

Minimally Invasive Sinus Tarsi Approach for Displaced Intra- Articular Calcaneal Fractures

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Abstract

Introduction: Operative treatment of displaced intra- articular calcaneum fractures remain challenging and are associated with a high rate of wound complications. Extensile lateral approach (ELA) is most commonly used and is associated with a high rate of wound related complications, deep infection and sural nerve injuries. A minimally invasive sinus tarsi approach for displaced intra- articular calcaneus fractures can be used to achieve fracture reduction and fixation as well as minimize wound healing complications. The purpose of this prospective observational case series study is to report clinical and radiological outcomes associated with the sinus tarsi approach in the treatment of displaced intra- articular calcaneal fractures.

Methods: Fifteen intra- articular fractures in 14 patients with displaced fractures were managed surgically between February 2020 and December 2021. Demographic and radiographic data were collected for all patients including, age, gender, smoking status, presence of diabetes, mechanism of injury, injury side, time to surgery, length of hospital stay, follow up duration, Sanders classification, Bohler and Gissane. Post- operatively we recorded clinical evaluations for wound healing complications, deep infections, sural nerve injuries, peroneal tendinitis, time taken to return to work after the injury, and radiographic measurements.

Results: Fifteen intra- articular calcaneum fractures in 14 patients with a mean age of 47.1 (range 28- 58) years underwent open reduction and internal fixation for displaced intra-articular calcaneus fractures. Using the Sanders classification, we identified 27% Type 2 and 73% Type 3. From this, 33% of fractures displaced had a negative Bohler's angle, 47% had an angle 0° to 20° and 20% over 20°. Post- operatively, all patients had an improvement in Bohler's angle with 33% with 0° to 20° and 67% over 20°. The angle of Gissane measured pre- operatively averaged 100.9° and the average post- operative angle was 120°. Approximately, 50% of the patients working prior to the injury had returned to work by 6 months and 80% by 9 months. Bony union was achieved in all cases. There were no cases of wound related complications such as superficial or deep infection.

Conclusion: Minimally invasive sinus tarsi approach for displaced intra- articular calcaneal fractures is a safe and useful approach with low wound complication rates even amongst active smokers.

Keywords: Calcaneal Fractures; Minimally Invasive; Sinus Tarsi Approach

Introduction

When treated operatively, displaced intra-articular calcaneum fractures are associated with a high rate of wound complications. The goal of operational management is to restore articular congruency of the subtalar joint, calcaneal height, width, and alignment. These goals can be achieved through different approaches and the most common being the extensile lateral approach (ELA). In the treatment of displaced intra-articular calcaneal fractures, this approach has been recognized as the gold standard by many surgeons. However, it is also associated with a high rate of complications [1]. They are wound related complications, deep infection and sural nerve injuries. To minimize these complications, particu-

larly wound related complications, a less invasive approach such as the sinus tarsi approach remains the best alternative at present. This approach together with the use of modern locking fixation should be considered as it has been shown to reduce the risk of soft tissue complications in the management of displaced intra- articular fractures [2]. This approach is demanding as it mostly allows only visualization of the posterior facet of the calcaneum and calcaneocuboid joint. There is less visualization of the calcaneal tuberosity and due to this, it has a steep learning curve associated with it [3]. This prospective observational case series study aims to evaluate clinical and radiological outcomes of displaced intra- articular calcaneal fractures managed surgically with a sinus tarsi ap-

proach as well as to report complications encountered. This study was conducted at 2 foot and ankle units in Malaysia.

Methods

A consecutive series of 15 intra- articular fractures in 14 patients with displaced fractures were managed surgically between February 2020 and December 2021 at both these centers. Patients who were less than 18 years old, had open fractures, extra- articular, loss to follow up, sinus tarsi approach was not used, follow up of less than 9 months were excluded from this study. Sanders IV fractures were also excluded because the fixation of such cases was not suitable through the sinus tarsi approach.

Demographic data were collected for all patients including, age, gender, smoking status, presence of diabetes, mechanism of injury, injury side, time to surgery, length of hospital stay and follow up duration. Demographic data are shown in table 1.

Radiographic evaluations included anteroposterior and lateral views of the calcaneus and the calcaneal axial view in all patients. The Bohler and Gissane angles were also measured in all patients. CT scans were also obtained and fractures were classified using Sanders's classification. Fracture classification was determined by reviewing the preoperative axial CT scan of the section with the widest dimension of the posterior facet of the talus and counting a fracture line if there was greater than 2mm of displacement.

Clinical evaluations were limited to wound healing complications, deep infections, sural nerve injuries and peroneal tendinitis.

A sinus tarsi approach was undertaken for all patients and was followed up for at least 9 months postoperatively. Informed consent was obtained from all patients for being included in this study.

The surgical technique will be outlined below

Surgery was performed between 4 and 20 days (average of 11.9 days) after injury. Patients who had minimal swelling or in the presence of wrinkle signs were identified as ready for surgery. All patients received spinal anaesthesia except one who had an associated lumbar spine fracture and received general anaesthesia. Second generation cephalosporin was the antibiotic prophylaxis of choice and was administered 30 minutes before inflation of the tourniquet. All patients were positioned in lateral decubitus with a thigh tourniquet.

Skin incision is made starting just beneath the tip of fibula towards the base of 4th metatarsal and measured between 4 to 5 cm long. Soft tissue are dissected along the line of skin incision. The extensor digitorum brevis muscle is sharply elevated off the ante-

rior process of calcaneum and reflected dorsally and distally. The peroneal tendons are retracted inferiorly allowing visualisation of the posterior facet of subtalar joint. Subperiosteal dissection is undertaken and remaining superficial to lateral wall fragment is ensured. A transaxial Steinmann pin is next inserted from medial to lateral through the calcaneum tuberosity to distract it and pull it out of varus, restoring length and alignment of the calcaneum. This was then provisionally stabilised with size 2.0mm Kirschner wires along the medial border of calcaneum. The lateral wall is then slightly retracted to identify and reduce the posterior facet. The posterior facet of the talus was used as a template where the depressed fragment is pushed against it, aligning it with the intact medial part of the posterior facet. This is then also provisionally stabilised with size 1.6mm Kirschner wires. A size 2.0mm Kirschner wire is also inserted from the calcaneum into the talus for provisional stabilization and removed after application of the plate. Fluoroscopy is performed to assess fracture reduction and fixation. In order to assess posterior facet reduction, a Broden view is required. As soon as the calcaneum has been reduced sufficiently, an anatomical plate is inserted subcutaneously. After the plate is applied, headless screws are inserted percutaneously from the calcaneum tuberosity to the anterior process and posterior facet for further stabilization. The incision is then closed in a layered fashion followed by compression bandaging. Each of the patients received 24 hours of post- operative intravenous antibiotics.

Radiographs were taken post- operatively to measure calcaneal anatomical parameters such as Gissane and Bohler's angle. Ankle range of motion exercises were initiated on post- operative day 1. Patients were then reviewed post- operatively in clinic and seen within the first 2 weeks for wound check and sutures were removed at this point. In general, all patients were kept non- weight bearing for approximately 6 – 8 weeks pending evidence of radiographic union on radiographs. Partial weight bearing ambulation is then subsequently permitted as tolerated. This is then followed by gradual return to full weight bearing at approximately 10- 12 weeks as determined by clinical and radiographic evidence of fracture healing. Clinical evaluation and assessment of radiographic union was undertaken at 1, 3, 6 and 12 months postoperatively.

Results

Fifteen intra- articular calcaneum fractures in 14 patients with a mean age of 47.1 (range 28- 58) years underwent open reduction and internal fixation for displaced intra-articular calcaneus fractures. The left side was involved in 9 cases, right side in 4 cases and both sides in 1 case. Mechanism of fracture was falling from height in 10 patients (71.4%), compared with road traffic accidents in the remaining 2 patients (14.3%) and another 2 patients (14.3%) were due to low energy trauma such as tumble from stairs.

Using the Sanders classification, we identified 27% Types 2 and 73% Type 3. From this, 33% of fractures displaced had a negative Bohler’s angle, 47% had an angle 0° to 20° and 20% over 20°. Post-operatively, all patients had an improvement in Bohler’s angle with 33% with 0° to 20° and 67% over 20°. Bohler’s angle measured pre- operatively averaged 2.5° across all 15 fractures and the average post- operative Bohler’s angle was 25°. The angle of Gissane measured pre- operatively averaged 100.9° and the average post- operative angle was 120°.

The average time from injury to surgery was 11.9 (range, 4- 20) days. Average length of hospital stay was 5 (range 2- 14) days. Smokers comprised 43% of patients in our series. None of the pa-

tients in this series were diabetics. All fractures were treated surgically with an anatomical plate and headless screws. All surgical wounds healed uneventfully at time of suture removal at 2 weeks.

The average length of post- surgical follow up was 9.5 months. Approximately, 50% of the patients working before the injury had returned to work by 6 months and 80% by 9 months. Bony union was achieved in all cases. There were no cases of non- union or loss of reduction in this study. However, one of the patients had a temporary sural nerve injury which resolved spontaneously by 6 months (7%). There were no cases of wound related complications such as superficial or deep infection.

Case	Sex	Side (Left/ Right)	Mechanism of injury	Sanders Classification	Smoker	Diabetes	Time to surgery (days)	Length of stay (days)	Complications
1	Male	Left	Fall	3	N	N	20	2	None
2	Male	Left	Fall	2	Y	N	14	2	Yes
3	Male	Left	Fall	3	N	N	9	3	None
4	Male	Right	Fall	2	Y	N	9	2	None
5	Female	Left	Fall	3	N	N	9	2	None
6	Male	Left	Fall	3	Y	N	12	3	None
7	Male	Right	Fall	3	Y	N	10	2	None
8	Female	Left	RTA	3	N	N	7	10	None
9	Male	Left	Fall	2	Y	N	4	3	None
10	Male	Left	Fall	3	N	N	11	14	None
11	Male	Right	Fall	3	N	N	7	3	None
12	Male	Right	RTA	3	Y	N	13	9	None
13	Male	Left	RTA	3	Y	N	13	9	None
14	Male	Left	Fall	3	N	N	13	4	None
15	Male	Right	Fall	3	Y	N	16	3	None

Table 1: Patient demographic data.

RTA: Road Traffic Accident

Discussion

Intra- articular calcaneal fractures are common and challenging to treat. Recommendations in the treatment of these fractures vary from operative to non- operative with a high selection bias [4]. Recent literature favours operative treatment for an appropriately selected group of patients [5-7]. Many surgeons still consider the extensile lateral approach to be the gold standard method for open reduction and internal fixation of calcaneal fractures despite the high rate of wound complications [8]. Besides the extensile lateral approach other approaches available are the medial, combined medial and lateral, posterior, percutaneous and sinus tarsi approach. The common goal of these different approaches is to minimize disruption to the soft tissue, while still allowing for optimum and reproducible fracture reduction and fixation [9].

Our treatment involves a minimally invasive sinus tarsi approach, which we believe prevents compromising the already damaged soft tissue coverage on the lateral side of the foot. We were able to expose and reduce the displaced posterior facet and anterolateral fragment by using this approach along with an indirect technique to correct the tuberosity varus. Minimally invasive techniques such as this, should reduce one of the most common and feared complications associated with managing these fractures operatively; being wound infection. A systematic review and meta-analysis by Nosewicz, *et al.* comparing the sinus tarsi approach with the extensile lateral approach in the operative treatment of displaced intra- articular calcaneal fractures describe fewer wound complications post- operatively with the use of the sinus tarsi approach. Furthermore, the authors pointed out that the risk of de-

veloping a wound infection decreases by 80% with the sinus tarsi approach [10]. Similarly in our series, we had no cases of wound infection which is comparable to other reported infection rates of the sinus tarsi approach where wound related complication rates are between 0% and 15.4% [11]. Smokers were also statistically more likely to have wound infections than non- smokers in managing these fractures operatively [12]. This increased risk of complication associated with smoking may tip the balance against benefit from surgical management. However as nearly half of our series of patients were smokers, none of them developed any wound complication.

The comparison of pre- and postoperative radiographs reveal an improvement in the Bohler's angle from 2.5° to 25° (which is within the normal range, i.e., from 20°- 40°) and the in the angle of Gissane, from 101° to 120° which is within its normal range. These results reflect the adequate restoration of the calcaneal anatomical shape with this surgical technique employed. These calcaneal radiographic parameters may be similar between the minimally invasive technique and the conventional extensile lateral approach, as reported by Yeo, *et al.* who compared the postoperative radiographic results between both these techniques [13].

Thus, we recommend minimally invasive sinus tarsi fracture repair for closed, displaced intraarticular calcaneal fractures.

In a series by Hospodar, *et al*, 16 calcaneal fractures were treated with open reduction via a sinus tarsi approach followed by internal screw fixation. They reported no major wound complications and with successful reduction in 14 of 16 patients. Seventy-five percent of his patients had returned to work at 6 months which is comparable with the findings in our series of patients [14].

This study has limitations. First, absence of long- term results. As our average follow up was 9 months and although this would have revealed any early complications that were present, it would not have captured all patients who developed symptomatic subtalar arthritis later on. In addition, we had a relatively small sample size of 15 and lack of a control group. Post- operative CT scans were not routinely obtained and thus we were not able to evaluate the quality of our reductions.

Conclusion

In conclusion, this study demonstrates that the minimally invasive sinus tarsi approach is safe and useful for the operative treatment of calcaneal fractures. This approach results in a low complication rate and has become the preferred approach for the treatment of these fractures in our practice.

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