft tissue flap was held back by K-wires, which had been inserted into the talus and lateral malleolus. Use of the joy-stick technique with a Schanz-screw placed through the tuber calcanei achieves reduction and in particular the length and axis are regained. The fractured lateral wall of the calcaneus is gently opened, leaving the fracture fragments within their periosteal envelope. The fragments are elevated; the articular surface is reduced using the articular surface of talus as template. The individually reduced bone fragments were fixed temporarily with K-wires and reduction was confirmed under image intensifier [13] (Figure-4). In GROUP 'A' patient's bone graft was taken from ipsilateral iliac bone without cutting iliac crest to decrease donor site morbidity [14]. The bone graft consisted of both inner & outer cortex with cancellous bone sandwiched between them. It was placed in the defect below articular surface. Bohler's angle was reconstructed and seen under C-arm. After satisfactory reduction, plate was applied and fixation of the plate was done with multiple screws. Particular care is taken to fix the central fragment (posterior subtalar fragment) in a good and stable position.



**Figure 3:** a) Incision. b) peroneal tendon sheath seen. c) peroneal tendons retracted with two K wires in talus and fibula with subtalar joint exposed. d) articular reduction provisionally fixed with K wires.



**Figure 4:** Intraoperative C-arm for assessing reduction and calculation of Bohler's angle

The mean operative time was 1 hr 45 minutes (range 1hr 25 min-2 hr 55min). In all cases a fluoroscopy was performed after reduction and temporary fixation of the fracture. All the 46 fractures were treated with low profile locking plate fixation [15]. Postoperatively radiographs were taken (Figure-5) and again the Bohler's angle were calculated manually for each patient and recorded. We did not regularly perform CT scan postoperatively. Clinical follow-up examination was performed at 4 weeks, 6 weeks, 10 weeks, 3 months, 6 months and 1 year. At each follow up visit a lateral radiograph was taken and Bohler's angle was calculated. Angles recorded till the fracture united were recorded with previous data of the patients.



**Figure 5:** Postop- X-ray showing union and maintained Bohlers angle

## Statistics

Statistical significance was taken as 0.05. The t test for equality was used to test for significance of difference.

### Group A- Surgery with bone grafting

| Group A  | Mean Bohlers angle | N  | Std. Deviation | Std. Error Mean |
|----------|--------------------|----|----------------|-----------------|
| -pre-op  | 9.52               | 21 | 3.763          | .821            |
| -post-op | 28.90              | 21 | 5.873          | 1.282           |

**Table 1.** Paired Samples Statistics

|                          | N  | Correlation | Sig. |
|--------------------------|----|-------------|------|
| Group A pre-op & post-op | 21 | .500        | .021 |

**Table 2.** Paired Samples Correlations

P value is < 0.05 i.e. 0.021, means there is significant difference in Bohler's angle after operation. At 20 degrees of freedom, 5% significant limit of t is 2.09. The observed t value is 7.237 times the SE hence there is no doubt that surgery improves Bohler's angle.

### Group B- Surgery with bone grafting

| Group B  | Mean Bohlers angle | N  | Std. Deviation | Std. Error Mean |
|----------|--------------------|----|----------------|-----------------|
| -post-op | 21.10              | 21 | 6.156          | 1.343           |
| -pre-op  | 10.95              | 21 | 2.906          | .634            |

**Table 3.** Paired Samples Statistics

|                          | N  | Correlation | Sig. |
|--------------------------|----|-------------|------|
| Group B post-op & pre-op | 21 | .839        | .000 |

**Table 4.** Paired Samples Correlations

P value is < 0.05 i.e. <0.0001, means there is significant difference in Bohler's angle after operation. At 20 degrees of freedom, 5% significant limit of t is 2.09. The observed t value is 11.50 times the SE hence there is no doubt that surgery improves Bohler's angle.

### Group A & Group B

| Group A & B |            | Mean  | N  | Std. Deviation | Std. Error Mean |
|-------------|------------|-------|----|----------------|-----------------|
| Pair 1      | -post-op A | 29.38 | 21 | 5.687          | 1.241           |
|             | -post-op B | 21.10 | 21 | 6.156          | 1.343           |

**Table 5.** Paired Samples Statistics

|                              | N  | Correlation | Sig. |
|------------------------------|----|-------------|------|
| Pair 1 post-op A & post-op B | 21 | -.165       | .474 |

**Table 6.** Paired Samples Correlations

|                                    | Paired Differences |                     |                    |                                              |        | t     | df | Sig.<br>(2-tailed) |
|------------------------------------|--------------------|---------------------|--------------------|----------------------------------------------|--------|-------|----|--------------------|
|                                    | Mean               | Std. Devia-<br>tion | Std. Error<br>Mean | 95% Confidence Interval of<br>the Difference |        |       |    |                    |
|                                    |                    |                     |                    | Lower                                        | Upper  |       |    |                    |
| Pair 1<br>post-op A &<br>post-op B | 8.286              | 9.045               | 1.974              | 4.168                                        | 12.403 | 4.198 | 20 | .000               |

**Table 7.** Paired Samples Test

At 20 degrees of freedom, 5% significant limit of t is 2.09. The observed t value is 4.198 times the SE hence Group A is better than Group B.

## Results

### Group A

In patients treated with plating and bone grafting partial weight bearing was started within 6-8 weeks and full weight bearing within 3- 6 months. 13 patients (61.90%) walked full weight bearing in 3 months' duration, while 08 patients (38.09%) took 4-6 months to walk full weight bearing due to delayed wound healing or associated injuries like vertebral fracture.

The time for union was 8–14 weeks. in 22 cases (95.65%) normal Bohler's angle (i.e. 20°-40°) was achieved. There were 3 cases (13.04%) of post-operative delayed wound healing [16]. The gaping was at the angle of the incision for 2-3 cm. It was deep till subcutaneous tissue but plate was not exposed. All healed with daily dressing and delayed mobilization within 3 weeks and had no further treatment [17]. 01 patient (4.34%) had superficial wound infection and was treated with oral antibiotics. None of the patients developed severe infection. None of the patients developed sural nerve complication in the form of loss of sensation on lateral aspect of foot or had painful hardware.

The overall results according to the AOFAS Ankle Hind Foot Scale were good and excellent in 20/23 (86.95%). Out of these 4 (17.39 %) of the patients had excellent results, 16 (69.56%) had good results, 2 (8.69 %) had fair result and 1(4.34%) had poor results

### Group B

In group B patients treated with plating without bone grafting, partial weight bearing was started within 6-8 weeks and full weight bearing within 3- 6 months [15]. 10 patients (47.61%) walked full weight bearing in 3 months' duration, while 11 cases (52.38%) took 4-6 months due to delayed wound healing or associated injuries.

The average time for union was 10– 16 wks. in 17 cases (73.91%) normal Bohler's angle (i.e. 20-40°) was achieved. There were 3 cases (13.04%) of operative delayed wound healing [16]. It was deep till subcutaneous

tissue but plate was not exposed. All healed with daily dressing and delayed mobilization within 3 weeks and had no further treatment [18]. 01 patients (4.34%) had superficial wound infection and treated with oral antibiotics. None of the patients developed severe infection. 01(4.34%) of the patient developed sural nerve complication in the form of loss of sensation on lateral aspect of foot and 01(4.34%) had painful hardware, so implant removal was done after bony union [18].

The overall results according to the AOFAS Ankle Hind Foot Scale were good and excellent in 17/23 (73.91%). 3/23 (13.04 %) had fair result and 3/23(13.04 %) had poor results.

We confirmed that autologous bone graft supplementation is beneficial in achieving and maintaining restoration of calcaneal height and anatomic reduction [14]. This study also demonstrates that there is statistically significant difference between the functional outcome of patients regarding the change in Bohler's angle obtained with surgery [6].

## Discussion

The treatment of calcaneal fracture has long been major topic of debate [4]. Because of its unique shape, difficulties arose in understanding the geometry of the fracture. CT scan with 3D reconstruction provided improved understanding of calcaneal fractures and led to a clinically relevant classification of these injuries [8-10]. Thus a better surgical planning became possible. The therapeutic modalities for displaced intra-articular calcaneal fractures can be divided into conservative and operative management. The latter comprises both the open reduction and internal fixation (ORIF) and percutaneous reduction and internal fixation (PRIF) [19,20]. Since the mid-nineties, ORIF is considered the gold standard treatment for displaced intra articular fractures of the calcaneus by most experts, as it generally provides overall good to excellent results and the ability to anatomically restore the subtalar joint [21]. Good results are achieved if the stable anatomical reduction of the posterior facet is possible. Several open surgical techniques have been described in the past, of which the extended lateral approach has been applied most frequently [22]. Alternative operative techniques include a medial approach, plantar approach, combined lateral and

medial approach, limited posterior approach, and the sinus tarsi approach. The results of ORIF and conservative treatment have been described and compared in several studies. These studies show improved outcome after operative treatment in subgroups and a higher rate of failed initial treatment with an increased need for a subtalar arthrodesis in conservatively treated patients [21].

Although surgical treatment of displaced calcaneal fractures is an established surgical standard it is still not clear, if accurate anatomic reduction is of major importance. The restoration of the tension of the plantar fascia by reconstruction of Bohler's angle and hind foot length is important for the biomechanics of the foot [6]. Special plates have been invented to suit the needs for the treatment of calcaneal fractures (e.g. AO calcaneal plate, Galveston plate, low contact plate) [13,22]. The selected implant should be able to neutralize the forces resulting from the Achilles tendon and maintain reduction of the fragments until bony consolidation.

Incidence and severity of posttraumatic subtalar arthrosis depends on the fracture type, calcaneal shape, and position after the osteosynthesis, chondral injury of the subtalar joint, and articular facet congruency. The treatment of calcaneal fractures is complex and has to be individualized depending on patient characteristics, fracture type and the condition of the soft tissues. While most of the surgeons while operating intra articular calcaneal fractures would want to achieve anatomical intra articular reduction, much less attention is paid to Bohler's tuber joint angle [6]. A severe heel fracture will result in a significant decrease or loss of the Bohler's angle. At present, there is only a limited amount of data available on predicting the functional outcome after open reduction internal fixation of calcaneal

fractures [20].

The purpose of this study is to evaluate the correlation between Bohler's angle and functional outcome in displaced intra-articular calcaneal fractures treated with internal fixation, with or without bone grafting.

In our study we observed lesser infection rate in bone graft group than without bone graft group there is also concern of donor site morbidity associated with iliac crest bone graft but we were able to decrease the donor site morbidity by preserving the iliac crest. Restoration of Bohler's angle was associated with better outcome (Figure-6). In our study post-operative Bohler's angle was significantly higher in bone graft group [23].



**Figure 6:** Functional results in range of motion

Restoration of Bohler's angle was statistically significantly better in the bone graft group than non-bone graft group. We have confirmed that in treatment of intraarticular calcaneum fractures bone graft augmentation could restore the Bohler's angle better and prevent late collapse. The patients with bone grafts could return to full weight bearing earlier.

## Acknowledgement

The treatment of calcaneal fracture has long been major topic of debate. Because of its unique shape, difficulties arose in understanding the geometry of the fracture.

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