

## Treatment of Joint Depression Intraarticular Calcaneal Fractures with and without Graft

S.M.Zahed, M.Sh.Abouzied and M.M.Salah

Orthopedic Dept., Faculty of Medicine, Benha Univ., Benha, Egypt

E-Mail: abouziedmz83@gmail.com

### Abstract

Intra-articular calcaneal fracture is one of the most challenging fractures in orthopedic surgery. The main complications of intra-articular calcaneal fractures are postoperative wound complications, subtalar arthritis, malalignment and subtalar stiffness. Conversion of the operative technique from the classic L shaped incision to the mini-invasive sinus tarsi approach renders the wound complications as less as possible. Subtalar arthritis can be minimized by anatomical reduction of the posterior facet. Malalignment can be simply prevented by calcaneal tuberosity reduction and fixation by percutaneous cannulated screws. Early subtalar range of motion without weight bearing can overcome the subtalar stiffness. In this study, we included 20 patients with unilateral intra-articular calcaneal fracture without ipsilateral lesions. The patients were treated by open reduction and internal fixation through sinus tarsi approach. The patients were divided in two groups. The first group A were treated by the mentioned above technique without operative supplementation of iliac bone graft. The second group B were treated by the same technique with supplementation of iliac bone graft. Significant improvement was observed in the two groups regarding pain, AOFAS score. No significant difference between the two groups apart from that the group B treated with supplementation of iliac bone graft had earlier bone consolidation and consequently earlier weight bearing which allow for rapid return to daily activities.

**Keywords:** Intararticular fracture calcaneus, Sinus tarsi, Bone graft.

### 1. Introduction

The calcaneus is the most frequently injured tarsal bone comprising 1-2% of all fractures and about 75% of those affecting the foot. Approximately 75% of calcaneal fractures are intraarticular [1].

The economic importance of the injury is considerable, as 80% to 90% occur in men in their prime working years. As a result, they may be disabled for several years after the injury and many are unable to return to their original occupation [3].

Approximately 50% of the foot's weight bearing occurs through the calcaneus and the complexity of its articular surfaces makes intraarticular fractures a significant challenge. Historically, intra-articular calcaneal fractures have been associated with poor outcomes so they were treated conservatively to avoid the additional morbidity of a surgical procedure. There are still proponents of closed treatment, but with technological advances in imaging, such as computed tomography (CT), and innovative surgical techniques and fixation devices, surgeons are finding improved results with open reduction and fixation. Better results have been associated with exact anatomic reduction [4].

Treatment of intra-articular calcaneal fractures can be divided into conservative and operative management. The latter comprises open reduction and internal fixation, percutaneous reduction and fixation and primary arthrodesis [5]. Conservative treatment might be considered in non-displaced or minimally displaced fractures, compromised soft-tissues and in patients with physical contra-indications (e.g., peripheral vascular disease, psychic patient). Open reduction and internal fixation 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 [5].

Several open surgical approaches have been described in the past, of which the extended lateral approach has been applied most frequently. Its main disadvantages are wound dehiscence and infection, which may occur in up to 30% of

patients. Alternative surgical approaches to the calcaneus include the limited lateral approach. Many methods of fixation were described including plates and screws, screws, k wires and external fixators [5].

Because of the high risk of soft tissue problems and since stable fixation with plates does not offer the possibility of early weight bearing, limited approach and minimal fixation to avoid compromising the already damaged soft tissue coverage on the lateral side may be favored [6].

The use of bone graft to fill the gap resulting after open reduction of calcaneal fractures was first described by Lenormant in 1928 [7].

Supporters of bone grafts believe that it could increase stimulation of fracture healing for early full weight bearing, prevent post traumatic arthritis, and add mechanical strength to avoid significant late collapse. Those opposed to bone grafts stated that the highly vascular calcaneus heals radiographically 4-8 weeks after surgery in the absence of bone graft [8].

### 2. Patients and methods

This study included 20 patients with unilateral intra-articular fracture calcaneus from march 2019 to September 2019.

The patients will treated by open reduction and internal fixation through minimal invasive sinus tarai approach using miniplate and cannulated screws for fixation. Iliac graft will be used in half of the patients and the others will be treated without graft. The study will be done in Benha university hospitals.

#### Inclusion criteria

- Age: skeletally mature patients.
- Sanders type II, III fractures.
- closed fractures.

#### Exclusion criteria

- Extra-articular fractures.
- Sanders type I and IV fractures.
- Associated ipsilateral other foot bones fractures.
- neglected fractures.
- Open fractures.

- Vascular compromise
- Bilateral fractures

**Patient’s evaluation and initial management:**

The patients were evaluated preoperatively by wrinkles test in which ankle dorsi-flexion and foot eversion was done to notice the wrinkles over the lateral aspect of the ankle. Presence of wrinkles favors surgical intervention.

Lateral x-rays of the ipsilateral hindfoot were obtained preoperatively to determine Böhler’s and Gissane angles together with the contralateral hindfoot to determine the normal Böhler’s and Gissane angles. Antero-posterior x-rays of the feet were obtained to exclude calcaneo-cuboid joint affection. CT scans were obtained in order to determine the Sanders classification type.

**Surgical technique**

**1- Anaesthesia:** All patients were operated under spinal anaesthesia.

**2- Position:** lateral decubitus placing the affected limb upwards on a radiolucent operating table.

**3-surgical approach**

A skin incision of 3 cm was done over the sinus tarsi at about 2 cm distal and anterior to the tip of the lateral malleolus. Deep dissection and removing the sinus tarsi fat was done to facilitate exposure of posterior facet.



Fig (1) Intraoperative photograph showing the sinus tarsi approach.

**4- Reduction and fixation**

Elevation and reduction of the posterior facet was performed assisted by hindfoot inversion and temporary stabilization with K-wires. Reduction was checked in the lateral and Broden’s views and Gissane angle was evaluated through image intensifier. One 2.4 mm mini-plate was used to stabilize the reduced posterior facet fragment to the anterior part of calcaneus.

Varusmalalignment of the tuberosity fragment was aligned with the calcaneal body using 5mm stiemen pin in the tuberosity fragment and the reduction was stabilized by insertion of two percutaneous 4 mm cannulated screws from the tuberosity fragment directed anteriorly to prevent varusmalalignment and to maintain the calcaneal length.

One or two additional cranially directed 4 mm cannulated screws were used to additionally support the posterior facet, to maintain calcaneal height, and to stabilize separated planter fragment of the tuberosity in some cases.

**5- Graft**

Iliac bone graft was used for the half of the patients randomly.

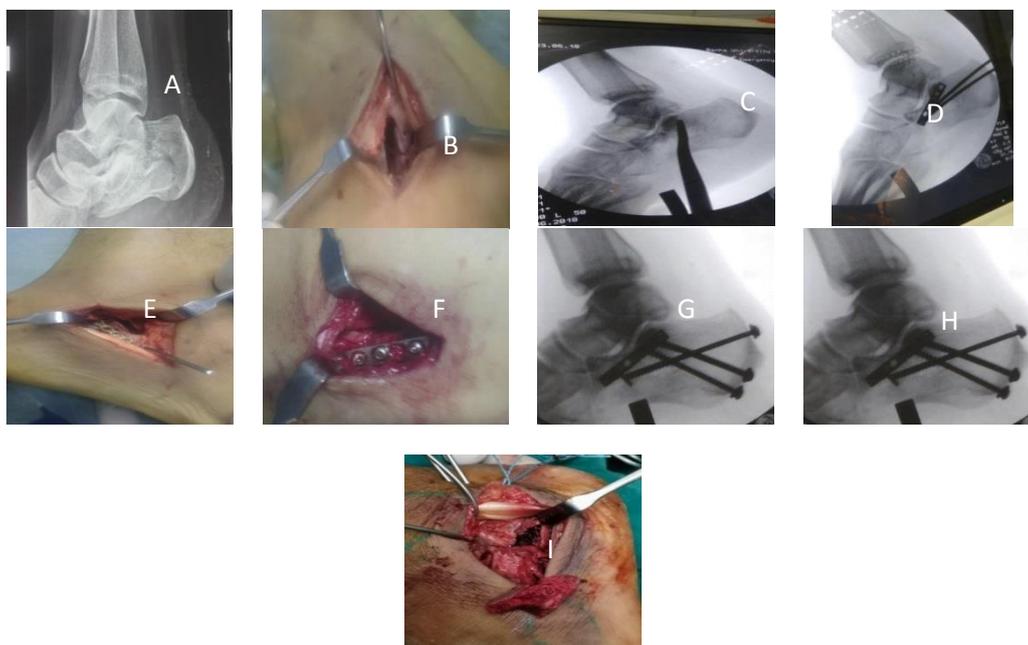


Fig (2) Steps of operative procedures.(A)preoperative lateral x-ray,(B)minimal invasive skin incision,(C)elevation of depressed intra-articular fragment under image control,(D)graft used (E)fixation with plate,(F)preliminary fixation of plate by k-wires,(G)final plate fixation with screws,(H)final fixation under image control

**6- Closure of the wound:** Closure in layers was done.

### Postoperative care

All the patients had postoperative oral antibiotics (amoxicillin +clavulanic acid) for 5 days, together with analgesic and anti-edematous drugs. The foot was protected by below knee slab for two weeks. Sutures were removed after 2 weeks with the removal of the slab. The patients were encouraged to start range of motion after slab removal. Strict non weight bearing lasts for 12 weeks in patients treated without graft and after radiological healing and consolidation in patients treated with graft.

### Radiological postoperative evaluation

The patients were evaluated radiographically by lateral, anteroposterior and Harris views. The radiographs were obtained in the postoperative day, 2 weeks, 6 weeks, 3 months, 6 months postoperatively. The radiographs were evaluated for reduction of the posterior facet, correction of varusmalalignment, radiological union and final measurements of Böhler's and Gisanne angles. CT scans were obtained at 6 months postoperatively to determine the status of subtalar joint.

### Postoperative clinical follow up

Clinical evaluation was standardized for all patients at 6 months postoperatively. The patients were evaluated by American orthopedic foot and ankle society (AOFAS) hind foot score. Results more than 90 points were graded as excellent, points >80 were good, points >70 were fair and poor for points < 70 points. Visual analogue scale (VAS) for pain was estimated 6 months postoperatively.

### Statistical methods

Data management and statistical analysis were done using SPSS vs.25. (IBM, Armonk, New York, United States). Numerical data were summarized as means and standard deviations or medians and ranges. Categorical data were summarized as numbers and percentages. Böhler's and Gisanne angles were compared pre and post-operative and post-operative angles were compared to contra-lateral one using paired t-test. All P values were two sided. P values less than 0.05 were considered significant.

### 3. Results

Patients whom treated without graft were considered group A.

The mean age of the patients in this group was 30 ±9 years. 7 patients were males and 3 were females. 4 patients were smokers.

**Table (1)** General characteristics group A.

| Age (years) | Mean ±SD      | 30 ±9    |
|-------------|---------------|----------|
| Gender      | Males n (%)   | 7 (70.0) |
|             | Females n (%) | 3 (30.0) |
| Smoking     | Yes n (%)     | 4(40.0)  |

Patients whom treated with graft were considered group B.

The mean age of the patients in this group was 34 ±2 years. 8 patients were males and 2 were females. 3 patients were smokers.

**Table (2)** General characteristics group B.

| Age (years) | Mean ±SD      | 34 ±2    |
|-------------|---------------|----------|
| Gender      | Males n (%)   | 8 (80.0) |
|             | Females n (%) | 2 (20.0) |
| Smoking     | Yes n (%)     | 3(30.0)  |

The preoperative delay in was 8±2 days ranged from 3 to 12 days in group A but in group B, IT was 7±4 ranged from 4 to 11 days.

The postoperative hospital stay was 2 ±1 days in group A and 3± 2 days in group B.

The follow up period was 11 ±2 months in group A and 12± 3 months in group B.

6 patients were classified as Sander type II and 4 patients were classified as Sander type III in group A.

8 patients were classified as Sander type II and 2 patients were classified as Sander type III in group B.

The final mean visual analogue of pain (VAS) score was 1 in both groups.

The final mean of American orthopedic foot and ankle society score (AOFAS) was 83 ±4 in group A and 85±2 in group B.

**Table (3)** Preoperative delay (days) A and B.

|                             |                | A        | B        |
|-----------------------------|----------------|----------|----------|
| Preoperative delay (days)   | Mean ±SD       | 8 ±2     | 7± 4     |
| Postop hospital stay (days) | Mean ±SD       | 2 ±1     | 3± 2     |
| Follow up (months)          | Mean ±SD       | 11 ±2    | 12± 3    |
| Sander type                 | Type II n (%)  | 6 (60.0) | 8 (80.0) |
|                             | Type III n (%) | 4 (40.0) | 2 (20.0) |
| VAS                         | Median (range) | 1 (0 -3) | 1 (0-3)  |
| AOFAS score post op         | Mean ±SD       | 83 ±4    | 85±2     |

VAS = Visual Analogue Scale

AOFAS = American Orthopedic Foot and Ankle Society

Significant improvement of Bohler angle was noticed in both groups. The preoperative mean Bohler angle was 5 ±2 degrees and became 25 ±4 degrees in group A. It changed from 7±3 degrees to 24±2 degrees in group B. The mean contralateral Bohler angle was 28 ±4 degrees in group A and 28±2 degrees in group B.

**Table (4)** Bohler angle A and B.

| Bohler angle   | A        | B     | P value |        |
|----------------|----------|-------|---------|--------|
| Pre-operative  | Mean ±SD | 5 ±2  | 7±3     | <0.001 |
| Post-operative | Mean ±SD | 25 ±4 | 24±2    |        |

Significant improvement of Gissane angle was noticed in both groups. The preoperative mean Bohler angle was 147 ±5 degrees and became 135 ±2 degrees in group A. It changed from 144±3 degrees to 131±1 degrees in group B.

The mean contralateral Gissane angle was 133 ±2 degrees in group A and 130±2 degrees in group B.

Table (5) Gissane angle A and B.

| Gissane angle  |      | A      | B | P value |
|----------------|------|--------|---|---------|
| Pre-operative  | Mean | 147 ±5 |   | <0.00   |
|                | ±SD  | 144±3  |   |         |
| Post-operative | Mean | 135 ±2 |   | 1       |
|                | ±SD  | 131±1  |   |         |

Table (6) Bohler angle A and B.

| Bohler angle   |          | A     | B    | P value |
|----------------|----------|-------|------|---------|
| Post-operative | Mean ±SD | 25 ±4 | 24±2 | <0.001  |
|                |          |       |      |         |
| Contralateral  | Mean ±SD | 28 ±4 | 28±2 |         |
|                |          |       |      |         |

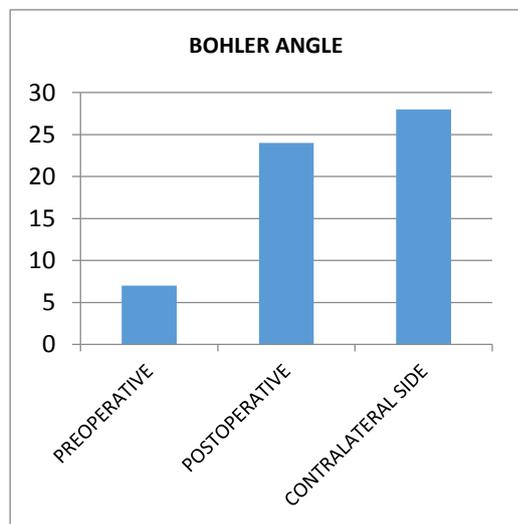
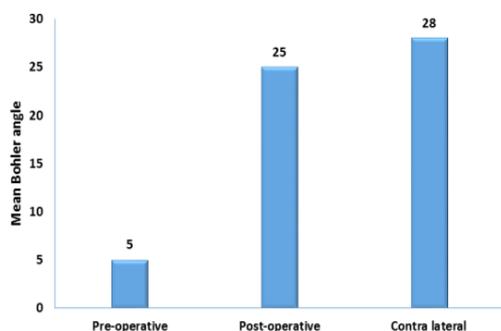


Fig (3) Paired t test was used Group A and Group B.

Table (7) Post operative and Contralateral A , B.

| Gissane angle  |          | A      | B     | P value |
|----------------|----------|--------|-------|---------|
| Post-operative | Mean ±SD | 135 ±2 | 131±4 | <0.001  |
|                |          |        |       |         |
| Contralateral  | Mean ±SD | 133 ±2 | 130±2 |         |
|                |          |        |       |         |

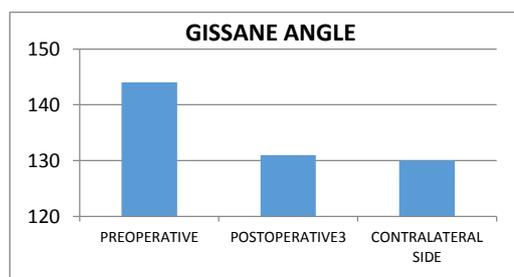
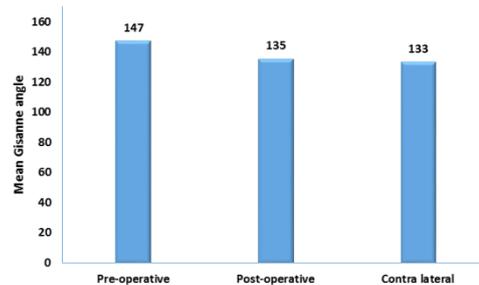


Fig (4) Paired t test was used Group A and Group B.

Weight bearing was allowed after 12 weeks in group A and ranged from 7 to 9 weeks in group B.

**Complications**

Were reported in 3 patients in the form of superficial wound infection which was treated by intravenous administration of antibiotics and daily dressings. One of the affected patients was belong group A and the other 2 patients were belong group B.

Two patients were in need for another hospital admission during the follow up period in order to remove the prominent cannulated screws. These 2 patients were belong to group A.

**Statistical methods**

Data management and statistical analysis were done using SPSS vs.25. (IBM, Armonk, New York, United states).

Numerical data was summarized as means and standard deviations or medians and ranges. Categorical data was summarized as numbers and percentages.

Bohler and Gissane angles were compared pre and post-operative and post-operative angles were compared to contra-lateral one using paired t test.

All P values were two sided. P values less than 0.05 were considered significant.

**4. Discussion**

A variety of techniques have been proposed for the fixation of calcaneal fractures, but the optimal fixation technique has not yet been identified [9].

Intra-articular calcaneal fractures constitute about 75% of all calcaneal fractures. The goal of surgery is to obtain anatomic reduction while retaining the geometry and structure of the calcaneus and restoring the joint axis of the ankle [10].

ORIF via extensile lateral approach is the recommended procedure for this fracture, but with increased risk of skin complications [11].

The main complications of treatment of calcaneal fractures are wound complications, malalignment, stiffness and arthritis.

Regarding wound complications, The sinus tarsi approach does not violate the angiosomes of the lateral hindfoot like the extensile lateral approach. It also decreases incision length and overall dissection, which should decrease wound healing issues. It allows for direct visualization of the lateral wall, posterior facet, anterolateral fragment, and anterior process to ensure quality reduction [12].

Regarding arthritis, the main issue is to anatomically reduce the articular surface of the posterior facet and its stabilization. A variety of fixation techniques have been used for the surgical treatment of intra-articular calcaneal fractures-Kirschner wires, H cervical plates [13], 3.5 mm reconstruction plates, and Y calcaneal plates [15].

Regarding stiffness, early range of motion should be encouraged as early as possible and not to be delayed more than two weeks. Early range of motion should include ankle and subtalar joints together allowing for normal gait.

Regarding malalignment, reduction of varus orientation of the calcaneal tuberosity with maintaining calcaneal length and height through percutaneous cannulated screws can prevent malalignment.

In this study the sinus tarsi approach was used in the 20 patients. 10 patients were fixed by miniplate with percutaneous cannulated screws technique and 10 patients were fixed by the same technique which augmented by iliac bone graft inserted through the sinus tarsi approach.

The results of this study were compared with the study of S.Xia et al [14] who used a specially designed plate to fix calcaneal fracture through sinus tarsi approach. The results of this study were also compared with the results of Cong Jin et al [17] who compared fixation of calcaneal fractures by plate through MIPO technique versus the extensile lateral approach. Also we compared the results of this study with the results of Abdelazeem et al [3] and Y.Khira [16] who used sinus tarsi approach and fixed calcaneal fractures with screws.

In this study 20 patients were included with 20 calcaneal fractures. The fracture was reduced and stabilized by the same technique in all patients. Group A treated without graft and group B treated with application of iliac bone graft.

The mean age of the patients in group A was  $30 \pm 9$  years. 7 patients were males and 3 were females. 4 patients were smokers.

The mean age of the patients in group B was  $34 \pm 2$  years. 8 patients were males and 2 were females. 3 patients were smokers.

In this table we compare the demographic data in the chosen studies with the demographic data in this study.

**Table (8)** Comparing the demographic results of the selected studies to this study.

|  | S.Xia et al<br>(2013)    | Cong Jin et<br>al<br>(2017)      | Abdelazeem et<br>al<br>(2013) | Y.Khira<br>(2016)                  | This study<br>(2020)         |
|--|--------------------------|----------------------------------|-------------------------------|------------------------------------|------------------------------|
| <b>Number of patients</b>                    | 38                       | 64                               | 33                            | 28                                 | 20                           |
| <b>Number of fractures</b>                   | 40                       | 64                               | 33                            | 30                                 | 20                           |
| <b>males</b>                                 | Not<br>mentioned         | 48.43%                           | 75.75%                        | 71.42%                             | 75%                          |
| <b>females</b>                               | Not<br>mentioned         | 51.5%                            | 24.24%                        | 28.57%                             | 25%                          |
| <b>Contralateral<br/>calcaneal fractures</b> | 5.2%                     | 0                                | 0                             | 7.14%                              | 0%                           |
| <b>Associated<br/>fractures</b>              | 10.52%                   | 10.9%                            | 0                             | Not<br>mentioned                   | 0%                           |
| <b>Medical<br/>comorbidities</b>             | 2 cases with<br>DM       | Not<br>mentioned                 | Not mentioned                 | Not<br>mentioned                   | 2 cases with<br>hypertension |
| <b>Sanders<br/>classification</b>            | 55% type 2<br>45% type 3 | 65.57% type<br>2<br>37.5% type 3 | 45.5% type 2<br>54.5% type 3  | 33.3% type<br>2<br>66.7% type<br>3 | 70% type 2<br>30% type 3     |

Regarding the number of patients the results of this study were comparable to Abdelazeem et al and Y.Khira.

In this study there was no contralateral calcaneal fractures nor other associated fractures which allow comparing to the other side.

In this study the cases were operated after a mean time of  $8 \pm 2$  days in plate group A and  $7 \pm 4$  days in group B. S.Xia et al operated after mean time of 8.3 days and Abdelazeem et al operated after mean time of 9 days. Y.Khira operated his cases at mean time of 4 days. Sinus

tarsi approach allow for early intervention without more delay decreasing the preoperative hospitalization in comparison to treatment with the classic extensile lateral approach which render early operative intervention is catastrophic regarding soft tissue complications.

In this study the mean follow up time was  $11 \pm 2$  months in group A and  $12 \pm 3$  months in group B, 12 month in S.Xia et al study, 16 month in Cong Jin et al study, 22 month in Y.Khira study and 28 month in Abdelazeem et al study.

**Table (9)** Showing comparison between the mean time to operation, mean operative time and mean follow up time.

|                               | S.Xia et al | Cong Jin et al<br>(MIPO group) | Cong Jin et al<br>(ELA group) | Abdelazeem<br>et al | Y.Khira | This study<br>(group A) | This study<br>(group B) |
|-------------------------------|-------------|--------------------------------|-------------------------------|---------------------|---------|-------------------------|-------------------------|
| Mean time to operation (days) | 8.3         | 6.2                            | 6.5                           | 9                   | 4       | 8 ±2                    | 7± 4                    |
| Mean follow up (month)        | 12          | 16                             | 15.7                          | 28.8                | 22      | 11 ±2                   | 12± 3                   |

In this study we followed our patients radiologically by serial X rays axial and lateral on the calcaneus to measure Bohler and Gissan angles. We also followed them clinically with the AOFAS ankle/hind foot score, visual analogue of pain (VAS) score, subtalar range of motion and the time needed for full weight bearing and return to daily activities. Complications were followed up and sorted as skin complications, hardware irritation, fibular impingement and failure of fixation.

In this study the mean AOFAS ankle/hindfoot score was 83 ±4 in group A and 85±2 in group B. It was comparable to the MIPO group in the study of Cong Jin et al with mean score of 84.4. It was also comparable to the score of the extensile lateral approach in the study of Cong Jin et al which was 83.9 but it was less than the mean score in Abdelazeem et al study which was 91.9.

The following table compares the scores of the patients in different studies, with the scores in this study.

**Table (10)** Showing comparison between the scores of the AOFAS ankle/hind foot score in the chosen studies and this study.

| AOFAS Ankle/hindfoot score | S.Xia et al | Abdelazeem et al | Y.Khira | This study<br>(group A) | This study<br>(group B) |
|----------------------------|-------------|------------------|---------|-------------------------|-------------------------|
| Excellent (90-100)         | 80%         | 72.7%            | 28.6%   | 30%                     | 20%                     |
| Good (80-90)               | 15%         | 21.2%            | 35.7%   | 50%                     | 70%                     |
| Fair (70-80)               | 5%          | 3%               | 21.4%   | 20%                     | 10%                     |
| Poor (less than 70)        |             | 3%               | 14.3%   |                         |                         |

In this study we had good/excellent results in 90% of cases. This was comparable to the result of S.Xia et al study that had good/excellent results in 95% of cases, and the results of Abdelazeem et al study that had good/excellent results in 93.9% of cases, but exceed the results of Y.Khira who had good/excellent results in 64.3% of cases.

In this study there was skin complication rate of 10% (one case) in the group A and 20% (2 cases) in group B, which was comparable to the results of Y.Khira study (13%), but higher than the results of S.Xia et al study (0) and the MIPO group in Cong Jin et al study (6.8%).

This superficial wound infection in the three cases was treated with intravenous antibiotics with daily sterile dressings and we did not have to remove the implants.

The extensile lateral approach group in Cong Jin et al study had higher rate of skin complications than our study, with complication rate of 37%. Abdelazeem et al had infection rate of 3% while Y.Khira had infection rate of 13%.

Regarding hardware irritation, 10% of the patients (2 cases belong to group A) had hardware irritation which were in need for hospitalization and hardware removal during follow up period. It was less than the results of Abdelazeem et al with 21.2% of cases having hardware irritation.

In the group A 20% of cases had hardware irritation. This complication may be due to the fact that in this study we did not use a bone graft which has a relatively high incidence of cannulated screws loosening.

No cases in the study groups had fibular impingement. This may be due to the buttress effect of the plate on the blown out lateral wall of the fractured calcaneus.

In group A, patients were not allowed to weight bear before 12 weeks for fear of collapse and failure of reduction. In group B, weight bearing is allowed earlier as application of iliac bone graft renders the healing faster with earlier bone consolidation. Weight bearing in group B was allowed within 7 to 9 weeks.

There is overall no difference between the two groups regarding articular reduction, early ankle and subtalar range of motion, calcaneal bony alignment and the resultant complications. The main issue is to allow earlier weight bearing with treatment augmentation by iliac bone graft in group B.

The strengths of this study include the use of the same preoperative evaluation, operative technique for all patients. All patients were operated upon in the same hospital. Another point of strength is exclusion of contralateral calcaneal fractures to allow comparison with the other side and exclusion of ipsilateral foot injuries which renders the results related only to the calcaneal fracture not affected by other injuries.

The weaknesses of this study are the limited number of patients included in the study and the limited follow up time.

## 5. Conclusion

In this study the conclusion was that the results in patients with intra-articular fracture calcaneus treated with miniplate through mini-invasive sinus tarsi approach plus percutaneous cannulated screws in addition of application of iliac graft was the same as patients treated by the same technique without graft regarding pain, clinical outcome, radiological improvement while the patients whom treatment was supplemented with iliac bone graft had

earlier weight bearing with earlier return to their daily activities.

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