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# A functional outcome of intra articular calcaneum fracture managed surgically with plate fixation: A prospective study

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**Abstract**
Intraarticular fractures account for approximately 75% of calcaneal fractures and historically have been associated with poor functional outcomes. The management of intraarticular calcaneal fractures remains a controversy, with strong arguments supporting both conservative & operative managements. Significant controversy remains over the results of nonoperative versus operative treatment. The lack of standardization of results has made it difficult to compare studies that have evaluated outcomes [1].
**Aims and Objective:** 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:** A prospective study including 25 patients with an intra-articular calcaneal fracture who met the inclusion criteria was conducted in SGITO, Bangalore, between November 2019 and November 2020. Patients were managed surgically with plate fixation and were followed up regularly at 6 weeks, 12 weeks, 24 weeks and 1 year. Radiological outcome and functional outcome evaluated using AOFAS score.
**Results:** Mean age of the patients was 33.6 years. The mean time duration between injury and surgery was 7.8 days. The mean time for fracture union was 13.64 ±2.56 weeks. The difference between pre and post-operative mean bohler's and gissane's angle was statistically significant with a p value <0.01. Out of 25 patients 4 patients (16%) had excellent, 16 patients (64%) had good, 4 patients (16%) had fair and 1 patient (4%) had a poor outcome.
**Conclusion:** We conclude that with proper pre-operative planning, the timing of surgery, intra- operative expertise of the surgeon, and post-operative care, surgical management of intra-articular fracture using a locking plate, gives a better outcome and minimal complications.

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

## Introduction
Calcaneal fractures account for up to 75% of all foot fractures and 1–2% of all fractures [1], being more common in males and those who work in an industrial profession. Intraarticular fractures account for approximately 75% of calcaneal fractures and historically have been associated with poor functional outcomes. These fractures are uniformly caused by an axial load mechanism, such as a fall from height or a motor vehicle accident, and may be associated with other axial load injuries such as lumbar, pelvic, and tibial plateau fractures [2].
The management of intraarticular calcaneal fractures remains controversial, with strong arguments supporting both conservative & operative managements. Recent studies are of varied opinion; some siting no difference between the two & others suggesting operative to be a better option. Significant controversy remains over the results of nonoperative versus operative treatment. The lack of standardization of results has made it difficult to compare studies that have evaluated outcomes [2].
Historically, there have been dramatic changes in management protocols as our understanding of the fracture has evolved. The historical statement by Cotton that ''the man who breaks his calcaneus is done'' [3]. Perhaps it does not hold well in the twenty-first century.

Over the past 25 years, however, marked advances in anesthesia, prophylactic antibiotics, CT scanning, and fluoroscopy have allowed surgeons to improve outcomes when operating on fractures, and these techniques have been applied to calcaneal fractures as well. Overall, operative treatment of acute fractures has become the standard of care for many authors who, critically evaluating their results, have concluded that good outcomes are possible.

**Aims and objectives of the study**

1. To evaluate the functional and clinical outcome of intra-articular calcaneal fractures managed by open reduction and internal fixation with a plate.

2. To analyse the radiological outcome of intraarticular calcaneal fractures following open reduction and internal fixation with a plate in terms of bohler's and gissane's angle and rate of the radiological union.

**Materials and Methods**

**Sampling Area:** Sanjay Gandhi Institute of Trauma and Orthopaedics, Bangalore.

**Study Duration:** Between November 2019 and November 2020.

**Study Design:** Prospective study.

**Sample Size:** A total of 25 patients with intra-articular calcaneal fractures meeting the inclusion and exclusion criteria were chosen for the study.

**Inclusion Criteria**

1. Patients aged between 18-60yrs
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

**Sampling Method**

The patients who sustained an intra-articular calcaneal fracture and presented to Sanjay Gandhi Institute of Trauma and Orthopaedics, Bangalore, between November 2019 and November 2020, who met the inclusion and exclusion criteria were included in the study.

**Methodology and procedure**

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 calcaneam 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 from the patients and ethical committee clearance, 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 5$^{th}$ 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 14$^{th}$ day. Ankle range of movements were started at 2$^{nd}$ 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 Orthopaedics 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 prospective 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 analysed in terms of functional outcome of a postoperative range of movement after the union, time for fracture union, early and late postoperative complications.

**Method of Statistical Analysis**

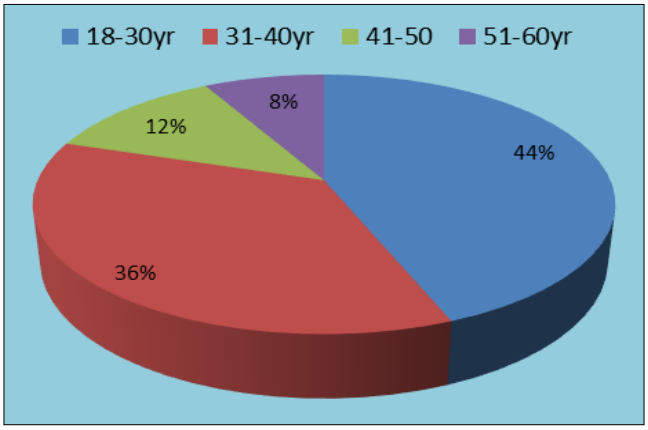
The data collected were entered into a Microsoft Excel spreadsheet and analysed using STATA 14 (StataCorp.2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP.)

The results were averaged (mean $\pm$ standard deviation) for

each parameter for continuous data and numbers and percentages for categorical data presented in Table and Figure.

**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 |

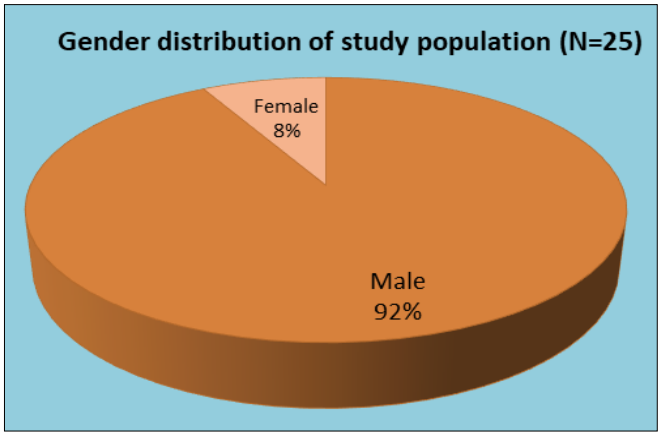



**Graph 1:** Age distribution of the study population (N=25) Mean ± SD 33.36±10.094

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 |

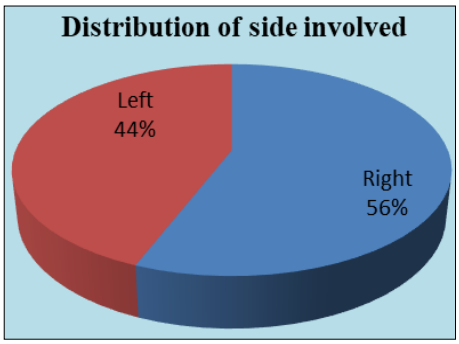



**Graph 2:** Gender distribution of study population

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 |

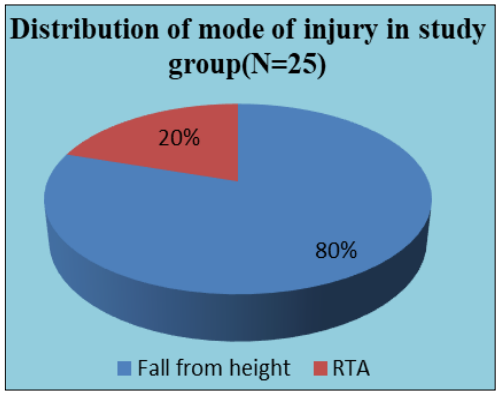



**Graph 3:** Distribution of sides involved in patients studied

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 |

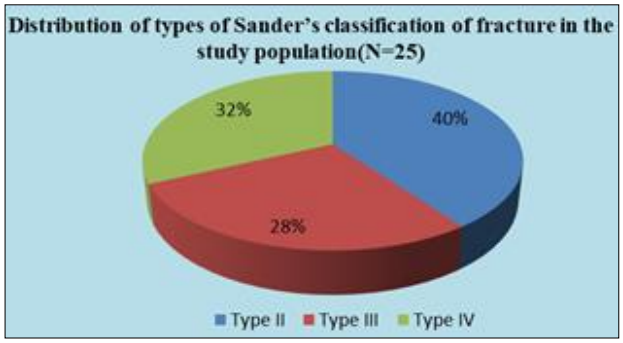



**Graph 4:** Distribution of mode of injury in the study group in percentage

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 | 1. No.of patients | Percentage (%) |
|---|---|---|
| Type II | 10 | 40 |
| Type III | 7 | 28 |
| Type IV | 8 | 32 |
| Total | 25 | 100 |

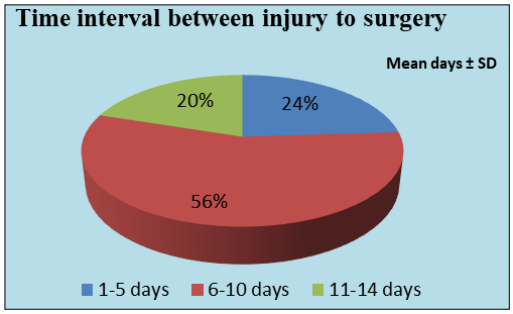



**Graph 5:** Distribution of types of Sander's classification of fracture in the study population

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 |

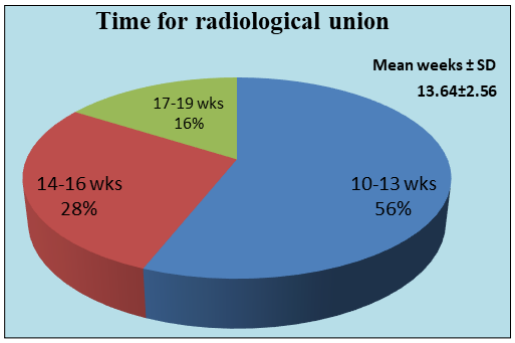



**Graph 6:** Time interval between injury to surgery

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 |




**Graph 7:** Distribution of period in weeks for complete radiologic union in patients studied in percentage

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 (%) |
|---|---|---|
| <10º | 7 (28%) | 00 |
| 10º-20º | 18 (72%) | 00 |
| 20º-30º | 00 | 12(48%) |
| 30º-40º | 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 10º-20º and in 28% of patients, it was <10º in the pre-operative period, with a mean bohler's angle of $11.75^0$. Whereas in the post-operative period, 48% of patients had a bohler's angle between $20^0$-$30^0$ and 52% had it between $30^0$-$40^0$, with a mean post-operative bohler's angle of $29.67^0$.

**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 | $11.75^0 \pm 2.59$ | $29.67^0 \pm 4.57$ | $P < 0.01$ |

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

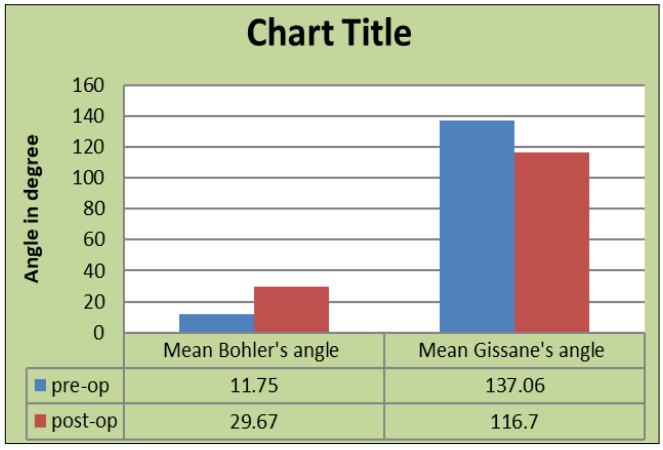
**Table 10:** Distribution of pre and post operative Gissane's angle in the study population

| Gissane's angle | Pre-operative (%) | Post-operative (%) |
|---|---|---|
| 110º-120º | 00 (28%) | 18(52%) |
| 120º-130º | 4(16%) | 7(28%) |
| 130º-145º | 18(52%) | 00 |
| >145º | 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 | $137.06^0 \pm 6.08$ | $116.7^0 \pm 4.75$ | $P < 0.01$ |

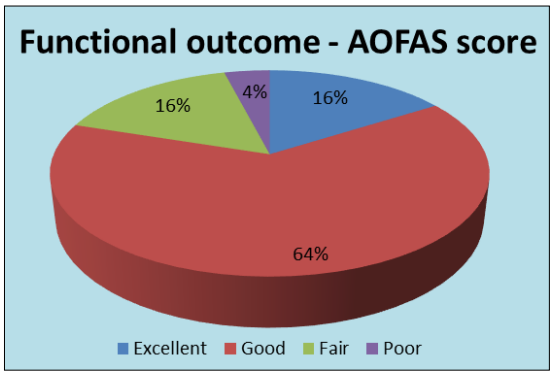
The difference between pre-operative and post-operative mean Gissane's angle was statistically significant with a p value <0.01. (Paired t test)




**Graph 8:** Comparison of pre and post -op mean Bohler's and Gissane's angle.

**Table 12:** Functional outcome using AOFAS score

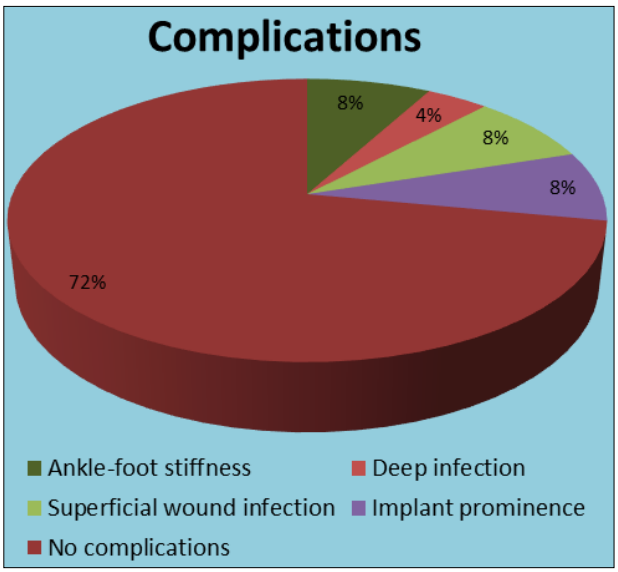
| Result | Frequency | Percentage (%) |
|---|---|---|
| Excellent | 4 | 16 |
| Good | 16 | 64 |
| Fair | 4 | 16 |
| Poor | 1 | 4 |
| Total | 25 | 100 |




**Graph 9:** Distribution of functional outcome using AOFAS score in the study population

**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 |




**Graph 10:** Distribution of complications in the study population

## Discussion

Our study consists of 25 cases of displaced intra-articular calcaneal fractures operated at the Sanjay Gandhi institute of trauma and orthopaedics from November 2019 to November 2020. 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 lateral extensile 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 meantime 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 (12weeks), 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 (<50points). 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 Voclav *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 it's surgical treatment. In this study, out of 25 patients, two patients had ankle and foot stiffness, two patients had implant prominence and 2 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

A prospective study of functional outcome of intra-articular calcaneal fractures managed surgically with plating, including 25 patients, was conducted at Sanjay Gandhi Institute of Trauma and Orthopaedics, Bangalore, during the period between November 2019 and November 2020 with the follow up period of 1 year, had excellent (16%) and good (64%) results. Hence 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. 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.

This study has some limitations, including a smaller number of the study population and a short follow-up duration. However, this study throw some lights on future long term and randomized study.

## Case Illustrations

**Case 1:** A 25y male with history of fall from height sustained right intra articular calcaneal fracture sander's type III.

**Fig 1a:** Pre op skin condition- wrinkle sign present

**Fig 1b:** Pre-op xray lateral and axial view

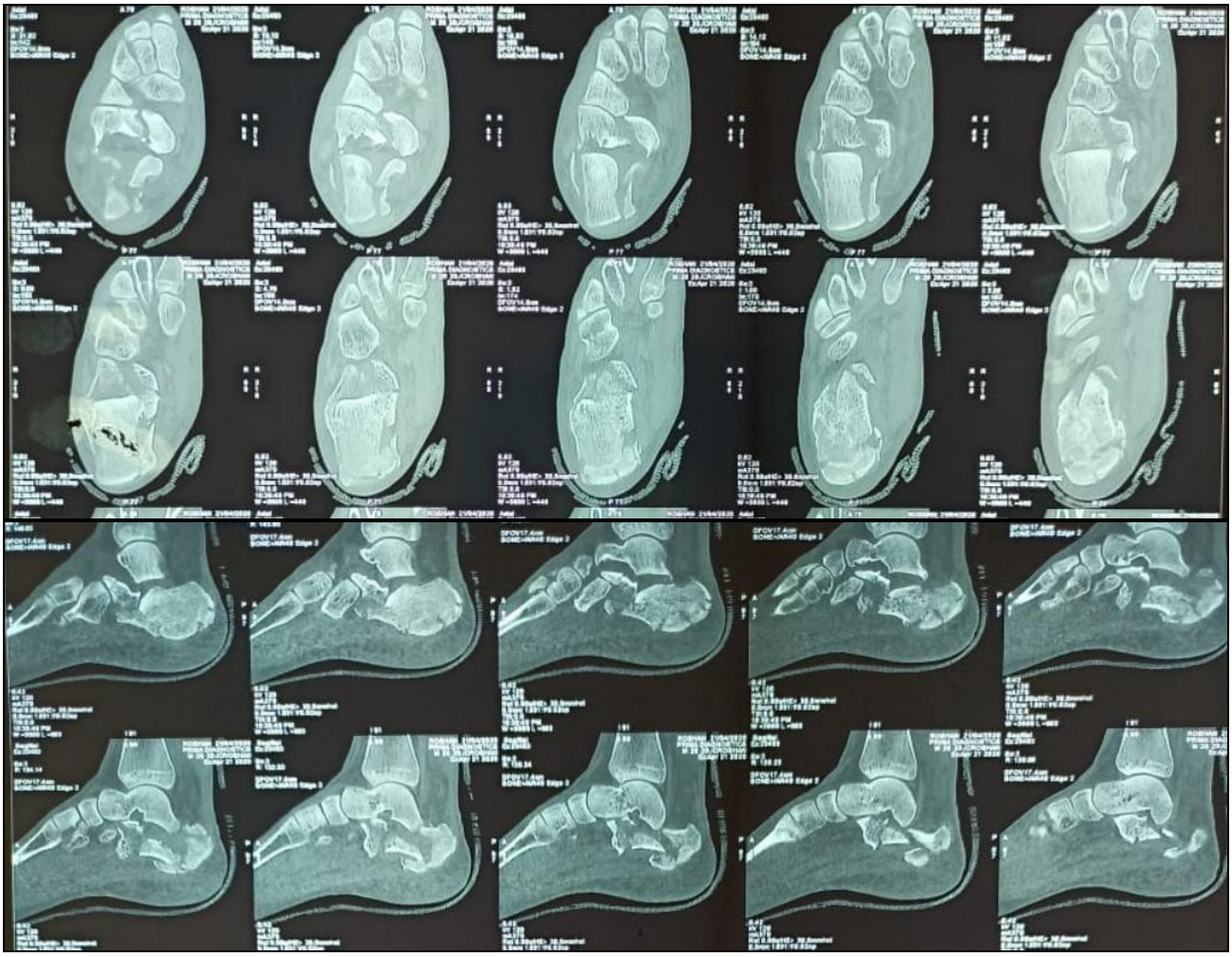


**Fig 1c:** Pre operative CT calcaneaum


**Fig 1d:** Immediate post operative xray axial and lateral view

**Fig 1e:** 12weeks post op Xray

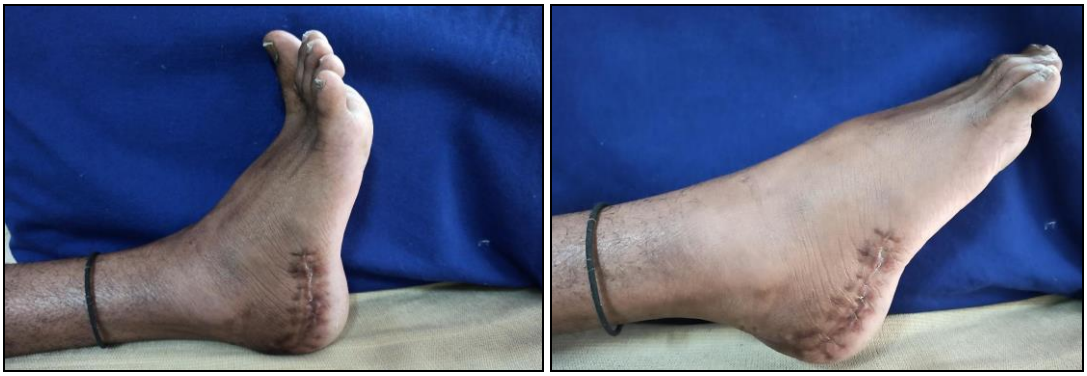


**Fig 1f:** Clinical picture-functional outcome

Case 2: A 28y male with history of RTA sustained left intra-articular calcaneal fracture Sander's type III


**Fig 2a:** Pre-op x-ray

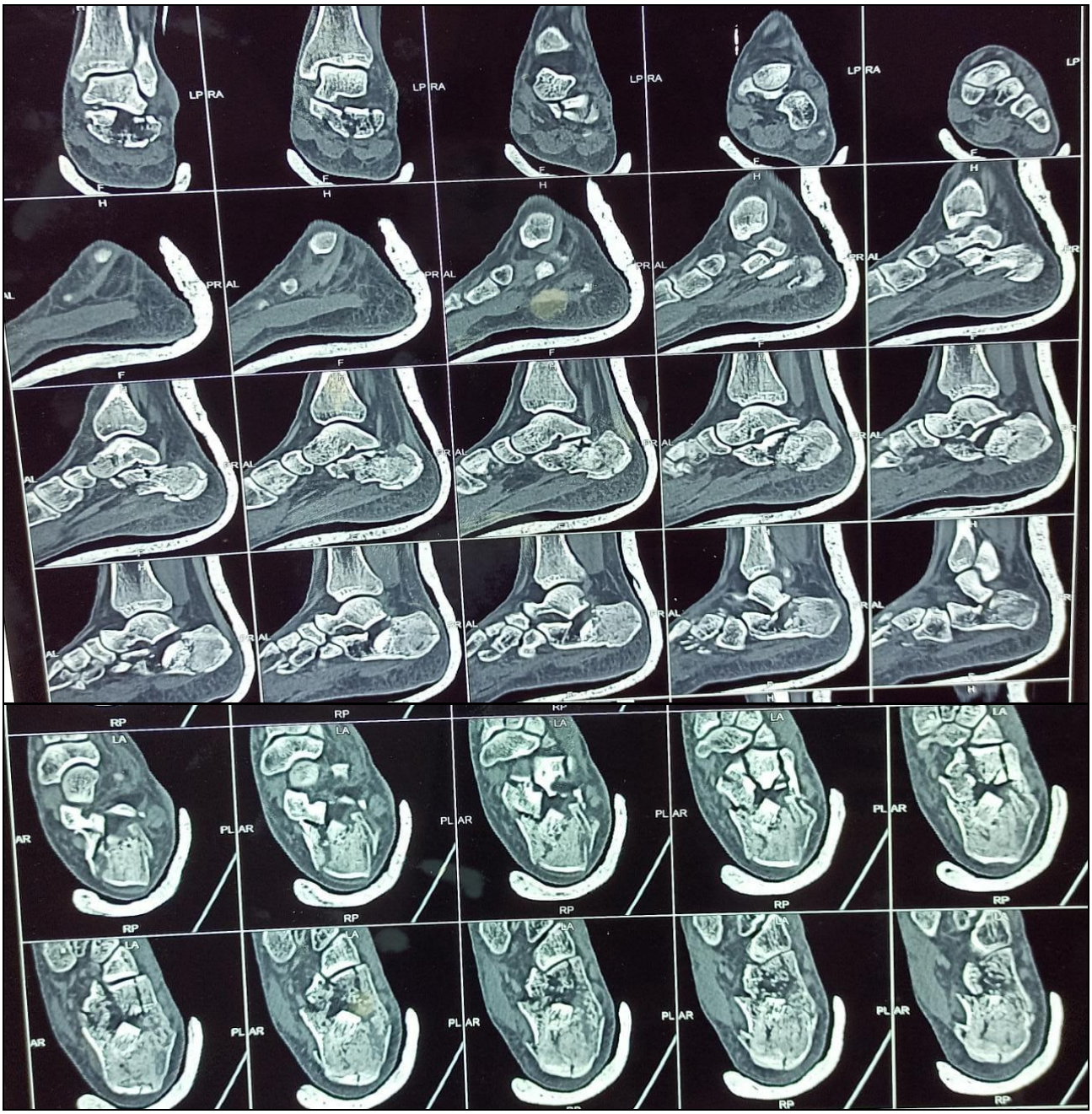


**Fig 2b:** Pre-op CT calcaneum

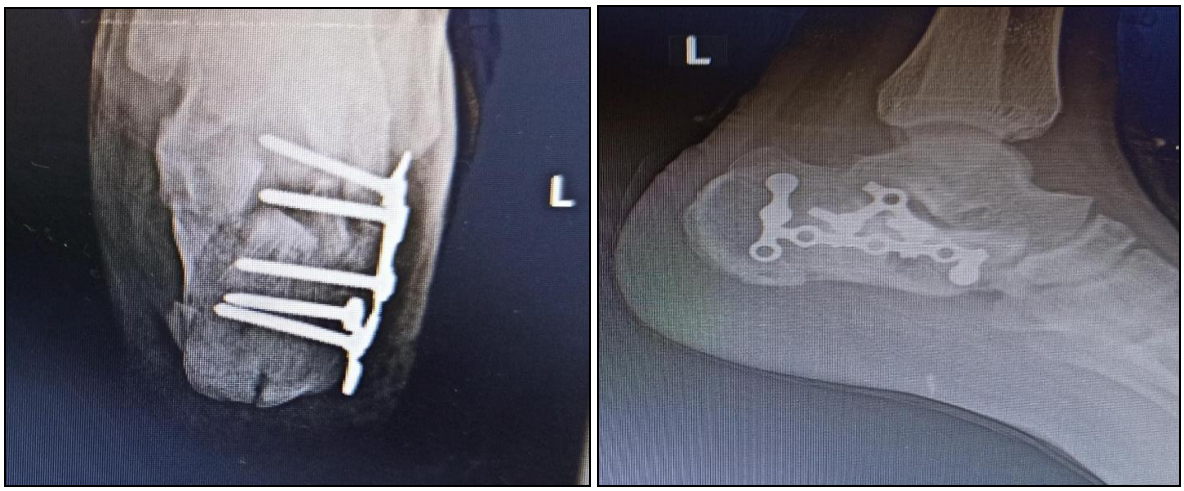



**Fig 2c:** Immediate post op x-ray

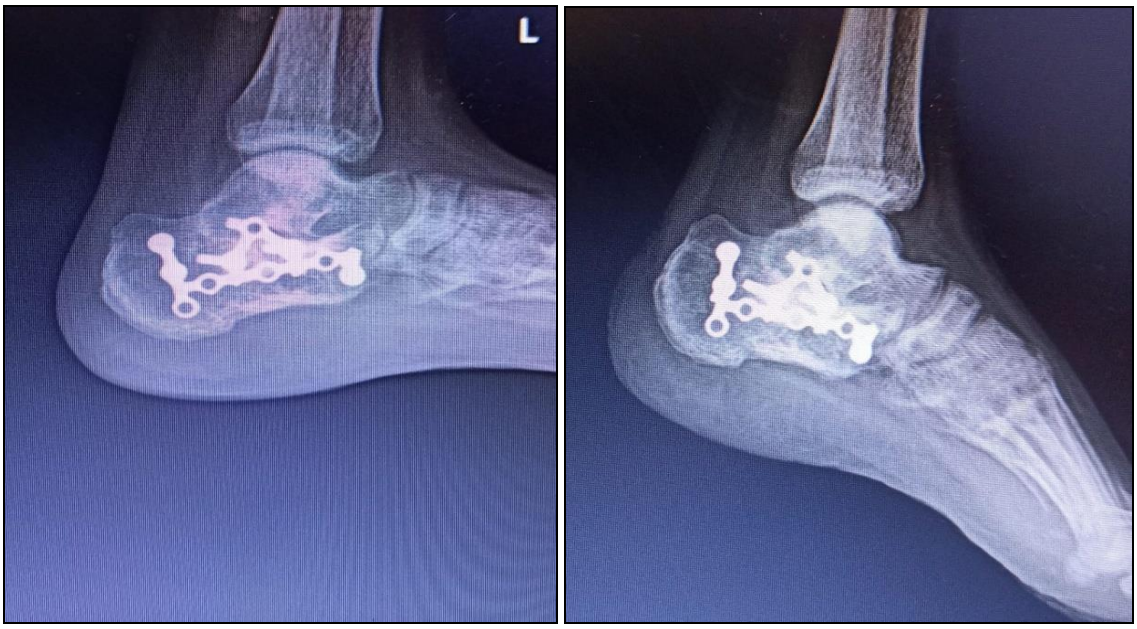



**Fig 2d:** 24weeks post –op xray Fig.31e. Post -op xray on final follow up

**Fig 2f:** Clinical picture–functional outcome

**Case 3:** A 28y male patient with history of fall from height sustained left intra-articular calcaneal fracture.


**Fig 3a:** Pre-op x-ray

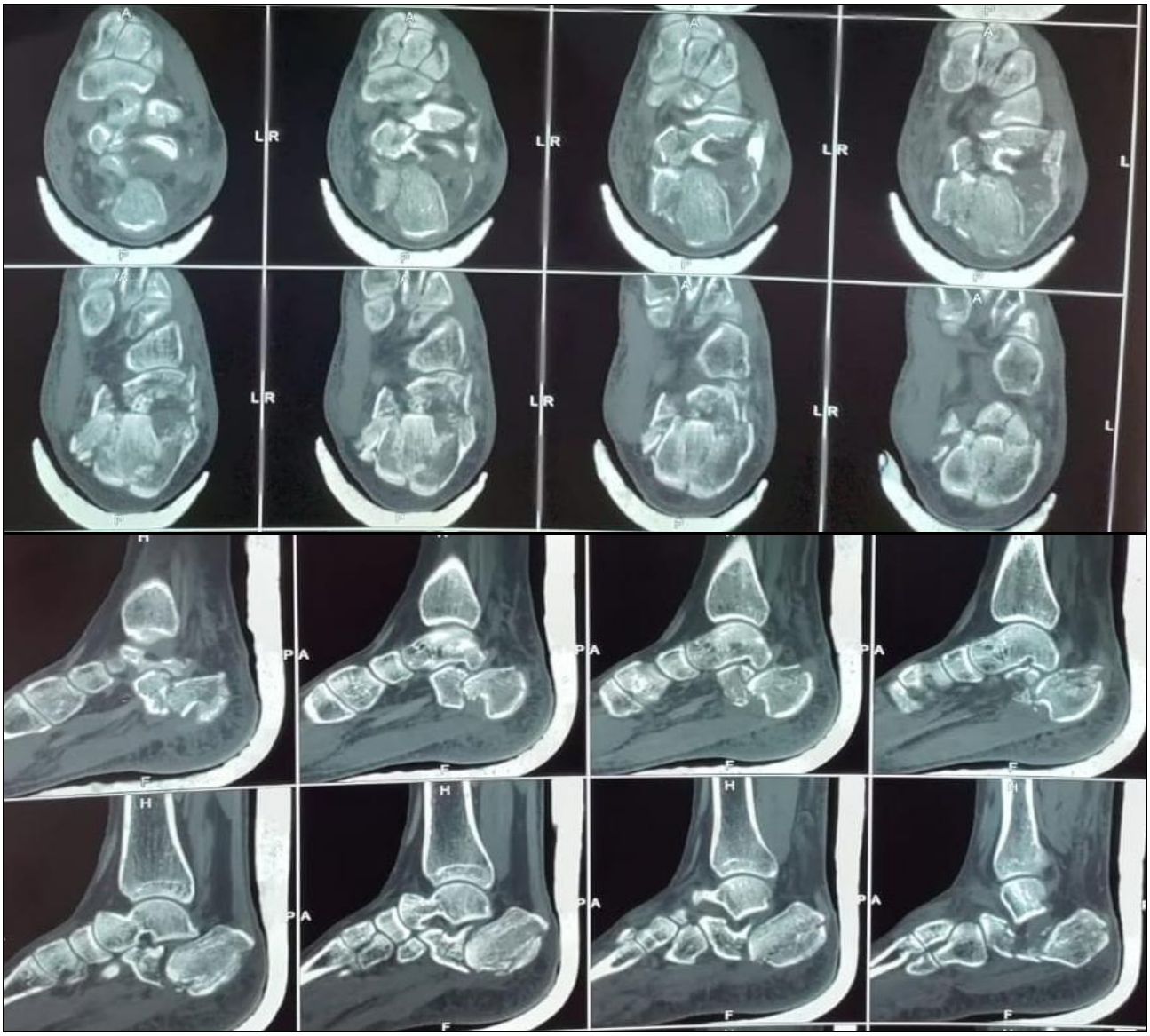


**Fig 3b:** Pre-op CT calcaneum

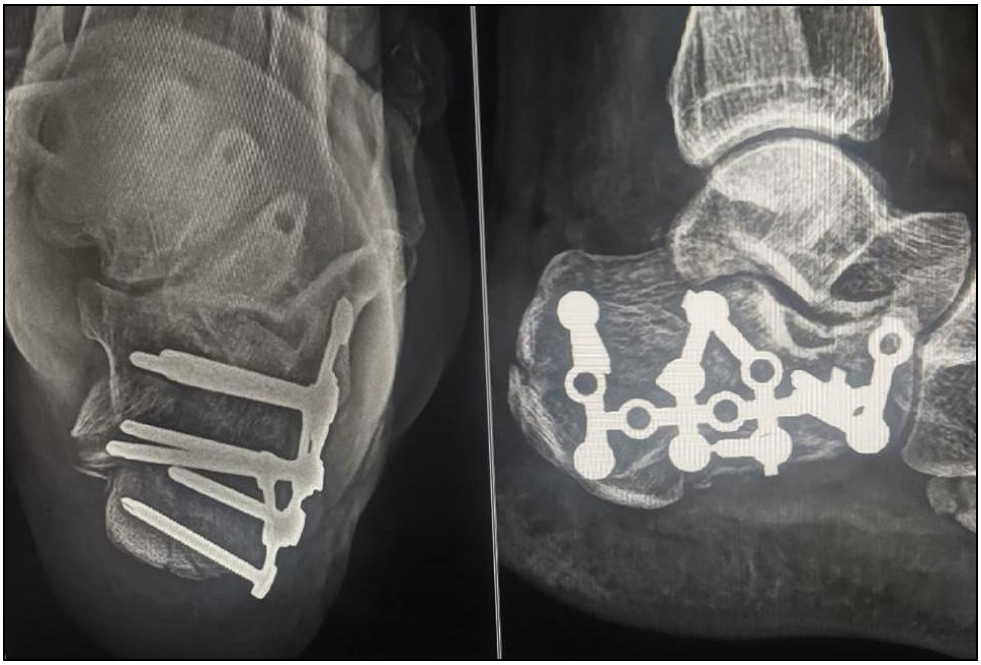


**Fig 3c:** Immediate post-op x-ray

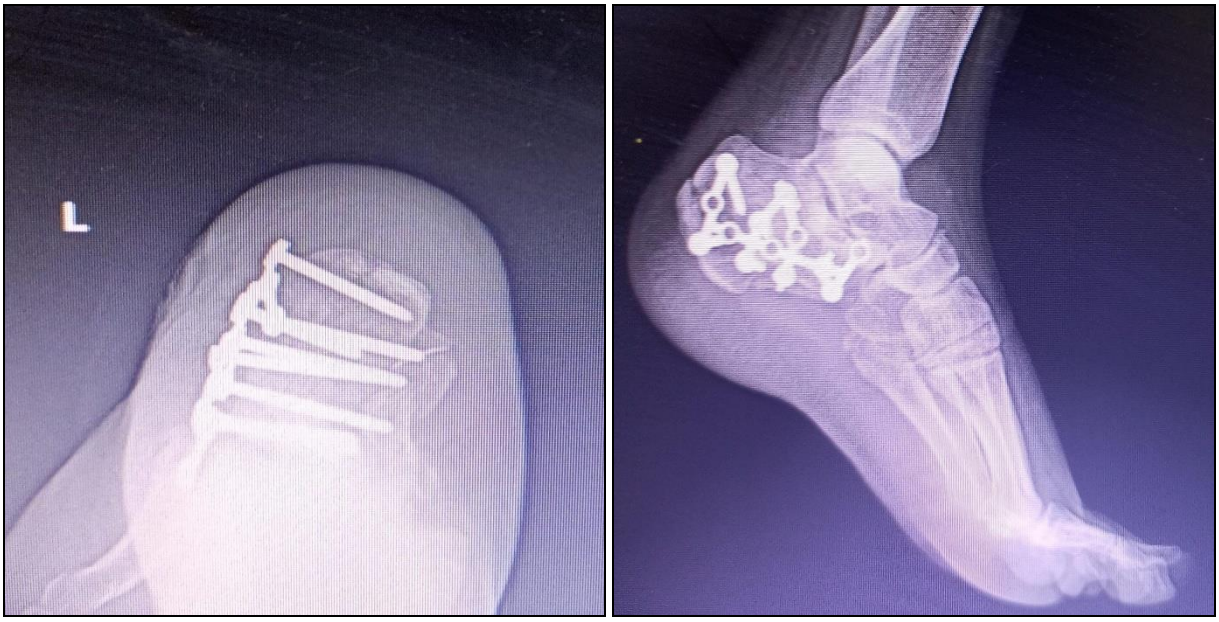


**Fig 3d:** 12weeks post op x-ray

**Fig 3e:** Clinical picture-functional outcome

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