Functional Outcome of Intra-Articular Joint Depressed Fractures of Calcaneum Treated by Lateral Plating- A Case Series of 35 Patients Followed For an Average Duration of 24 Months

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Abstract
Background: There is no consensus as to which is the best treatment for intraarticular fractures of the calcaneus. Many people treat it conservatively whereas many go for operative procedures. Even for surgical treatment many do it by percutaneous technique many go for open reduction and internal fixation with plate or cancellous screws.

Purpose: To present a case series of 35 patients with intra-articular joint depressed fractures of calcaneum treated by open reduction and internal fixation with plate through a lateral approach.

Material and Methods: A retrospective study was done in a level 1 trauma centre in which 35 patients (29 males and 6 females) of joint depressed type of calcaneum fractures were treated by open reduction and fixation by plate. All had acute trauma. Based on 2-dimensional CT scans, the fractures were categorized using Sanders classification. Radiographs and Maryland foot scores were used for evaluation of the results. Average follow-up was 24 months.

Results: 30 patients had full sub-talar range of movement and 5 patients had restricted range of movement. 11 of 12 patients returned to manual labour jobs, the others were not employed at the time of injury. 26 patients had an excellent Maryland foot score and 9 patients had a good score.

Interpretation: Intra-articular calcaneum fractures are associated with high chances of sub-talar arthritis with loss of sub-talar movement if not treated properly. Reduction of posterior facet is more important in joint depressed type of fracture. Lateral plating for these complicated fractures resulted in good to excellent sub-talar joint function with restoration of heel height, width and normal heel valgus.

Keyword: Intra-articular calcaneum fractures, trauma, plate, treatment outcome.

Introduction
Injury mechanisms and fracture patterns largely determine treatment results of calcaneal fractures.1 Controversy has existed over closed7,13,14,21 versus open1,4,15,5,22 treatments. A number of treatment classifications have been proposed based on plain radiography.7,17,18,20
Improvement in imaging technology has allowed a better understanding of fracture pathology and provided the basis for newer classifications.\(^5\) Intra-articular fractures of the calcaneum are amongst the most challenging fractures for orthopaedic surgeon because of complicated anatomy and difficulty in evaluating the fractures properly. Those who sustain them face a slow recovery, with possible permanent deformity and disability. When the fracture is joint depressed type of fracture, formal open reduction of fracture through a lateral approach, elevation of depressed posterior facet and fixation with a plate is required. This is a case series using a lateral approach for intra-articular fractures of calcaneum as previously described.

**Patient and Methods**

(a) **Patient Selection:** This is a retrospective review of case series 30 intra-articular joint depressed fractures of calcaneum that came to our institute from April, 2013 to August, 2016. All the patients had joint depressed type of fracture according to Essex-Lopresti classification and had Sander’s type ranging from Type 1 to Type 4. There were 27 males and 3 females with age range from 20-60 years. All the injuries were due to road traffic accident (RTA). 32 fractures were closed and 3 were compound Grade 1 (Gustilo-Anderson type). 21 patients had right sided calcaneal fracture whereas 11 patients had left side and 3 patient had bilateral calcaneal fracture. The mean time from injury to surgery was 5 days after confirming the “wrinkle test”. All the patients were operated by open reduction and internal fixation with a plate. Patients with more than 3 week old or general conditions precluding surgery were excluded. The mean follow up duration was 24 months (range 11 to 36 months). The procedure was performed in lateral position. A pre-operative planning after studying the x-rays (antero-posterior view, lateral view, Harris axial view (Fig 1(b)), Brodens view (Fig 1(a))), CT scan and the 3-D reconstruction was done. The major fragments were labeled and the set of instruments and implants were kept ready accordingly. The depressed posterior facet in depressed type of fractures was first elevated and then the plate was fixed. The void created after elevation of depressed posterior facet was filled by bone graft in 2 patients. Congruity of anterior facet, middle facet and calcaneo-cuboid joint was also confirmed. Newer plates like calcaneum locking compression plates (LCP) were used in 2 cases.

(b) **Operative Procedure:** After induction of spinal/epidural anaesthesia, the patient was placed in the lateral position with a pneumatic tourniquet placed high in the thigh with sandbag behind and all the bony prominences well padded. Prophylactic antibiotics are administered. An L-shaped incision\(^9\) (Fig 1(c)) was taken halfway between the Achilles tendon and the fibula proximally and at the junction of the plantar and lateral skin distally which created a viable skin flap. The peroneal tendons were freed after releasing the calcaneofibular ligament. Special care to explore sural nerve and retract it, so as to avoid post-operative anesthesis over lateral aspect of foot was taken. After exploration of fracture site the posterior facet was visualized, most of times the fracture was an intra-articular depressed type which was elevated with the help of homanns elevator or a bone hook or by joystick maneuver with the help of Steinmann pin and was fixed with a 4.0mm cancellous screw. Sometimes a second cancellous screw is required to fix the fragment. Reduction of anterior and middle facet was also performed. Intra-operative Brodens view and Harris axial views were taken on image intensifier to judge the reduction. A pre-contoured plate was fixed to lateral aspect of calcaneum and screws were passed from lateral to medial taking care it just pierces the medial cortex to avoid any neurovascular injury. Two screws were tried to accommodate in sustentaculum tali. Again a antero-posterior view, Lateral view, Brodens view, Harris axial view was taken and reduction was judged in terms of heel width, height, articular congruency, positioning of screws and plates. (figure 3)
The wound was irrigated and closed over a suction drain. Post-operative patient was given a below knee plaster splint which was converted to a below knee plaster cast after a week once the wound condition was good. The plaster cast was cut after 4 weeks. The patient was kept non weight bearing 6 weeks post-operatively. Routine radiographs were obtained 4 weeks after surgery and every 4 weeks after until fracture healing.

The Bohler and Gissane angles as well as calcaneal height and width before and after surgery were compared. Subtalar movement was compared with that of the normal foot and expressed as a percentage. Functional assessment was carried out at the one-year follow-up, using the Maryland Foot Score.19 (Table 1).

![Fig 1(a) Brodens View](image1)
![Fig 1(b) Harris Axial View](image2)
![Fig 1(c) Incision Mark for ORIF](image3)
![Fig 1(d) Final Plate Fixation](image4)
Results

26 patients had full sub-talar range of movement and 4 patients had restricted range of movement. All the patients returned back to their routine activities. 2 patients with compound fractures had superficial infection at the incision site which was treated with debridement\textsuperscript{11} and antibiotic impregnated beads insertion after which the infection subsided. 23 cases had post operative Bohlers angle in normal limits, that is 25-40\textdegree. 7 cases had Bohlers angle <25\textdegree. 23 cases had post operative crucial angle of Gissane in normal limits. 23 cases had normal heel height and 7 patients had minimal decrease in heel height. At the latest follow-up, there were 3 patients who had early sub-talar arthritis (figure 4) with restricted range of motion. 27 patients had normal heel valgus, 2 had neutral heel alignment, 1 had varus heel alignment in the last follow-up. 2 patients had partial wound dehiscence\textsuperscript{8,16} which healed by daily dressing by secondary intention. All the fractures went on to full healing without signs of collapse of posterior facet. None of the patients required any fusion. None of the patients had any peroneal tendon entrapment especially in the patients who had post-operative varus heel (figure 2) alignment. 23 patients had Maryland foot score which was excellent and 7 patients had score which was good (Table 2).

Table 1

* Based on the Maryland Foot Score Excellent = 90-100 points, good = 75-89 points, fair = 50-74 points, and failure less than 50 points.

Table 2

| Sr. No. | Age | Sex | Case/Classification | Plate type | Subtalar ROM | Bohlers angle pre-op | Bohlers angle post-op | Gissanes angle pre-op | Gissanes angle post-op | Congruity of subtalar joint | Medial/Posteromedial Alignment | Lateral/Posterolateral Alignment | Maryland Foot Score |
|--------|-----|-----|---------------------|------------|--------------|---------------------|-----------------------|-----------------------|--------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| 1      | 24/M| 3A  | Mod.sanders         | Full       | 2            | 25                   | 140                  | 105                   | Congruent               | N.valg                      | 34                          | 5\textdegree valgus            | 92                          |
| 2      | 28/M| 3A  | Mod.sanders         | Full       | 18           | 29                   | 124                  | 110                   | Congruent               | N.valg                      | 32                          | 6\textdegree valgus            | 96                          |
| 3      | 34/M| 3B  | Mod.sanders         | Full       | 5            | 26                   | 125                  | 106                   | Congruent               | N.valg                      | 32                          | 5\textdegree valgus            | 91                          |
| 4      | 22/M| 1   | LCP                 | Full       | 3            | 25                   | 150                  | 108                   | Congruent               | N.valg                      | 33                          | 4\textdegree valgus            | 93                          |
| 5      | 28/M| 2C  | 3.5mmDCP            | Full       | 40           | 40                   | 123                  | 110                   | Congruent               | N.valg                      | 34.5                        | 6\textdegree valgus            | 90                          |
| 6      | 32/M| 3B  | 1/3\textdegree tubular | Full       | 6            | 25                   | 122                  | 110                   | Congruent               | N.valg                      | 33.5                        | 7\textdegree valgus            | 85                          |
| 7      | 37/M| 4   | 3.5mmDCP            | Full       | 7            | 27                   | 129                  | 104                   | Congruent               | N.valg                      | 32.5                        | 4\textdegree valgus            | 93                          |
| 8      | 29/M| 2B  | Mod.sanders         | Full       | 2            | 14                   | 119                  | 84                    | Congruent               | N.valg                      | 28                          | Neutral                     | 96                          |
| 9      | 22/M| 2A  | 1/3\textdegree tubular | Full       | 20           | 34                   | 141                  | 106                   | Congruent               | N.valg                      | 32                          | 5\textdegree valgus            | 91                          |
| 10     | 26/M| 1   | Mod.sanders         | Full       | 30           | 30                   | 136                  | 101                   | Congruent               | N.valg                      | 33                          | 7\textdegree valgus            | 91                          |
| 11     | 33/F| 3C  | 3.5mmDCP            | Full       | 5            | 28                   | 138                  | 106                   | Congruent               | N.valg                      | 33                          | 7\textdegree valgus            | 94                          |
| 12     | 47/M| 3A  | 3.5mmDCP            | Full       | 3            | 17                   | 160                  | 90                    | Incongruent             | N.valg                      | 29                          | 6\textdegree valgus            | 92                          |
| 13     | 27/M| 4   | Mod.sanders         | Full       | 5            | 32                   | 137                  | 98                    | Congruent               | N.valg                      | 31.5                        | 5\textdegree valgus            | 79                          |
| 14     | 31/F| 1   | 1/3\textdegree tubular | Full       | 12           | 28                   | 144                  | 110                   | Congruent               | N.valg                      | 34                          | 5\textdegree valgus            | 90                          |
| 15     | 25/M| 2A  | 1/3\textdegree tubular | Restricted | 15           | 15                   | 146                  | 96                    | Incongruent             | N.valg                      | 28                          | 6\textdegree valgus            | 88                          |
| 16     | 55/M| 3B  | Mod.sanders         | Full       | 17           | 32                   | 138                  | 104                   | Congruent               | N.valg                      | 32.5                        | 6\textdegree valgus            | 93                          |
| 17     | 24/M| 2C  | Mod.sanders         | Restricted | 14           | 17                   | 135                  | 88                    | Congruent               | Neutral                    | 28                          | Neutral                     | 95                          |
| 18     | 44/M| 3A  | 1/3\textdegree tubular | Full       | 8            | 38                   | 152                  | 104                   | Congruent               | N.valg                      | 32                          | 7\textdegree valgus            | 92                          |
| 19     | 28/M| 2B  | 1/3\textdegree tubular | Full       | 2            | 27                   | 141                  | 101                   | Congruent               | N.valg                      | 32.5                        | 5\textdegree valgus            | 86                          |
| 20     | 21/M| 2A  | LCP                 | Full       | 7            | 30                   | 128                  | 101                   | Congruent               | N.valg                      | 31.5                        | 5\textdegree valgus            | 94                          |
| 21     | 27/M| 1   | 1/3\textdegree tubular | Full       | 12           | 19                   | 122                  | 93                    | Congruent               | N.valg                      | 30                          | 7\textdegree valgus            | 77                          |
| 22     | 28/M| 3C  | 1/3\textdegree tubular | Full       | 19           | 37                   | 131                  | 102                   | Congruent               | Neutral                    | 34.5                        | 4\textdegree valgus            | 96                          |
| 23     | 29/M| 3C  | Mod.sanders         | Full       | 4            | 33                   | 127                  | 106                   | Congruent               | N.valg                      | 32.5                        | 4\textdegree valgus            | 91                          |
| 24     | 23/M| 3A  | Mod.sanders         | Full       | 16           | 31                   | 120                  | 100                   | Congruent               | N.valg                      | 31                          | 5\textdegree valgus            | 91                          |
| 25     | 36/M| 4   | Mod.sanders         | Full       | 11           | 29                   | 118                  | 103                   | Congruent               | N.valg                      | 32.5                        | 4\textdegree valgus            | 94                          |
| 26     | 26/M| 4C  | 1/3\textdegree tubular | Restricted | 7            | 12                   | 143                  | 90                    | Incongruent             | N.valg                      | 27                          | 7\textdegree valgus            | 97                          |
| 27     | 21/M| 3B  | Mod.sanders         | Full       | 14           | 33                   | 126                  | 107                   | Congruent               | N.valg                      | 31                          | 5\textdegree valgus            | 93                          |
| 28     | 21/M| 3C  | Mod.sanders         | Restricted | 11           | 12                   | 133                  | 88                    | Incongruent             | N.valg                      | 27                          | 5\textdegree varus            | 93                          |
| 29     | 27/M| 1   | 3.5mmDCP            | Full       | 20           | 34                   | 132                  | 103                   | Congruent               | N.valg                      | 32                          | 4\textdegree valgus            | 79                          |
| 30     | 28/M| 4   | 3.5mmDCP            | Full       | 13           | 30                   | 121                  | 107                   | Congruent               | N.valg                      | 31                          | 7\textdegree valgus            | 84                          |

N=Normal     Sup.=Superficial     Mod.=Modified
Thus the difference between pre-operative Bohlers angle and Gissanes angle and post-operative Bohlers and Gissanes angle is significant after T-TEST with probability<0.01.

|                        | MEAN  | STANDARD DEVIATION | T – TEST | PROBABILITY |
|------------------------|-------|--------------------|----------|-------------|
| PRE – OP BOHLERS ANGLE | 11.6  | 8.518              | 7.40     | P<0.01      |
| POST – OP BOHLERS ANGLE| 26.966| 7.53               |          |             |
| PRE-OP GISSANES ANGLE  | 133.366| 10.6              | 13.67    | P < 0.01    |
| POST – OP GISSANES ANGLE| 101.366| 7.29             |          |             |

Discussion

Intra-articular fractures of calcaneum can be treated either conservatively in the form of closed reduction and cast or it can be treated operatively with open reduction and fixation with screws and plate. Buckley et. al⁸ have done a comparative study of non-operative treatment in the form of closed reduction and cast with operative treatment in the form of open reduction and cast. They found that the short term results of both the modalities of treatment is the same but medium term and long term results of the operative treatment were much better as compared to cast treatment. The patients treated with cast had residual pain and over a course of time gradually developed sub-talar arthritis and were performing functionally less than the patients in operative group. The patient with operative approach were able to perform better and functionally had no residual pain and had minimum chances for developing sub-talar arthritis.

Figure 2(a) Pre-operative radiograph showing depressed intra-articular fracture

2(b) Follow up X-ray showing restoration of joint congruity
The guideline principles for treating these fractures were

1) Reduction of depressed posterior facet, anterior and middle facet.
2) Stabilization of the fragment by 4.0mm cancellous screws
3) Proper sized plate fixation laterally with screws directed from lateral to medial
4) Restoration of heel width, height, valgus alignment.
5) Intra-operative fluoroscopy to judge the reduction of the fracture and calcaneocuoid joint.
6) Decompression of subfibular space available for the peroneal tendons.

Controversy exists over non-operative versus operative treatment. 17 of 27 fractures treated by conservative means attained fair to poor results. Results are worse with increasing degrees of comminution of the posterior facet. The results of operative treatment are variable, mostly related to the quality of the posterior facet reduction; 80% of patients with successful reductions had satisfactory results. In another series, 76% of patients attained satisfactory results based on CT assessment of the fracture reduction. Unsatisfactory results were associated with failure to obtain or maintain a satisfactory reduction.

Figure 3: (a) Lateral (b) Harris axial (c) Brodens view radiographs of intra-articular calcaneum fracture. Post operative follow up (d) Harris axial (e) lateral views showing restoration of anatomy after open reduction.
Figure 4: (a) Harris axial, (b) Broden view radiograph of depressed fracture of calcaneum. Immediate post operative (c) lateral and (d) harris axial view. Follow up (e) lateral, (f) Harris axial radiographs showing subtalar arthritis with fracture united.

Lateral, axial, anteroposterior and Broden view radiographs are used to examine calcaneal fractures. Extension of the fracture into the posterior facet is clearly visualized using the Broden view, but overlap of tarsal bones and articular surfaces makes assessment of the exact fracture anatomy difficult. 2-Dimensional CT scans helps in pre-operative planning and give additional information on

- Calculation of Bohlers and Gissanes angle.
- Calculation of heel height and width.
- Size and number of fracture fragments.
- Proper labeling the major fragments and methods to stabilize them.
- Size and displacement of sustantacular tali relative to superomedial fragments.
- Presence of step or diastasis of the posterior facet.
- Impingement of the fibular malleolus on the tuberosity of calcaneum\(^\text{10}\).

Such scans also provide information regarding fractures involving the sinus tarsi, calcocuboid joint, and anterior calcaneal process, all of which could be relevant while planning lateral surgical approach.

Buckley R, Meek R compared closed and open reduction of intra-articular fractures of calcaneum and found good results in open reduction methods for this fractures. Freeman BJC, Duff S, Allen PE, et al advocated extended lateral approach for treating intra-articular fractures of calcaneum. With direct visualization of fracture through a lateral approach, anatomic reduction of the fracture was possible, also the elevation of depressed posterior facet fragment was possible, easier decompression of the lateral wall and the plate was applied on the lateral surface of calcaneum which acted as a buttress.
Conclusion
Intra-articular fractures of calcaneum are challenging fractures with a significant potential for complications. However ORIF (open reduction and internal function) utilizing lateral incision can result in excellent sub-talar and hindfoot function for these patients.

In conclusion, this study confirms that the intra-articular fractures of calcaneum can be best treated by open reduction and internal fixation with a plate and function of the calcaneus and subtalar joint be restored.

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