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Management of displaced intraarticular calcaneal fractures by minimally invasive technique: A prospective study

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Abstract

Introduction: Intra-articular calcaneal fractures are conventionally treated by extensive open surgical reduction to achieve anatomical reduction of the subtalar joint and also to maintain the calcaneal height and width. At the same time many studies have shown that they are associated with various complications like wound dehiscence, necrosis, infection and hard-ware problems. Our study is aimed at surgically treating displaced intra-articular fractures through minimally invasive techniques and study the outcome in terms restoration of Bohler's angle, Gissane's angle, calcaneal width and height.

Materials and Methods: This is a prospective study done in Bokaro General Hospital from April 2017 to June 2018. It included 20 patients with displaced intraarticular calcaneal fractures. Patients were followed up for 3 months and assessed subjectively and objectively using Maryland foot score. Radiographs were taken to evaluate the Bohler's angle, Gissane's angle, calcaneal width and height. All data were Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) Version 20.

Results: The final mean Maryland foot score was 86.62. 8 patients (38.1%), in the operated group had an excellent result, 10 (47.62%) had a good score. 2 patients (9.52%) showed fair result. Only 1 patient (4.76%) showed poor result. The Bohler's angle, Gissane's angle, calcaneal height and width also showed improvement post-operatively.

Conclusion: From our study it was confirmed that the operative treatment of intra-articular fractures of the calcaneum involving the subtalar joint, using minimally invasive techniques provided good results.

Keywords: Calcaneum, minimally invasive

Introduction

Fractures of calcaneum make up a large proportion of major fractures of the tarsal bones. The economic importance of the injury is considerable, as 80% to 90% occur in men in their primary 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. Intra-articular fractures of calcaneum comprise 60% of all tarsal injuries and 75% of all calcaneal fractures. These fractures are uniformly caused by an axial load mechanism; a fall from height or a motor vehicle accident. The treatment of displaced calcaneal fracture has been a topic of intense discussion and controversy for the last century with supporters of both operative and non-operative treatment. Earliest attempts at the management of these fractures have been essentially non operative. In the 18th century, Pettit & Desault, advised rest, until fragments had consolidated as the ideal form of therapy. While others have recommended compression, elevation and early active motion with non-weight bearing for all intra-articular calcaneal fractures.

Overall the outcome after non operative management has universally been poor. The major cause being failure to restore congruity of the displaced intra-articular fragment.

In 1947, Whittacker ^[1] abandoned conventional methods of treatment and introduced medial surgical approach for open reduction and internal fixation of these fractures. Essex Lopresti ^[2] in 1952, recommended an oblique lateral incision for ORIF of these fractures with axial pin.

By the end of 1960's, a standard protocol was developed that required two conditions: (a) perfect reconstruction of calcaneal joint surfaces and maintained with lag-screws (b)

restoration of the whole morphology of the bone, vis a vis. to the position of articular surface, relative to the overall status of the anterior process and the tuberosity. Stephenson [3] in 1987, described a combined lateral and medial approach which required careful exposure and mobilization of the medial neurovascular bundle. Benirishke & Sangeorzan [4] in 1993, introduced the lateral extensile incision technique. This was later endorsed by Sanders *et al.* [5] in 1993.

Surgery is challenging with an extensile learning curve and the results related to the exactness of reduction. Now, it is believed that displaced intra articular fractures of the calcaneum, shall be treated on the same principle as the other injuries of weight bearing joints, i.e., by anatomical reduction of the joint surface and rigid internal fixation followed by early movements and delayed weight bearing.

The purpose of this study is to analyze the outcome of displaced intra articular calcaneal fractures treated by minimally invasive techniques.

- The primary objectives are to restore the congruity of the posterior facet and of the subtalar joint, to restore the height of the calcaneus (Bohler's angle), to re-establish the integrity of calcaneocuboid joint, to decompress retro-peroneal space and to avoid varus or valgus deformity and without many complications.
- The purpose of this study is to duly represent the views of the developing countries in this particular field of trauma surgery.

Materials and Methods

This is a prospective randomised controlled study done in department of orthopaedics, Bokaro General Hospital between April 2017 – June 2018. We included 20 patients in this study who presented with calcaneal fracture to the OPD or emergency department. We included patients of either sex in age group 15-60 years, all displaced intra-articular fractures, patients with closed fractures and fractures of type 2, 3, 4 (Sander's classification). We excluded patients with conditions that might affect gait (CVA, quadriplegia, paraplegia, any neuropsychiatric conditions) and those with extra articular and undisplaced intraarticular fractures.

Methodology

History, clinical examination and routine pre-op evaluation were done in each patient. Radiographic evaluation involved axial views, Broden's view, lateral view and CT scan of the involved calcaneum. The fracture was classified based on Sander's classification.

The fractures were then treated surgically by open reduction and internal fixation through minimally invasive techniques either sinus tarsi or Essex-Lopresti approach. We used 4mm and 6.5mm cannulated cancellous screws. Post-operatively cast conversion was done at 2 weeks. Post operatively the patients were assessed clinically and radio graphically at 2, 4, 8 and 12 weeks. Subjective and objective assessment were carried out using Maryland foot score. Controlled weight bearing was done at the end of 3 months.

Subjective assessment was carried out by personal interview, regarding the discomfort or pain during activity and rest; ability to stand and walk, ability to return to work, duration of absence from work and any change in shoe-size. Clinical (objective) assessment was carried out by the measuring width of hind part of the foot, assessing movement of the ankle joint using a simple goniometer.

All measurements were compared with the normal foot / joints. The data from normal feet will be used to obtain

normal / control values. Radiographic assessment was made by lateral, axial, and Borden's views of the affected calcaneum.



Fig 1: Sinus Tarsi approach



Fig 2: Essex-Lopresti approach

From lateral view, we assessed Bohler's angle, crucial angle of Gissane and height of the calcaneum. From axial film, we measured width of calcaneum, reduction of medial border of the calcaneum.



Fig 3: Pre-Op Lateral View



Fig 4: Pre-Op Axial View



Fig 5: Post-Op Lateral View



Fig 6: Post-Op Axial View

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) Version 20. The statistical significance of categorical variable was tested by Chi square or Fischer exact test, whenever applicable and of continuous

variable by unpaired T test for independent. All tests were two tailed, and a P value of ≤ 0.05 was considered significant. All confidence intervals were calculated at 95% level.

Results

A total of 21 displaced intraarticular calcaneal fractures in 20 patients were initially taken up in this study. There were 14 male and 6 female patients in the study. The mean age of the patient was 39 ± 6.84 years. 14 patients presented with history of fall from height and 6 with road traffic accident. 5 patients also had associated fractures of tibia, humerus, foot and spine. According to Sanders classification there were one type 2a, three type 2b, eight type 3ab, four type 3bc, two type 3ac and three type 4 fractures.

Table 1: Pre-op and Post-op Bohlers angle, Gissane's angle, Calcaneal height and width

Variables	Pre-op Mean \pm SD	Post op Mean \pm SD	Paired t test	p value
Bohler's angle (in degrees)	6.738 \pm 7.3990	20.48 \pm 7.229	12.702	<.001
Gissane angle (in degree)	113.43 \pm 9.485	100.90 \pm 8.185	9.638	<.001
Calcaneal height (in mm)	35.238 \pm 2.2971	40.048 \pm 2.1791	19.141	<.001
Calcaneal width (in mm)	36.376 \pm 1.4707	34.467 \pm 1.5127	12.364	<.001

Six patients were operated within 24 hours. Five patients were operated in the next 24 hours. Four (20%) were operated between 48 to 72 hours of sustaining injury. For three patients (15%), it took 3 to 4 days while the maximum delay was of 5 days for two patients (10%) either due to late presentation or skin condition. The patient having bilateral calcaneal fracture was operated on the same day on both the sides. 9 foot were operated through Essex-lopresti and 12 through sinus tarsi approach. The final mean Maryland foot score was 86.62. 8 patients (38.1%), in the operated group had an excellent result, 10 (47.62%) had a good score. 2 patients (9.52%) showed fair result. Only 1 patient (4.76%) showed poor result. Radiographic analysis revealed that observed that, the mean Bohler's angle (in $^{\circ}$) was lower (6.7 ± 7.4) in pre-op group than those in post op group (20.5 ± 7.2) and this difference in means was statistically significant in paired t test analysis ($p < .001$). Gissane angle (in $^{\circ}$) was higher (113.4 ± 9.5) in pre-op group than those in post op group (100.9 ± 8.2) and this difference in means was statistically significant in paired t test analysis ($p < .001$). Mean calcaneal height (in mm) was less (35.2 ± 2.3) in pre-op group than those in post op group (40.0 ± 2.2) and this difference in means was statistically significant in paired t test analysis ($p < .001$). Calcaneal width (in mm) reduced from 36.4 ± 1.5 in pre-op group to 34.5 ± 1.5 post op group and this difference in means was statistically significant in paired t test analysis ($p < .001$).

Discussion

In our study it was found that the post-operative clinical outcome was well correlated with the radiological findings. The operated group showed significantly better restoration of the radiological anatomy and the appearance of the subtalar joint along with near perfect anatomical reduction. The shape of the hind foot of the operated patients was normal and longitudinal arches were well preserved. No signs of arthritic changes or articular incongruity was found in our patients. Rosario Spagnolo *et al.* [5] in their study showed Bohler and Gissane angles was restored from 90 to 97% of the cases in Sanders type II and III fractures, while 15% in type IV fractures; height and thickness was restored from 87 and 95% in Sanders type II and III, and 19% in type IV. According to Maryland foot score, the mean score was 87 in type II, 83 in type III and 60 in type IV; 10 fractures resulted excellent, 19

good, 7 not satisfactory and 3 bad. The reduction of the posterior facet has been obtained in 29 of 39 patients.

Various techniques and incisions have been reported in the literature for the open reduction and internal fixation of these fracture. Each approach has its advantages and disadvantages. Stephenson [3] introduced his two-incision technique. He used medial approach for reduction of tuberosity fragment and lateral approach for facet reduction. But rigid stabilization of the fracture was very difficult to achieve as lateral wall decompression was more difficult and there was little area for plate fixation on the lateral side.

In the present series minimally invasive approach was used. As compared to the extensile lateral approaches performed prior to this technique, anatomy and the posterior facet were restored in a similar manner. Postoperative measurements of Bohler's and Gissane's angles showed improvement. No major wound complications were seen. With follow-up evaluations using the Maryland Foot Score, ratings of excellent or good were achieved in 85% of patients treated with this approach. Post operative complication was seen (in the form of superficial skin necrosis around the incision site in small areas) in only one patient which were amenable to conservative measures. None of the operated patients had any symptoms related to sural nerve or peroneal tendons.

Various authors have advocated lateral approaches. Various incision techniques had been used for the lateral approach, but the main disadvantage of these incisions has been problems of skin necrosis, sural neuritis and neuromas. Lateral extensile approach was introduced by Benirshke and Sangeorzan [4] in 1990 and has been endorsed by various authors. Advantages of this approach include a wide exposure to the subtalar joint allowing more accurate reduction of the facet fragment, ability to decompress the lateral wall, exposure of the calcaneo-cuboid joint and sufficient area available laterally for plate fixation. Sanders *et al.* [6] in their series employed this approach, in addition to other lateral approaches. They noted that reduction of the body with reconstruction of height, width and length of the bone was not difficult and in fact, was consistently reproducible, irrespective of the comminution. They achieved an anatomical reduction in majority of their patients and believed that a medial approach is only rarely needed. In their series 12 patients had symptoms related to sural nerve. They reported that sural nerve complications

occurred only with lateral approaches other than the extensile approach. When the extensile approach was used, they did not come across any case with this complication. However, serious wound complications are common. Palmer ^[7] described a curved incision below the lateral malleolus along the course of the peroneal tendons. While the limited dissection would seem to place the patient at a decreased risk of wound complications, 10% incidence of wound-healing complications has been reported.

The lateral surface of the calcaneum is better suited to the application of plates and rigid fixation. Serious complications are associated with this approach, the most common being wound dehiscence, which may occur as much as four weeks after surgery. Folk, Starr ^[8] reported that in 190 fractures, four patients required amputation, there was a 25% wound complication rate, 22 Patients required early removal of their implants and 11 needed flap cover. Abidi and Gruen ^[9] reported problems with wound healing in 32% of their cases. Sanders noted three amputations and five free flaps in 120 patients. Schuler *et al.* found that their patients took a mean of 47 days to heal. Shuler *et al.* ^[10] observed that the better the correction of Böhler's angle and the restoration of calcaneal height and length, the greater the soft tissue tension, resulting in wound dehiscence.

To prevent these potentially disastrous complications, careful patient selection is necessary. Diabetics, smokers, patients with vascular impairment, compound fractures or fractures with blisters and persistent swelling should be excluded. Surgery should be undertaken only when the swelling subsides, usually seven to ten days after the initial injury.

By contrast, our minimally-invasive techniques have very few contraindications and excludes only patients with infected blisters and those who are too unwell for surgery. The overall reduction of the calcaneum, as judged by restoration of length, height, width and correction of varus deformity, is very good. Reduction of the articular surface was good on image intensification. The clinical results of this technique compare favourably with those of patients treated by open reduction, particularly because patients with highly comminuted fractures were included in our study. Our figures of 5% superficial and no deep infection are significantly lower than those in most series of formal open reduction. No patient required amputation. Patients treated using our technique were operated on as soon as possible after injury, while for open reduction, using the extensile lateral approach an interval of five to nine days between the trauma and surgery has been advised to prevent complications with wound healing. Attempts to reduce hospital stay by pre-operative out-patient management of patients to be treated by open reduction has proved unsuccessful. Shuler *et al.* ^[10] had problems in wound healing in 42.5% of patients operated on through a lateral extensile approach after a mean of ten days as out-patients, compared with only 16.6% when treated as in-patients.

Our technique requires manipulation of the posterior facet. Other authors advocate a similar method only for fractures in which the posterior facet remains attached to the tuberosity fragment. This permits the Essex-Lopresti manoeuvre and relatively easy manipulation. Tornetta ^[11] reported patients treated with percutaneous fixation, of whom 39 had a Sanders type-IIC fracture and seven a type-IIB. He believes that Sanders type- IIC fractures, where the entire posterior facet is in continuity with the tuberosity fragment and the facet itself is intact, are best suited for percutaneous fixation. He reported 85% excellent or good results, and concluded that for selected

fracture types the method gives comparable or possibly better results than open fixation.

Levine and Helfet ^[12], in their series of intra-articular fractures of the calcaneum treated with a minimally-invasive technique, were surprised that subtalar movement was almost completely preserved despite an articular surface reconstruction described as 'nearly anatomical'. They believe that minimal dissection results in less post-operative swelling, less peri-articular scarring and an improved range of movement than formal open reduction, despite imperfect restoration of the joint surface. Thermann *et al.* ^[13] advised minimally-invasive fixation for cases with severe soft-tissue contusion, compound and Sanders type-IV fractures, and in multiply-injured patients. Zwipp *et al.* ^[14] advocated percutaneous reduction of fractures of the calcaneum with severe soft-tissue compromise, and in patients in whom there are systemic contraindications to open surgery. He believes that it is suitable for Sanders type-IIC fractures and that, if used for Sanders type-IIA or IIB fractures, should be performed under arthroscopic control of reduction of the articular fragment. In our series, both joint-depression and tongue-type fractures of all grades of severity (Sanders type II, III, IV) were treated using the same protocol. Both the extra-articular anatomy and joint congruity were restored in most of our patients, resulting in 85% good to excellent long-term results. Carefully performed semi-open reduction and percutaneous fixation is an effective treatment for displaced intra-articular fractures of the calcaneum, especially in patients where formal open reduction is considered to constitute a significant risk.

We believe that a limited approach avoids compromising the already damaged soft tissue coverage over the lateral aspect of the foot. In our experience, this approach was sufficient to expose and reduce the displaced posterior facet and anterolateral fragment, while allowing for adequate correction of the tuberosity varus with an indirect technique.

Mini-open techniques can be used in patients in critical conditions (Polytrauma) and in patients in whom ORIF would be contraindicated, as in elderly patients, smokers, decompensated diabetes, immunodeficiency or feet soft tissue injuries. In this case, these techniques have been showed to be valid and with satisfactory results. Less invasive fixation has the advantage to correct the alignment of the posterior part of the foot and the articular congruity as good as the classic fixation, but with less damage to soft tissues decreasing the risks of complications due to its healing. The fixation is executed with percutaneous cannulated screws; the first author who presented this technique was Essex-Lopresti. Other treatments using external fixation with Ilizarov technique have been described but reserved to complex fractures or severely compromised patients, because it does not allows anatomic reduction of the articular fragments and is burdened by a risk of displacement of 40% when the weight bearing is allowed and the reduction of the lateral wall is not possible. The less invasive techniques permits to rebuild the articular surface of the anterior and medium facet; with a simple window at the sinus tarsi, the section of Periosteum of the bone is decreased, increasing the vascularisation with a consequent decreased risk of acute or secondary post-operative complications, as infections or hardware failure.

Conclusion

The working group of male population was more common, among the patients, who presented with fracture of the calcaneum and the most common mode of injury has been,

fall from height. The outcome of displaced intraarticular fractures treated surgically using minimally invasive techniques, anatomical reduction and rigid internal fixation and early mobilization was good. The minimally invasive techniques were associated with advantages of less post-operative complications such as wound dehiscence; skin necrosis, sural nerve neuritis and peroneal tendinitis. Internal fixation after good anatomical reduction, made, early mobilisation possible, which in turn provided chance for gaining normal subtalar and ankle movements.

Recommendations

In this study it was confirmed that the operative treatment of intra-articular fractures of the calcaneum involving the subtalar joint, using minimally invasive techniques provided good results. This study had its shortcomings too, as this was a short term study and involved a small number of patients. Although short term results have been good, long term follow up of the patients is needed to see whether they develop complication of chronic pain or subtalar arthritis or not. It is only then, this protocol of management can be advocated and recommended with confidence.

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