

Outcome Of Displaced Intra-Articular Calcaneal Fractures Using The Sinus Tarsi Approach In Hong Kong

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Abstract

Purpose: To review the outcome of surgery for displaced intra-articular calcaneal fractures using the sinus tarsi approach in Hong Kong

Methods: This is a case series including patients with displaced intra-articular calcaneal fractures who received operation using the sinus tarsi approach in a Hong Kong public hospital. All patients received computed tomography pre-operatively. Pre-operative and post-operative Bohler's and Gissane's angles were measured. Wound status were documented and the AOFAS Ankle-Hindfoot score was used to evaluate clinical outcome. Secondary outcomes included length of stay and return to work.

Results: Thirty patients were included in the study. The mean time to operation was 9 days. The mean operative time was 118 minutes. The mean length of post-operative stay was 10 days. Three (10%) patients developed wound infection. Two patients had superficial infections that resolved with oral antibiotics and one patient had a deep infection requiring removal of implant. The average Bohler's angle improved from 10° pre-operatively to 24.8° post-operatively ($p < 0.01$). The mean AOFAS score was 84. Six patients (20%) achieved excellent outcome, seventeen (57%) had good outcome, six (20%) fair, and one (3%) poor.

Conclusion: The sinus tarsi approach is a good alternative to the extensile lateral approach. Most patients achieved good to excellent functional outcome. It is associated with a low wound complication rate.

INTRODUCTION:

Calcaneal fractures are debilitating injuries that can be difficult to treat. The optimal treatment remains controversial. Factors to consider include fracture configuration and patient factors¹³. Sanders et al proposed a prognostic system based on computed tomography², and stated that displaced intra-articular fractures should be managed with open reduction and internal fixation (ORIF). This facilitates anatomical reduction of the subtalar joint, which has been shown to correlate with better joint function and a higher rate of return to work^{3,13}. ORIF has traditionally been done using the lateral extensile approach, which allows for good exposure to the lateral calcaneus and subtalar joint but is associated with a high rate of wound complications^{4,5,6,7}. Two retrospective series showed high rates of post-operative wound infections following surgery using the extensile lateral approach, 24.6% and 25%^{4,21}. Therefore, less invasive approaches have been developed to reduce the risk of wound complications. The sinus tarsi approach is

gaining popularity and studies have shown that it is associated with satisfactory outcomes and lower wound complication rates^{10,11,12,13}. A meta-analysis by Nosewicz and colleagues found that the sinus tarsi approach yielded similar functional outcome with significantly less wound healing complications⁶. Among these studies, the wound infection rate using the sinus tarsi approach ranged from 0-6%; whereas the wound infection rate using the extensile lateral approach ranged from 7-33%. However, a recent meta-analysis by Yao et al concluded that there was no significant difference in clinical efficacy and complications between the two approaches¹⁸.

In this prospective study, we aim to provide local data within Hong Kong on the outcome of surgery using the sinus tarsi approach. We hypothesize that patients will be able to achieve satisfactory outcome with a low rate of wound complications.

METHODOLOGY

Patients who received ORIF for calcaneal fractures using the sinus tarsi approach in our hospital from November 2018 to December 2021 were included in this study. Only patients with displaced intra-articular calcaneal fracture (DIACF) were included. Exclusion criteria included open fractures, insulin-dependent diabetes, immunocompromised, and delayed presentation > 2 weeks.

Admission protocol:

On admission, the date of injury and mechanism of injury was documented. The injured limb was examined for any open wounds and the soft tissue status was documented for any swelling or blistering. Patients were given bed rest with elevation of the injured limb. Pre-operative AP and lateral X-ray and computed tomography (CT) of the calcaneum was performed for all patients. Monitoring of soft tissue status was performed daily. Patients were arranged for operation when soft tissue status was satisfactory, as evident by the presence of the wrinkle sign.

Peri-operative care and operative technique:

A single dose of intravenous cefazolin 1g was given to patients on induction of anesthesia. Patients were placed in the decubitus position on the non-injured side. The limb was exsanguinated either by elevation alone or in combination with Esmark bandage and tourniquet was inflated over the thigh to minimize bleeding. The sinus tarsi approach was utilized in all cases. Incisions were made from the distal tip of the lateral malleolus towards the base of the 4th metatarsal (Photo 1). Meticulous soft tissue dissection was performed. The peroneal tendons were retracted inferiorly and the sural nerve protected. Further dissection was performed to expose the subtalar joint and fracture site (Photo 2). Hematoma and callus were removed to better visualize the fracture site. Before attempting reduction of articular fragments, a Schanz screw was usually inserted posteriorly into the tubercle. This was used as a joystick to restore the extra-articular deformity, as often times the displaced calcaneal tubercle could hinder the reduction of the articular fragments. After correction of the extra-articular deformity, an assistant would hold the Schanz screw while the chief surgeon performed reduction of the articular fragments under direct visualization. For reduction of depressed articular fragments, an artery forcep was inserted through the primary fracture line to elevate these fragments. In comminuted fractures, reduction of the intra-articular fragments might be difficult. In these cases, the talus could

be used as a template for reduction. Once reduced, fracture fixation could be temporarily held by K wires or fixed with lag screws if needed. The Acumed Calcaneal Plating System was used for definitive fixation (Photo 3). A separate small incision was made posterior to the initial incision to facilitate insertion of screws over the posterior limb of the plate. During screw fixation of the plate, care must be taken to avoid injury to medial structures. In particular, the flexor hallucis longus tendon could become entrapped by a long screw, resulting in a flexion deformity of the big toe. To avoid this, we must perform drilling and measuring diligently, taking care to just drill through but not overshoot past the medial cortex. In addition, after insertion of screws, fluoroscopy screening should be performed. Any screw that is too long can be easily visualized on axial view and should be exchanged. Finally, intra-operative C-arm fluoroscopy was used to confirm satisfactory reduction and fixation (Photo 4).

Post-operative care:

Two more doses of intravenous cefazolin 1g were given every 8 hours post-operatively. Post-operative XR including AP, lateral, axial, and Broden's views were performed. Post-operatively, patients received a short course of physiotherapy for non-weight bearing walking exercise. They were referred to the outpatient physiotherapy on discharge.

Rehab protocol:

Patients were kept non-weight bearing for 6 weeks, followed by partial-weight bearing for the next 6 weeks. They were allowed to resume full weight bearing or weight bearing as tolerated afterwards. Follow ups were arranged at 2, 6, and 12 weeks, and then every 12 to 24 weeks. Wound examinations and X-rays were repeated on follow ups (Photo 5). The American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot score (Figure 1) was charted on follow ups. Physiotherapy would be continued until condition plateaued. Early outpatient physiotherapy included ankle and toe mobilization exercises, strengthening exercises, and ambulation training. As fracture healing permits, further range of motion and strengthening exercises were included. Patients would also start partial weight bearing and full weight bearing according to the protocol. Patients were also referred to occupational therapy to facilitate return to work. ADL assessment, training, and work hardening were usually performed by the occupational therapist. Work hardening was variable and tailored to each

patient. These included ladder training, stairs training, manual carrying of heavy weights, and squatting.

Outcome assessment:

Primary outcomes for this study include wound complication rates, functional outcome, and radiological outcome. Wound complications such as early infection, necrosis, and dehiscence were documented. We defined wound infection as persistent discharge with a culture positive swab. Sural nerve injuries were also charted. Functional outcomes based on the latest AOFAS scores were charted. A score of 90-100 points is considered “excellent”, 80-89 “good”, 60-79 “fair”, and ≤ 59 “poor”¹⁹. The Radiological outcome was assessed by measuring changes in Bohler’s angle and Gissane’s angle and whether they were restored to normal values. The pre-operative and post-operative angles were compared using the Paired T-test. Secondary outcome included return to work.

Statistical analysis was performed to identify factors that may affect outcome. The Student’s T-test, Fisher’s exact test, linear regression, and logistic regression were used.

Research ethics and patient consent:

This study has obtained approval by the Kowloon West Cluster Research Ethics Committee. Informed consent was obtained from each patient in this study.

RESULTS:

32 patients with calcaneal fractures underwent operation during this time period. Two patients were excluded due to loss to follow up.

In the end, 30 patients were recruited into the study. The average age was 52, and ranged from 33 to 77 years old. There were 20 males and 10 females. 14 were smokers and 16 were non-smokers. Two patients were diabetics. Otherwise, most patients enjoyed good past health and no participants were excluded due to co-morbidities. 19 patients reported injury on duty. There were 10 Sanders type II fractures, 20 type III. The mean duration of operation was 119 minutes (range 78-180 minutes). The mean length of post-operative stay was 10 days (range 1-23 days). The mean follow up duration was 20 months (range 6-42 months).

Wound complications:

Overall, there were 3 wound complications out of 30 operations (10%). None of our patients suffered from serious wound complications such as flap necrosis, wound dehiscence, or exposed implant.

2 patients developed superficial wound infections. One of these patients was a patient with schizophrenia with poor self-hygiene. He presented with serous discharge over the wound on follow up at 10 weeks. He was not compliant with our rehabilitation protocol and had already started full weight-bearing walking. He reported multiple contusions to the wound due to gait instability. Physical examination found mild serous discharge over the posterior limb of the wound. Wound swab was taken, which yielded growth of methicillin-sensitive *Staphylococcus aureus*. He was given one-week course of oral amoxicillin-clavulanate. The infection was eradicated and his wound had healed on follow up two weeks after. The other patient suffered from poorly controlled diabetes despite being on two oral hypoglycemic agents. During admission, her random glucose was 13.2mmol/L and her HbA1C was 10.0%. She presented with serous discharge over the wound. Wound swab yielded methicillin-resistant *Staphylococcus aureus* and *Pseudomonas aeruginosa*. She was given a course of oral cotrimoxazole and levofloxacin. Her wound healed and there was no evidence of osteomyelitis.

One patient developed a deep infection and required removal of implant. He was young with no significant medical history. However, he did not comply with our rehabilitation protocol due to financial reasons. He was self-employed as a butcher in a wet market and returned to work before removal of stitches at 2 weeks. He presented with a recurrent discharging sinus over the posterior limb of the wound. Serial X-rays did not show obvious evidence of osteomyelitis or implant loosening. Excisional debridement and removal of implant was performed 5 months after the initial operation. Intra-operatively, there was a layer of pus-like tissue covering the posterior limb of the implant. Tissue culture yielded scanty growth of methicillin-sensitive *Staphylococcus aureus*. Pathology showed acute suppurative inflammation. On his last follow up, he was able to walk unaided and experienced mild residual foot pain.

Radiological outcome:

Restoration of Bohler’s angle and critical angle of Gissane was achieved in 28 patients. The average Bohler’s angle improved from 10.0° to 24.8° ($p < 0.01$) and the Gissane angle from 112° to 120° ($p = 0.0159$). Broden’s view showed restoration of the subtalar joint with no significant gap or intra-articular stepping in all patients. There was no implant loosening or loss of reduction. Serial Xrays showed no change in Bohler’s angle or angle of Gissane in all patients.

Functional outcome:

The average AOFAS score was 84.9 (range 61-100). Six patients achieved “excellent” outcome, seventeen “good”, and six “fair”, and one “poor” (Figure 2). For Sanders II patients, 3 had excellent outcomes, 6 good, and 1 had poor outcome. For Sanders III patients, 3 had excellent outcomes, 11 good, and 6 fair (Figure 3). There was no significant difference between the average AOFAS score between Sanders II and III fractures (84.4 for Sanders II, 84.35 for Sanders III, mean difference = 0.05, 95% CI -5.68 to 5.78, $P = 0.9859$). There was no correlation between age and AOFAS score according to our data ($R^2 = 0.0359$).

Smokers and non-smokers achieved similar AOFAS scores (84 for smokers, 85.31 for non-smokers, mean difference = -1.31, 95% CI -7.08 to 4.46, $P = 0.6449$). There was no significant difference between the average AOFAS scores between males and females. (83.6 for males, 86.9 for females, mean difference = -3.3, 95% CI -9.3 to 2.7, $P = 0.2692$).

Twenty four patients were employed at the time of injury. Nineteen of these patients suffered from an injury on duty (IOD). Eleven patients were able to resume their previous work. The mean duration to return to work was 13 months (5 to 24 months). The remaining eight patients either had a change of job or retired. Of the 11 patients who were able to resume their previous work, 4 were Sander II fractures and 7 were Sanders III. Of the 10 patients who were unable to resume their previous work, 2 were Sander II fractures and 8 were Sanders III. There was no statistically significant difference between the two groups ($OR = 2.2857$, $P = 0.635$).

Nine out of nineteen IOD patients returned to their previous work while two out of five non-IOD patients return to work. The result was not statistically significant. ($OR = 1.35$, $P = 1.00$). There was no significant difference in the rate of return to work between the two genders. ($OR = 1.35$, $P = 1.00$).

Figure 1

AOFAS Ankle-Hindfoot Scale (100 points total)				
1. Pain (40 points)				
None: 40		Mild: 30	Moderate: 20	Severe: 0
2. Function (50 points)				
A. Activity limitations, support requirement				
No limitations, no support: 10	Limited recreational activities, no support: 7	Limited daily activities, cane: 4	Severe limitation, walkers / wheelchair: 0	
B. Maximum walking distance (blocks)				
> 6: 5	4-6: 4	1-3: 2	<1: 0	
C. Walking surfaces				
No difficulty on any surface: 5	Some difficulty on uneven terrain / stairs: 3		Severe difficulty on uneven terrain / stairs: 0	
D. Gait abnormality				
None: 8	Obvious: 4		Marked: 0	
E. Sagittal motion (flexion + extension)				
> 30°: 8	15-29°: 4		< 15°: 0	
F. Hindfoot motion (inversion + eversion)				
75-100%: 6	25-74%: 3		< 25%: 0	
G. Ankle-hindfoot stability				
Stable: 8		Unstable: 0		
3. Alignment (10 points)				
Good: 10		Fair: 8	Poor: 0	
90-100 points = Excellent, 80-89 = Good, 60-79 = Fair, ≤59 = Poor				

Figure 1

Figure 2

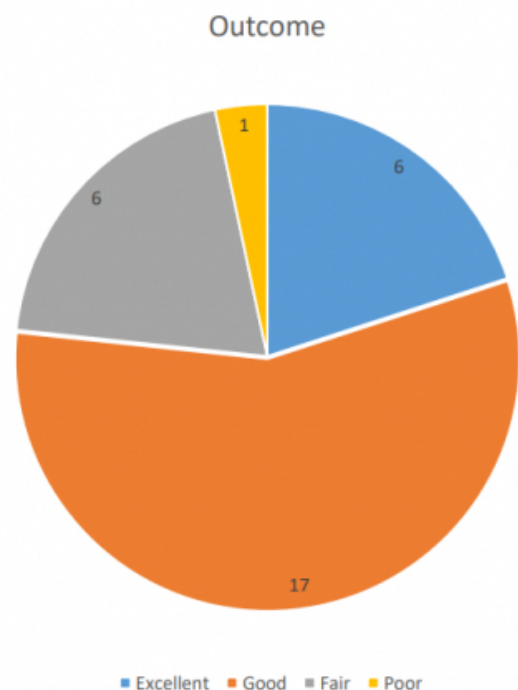


Figure 2

Figure 3

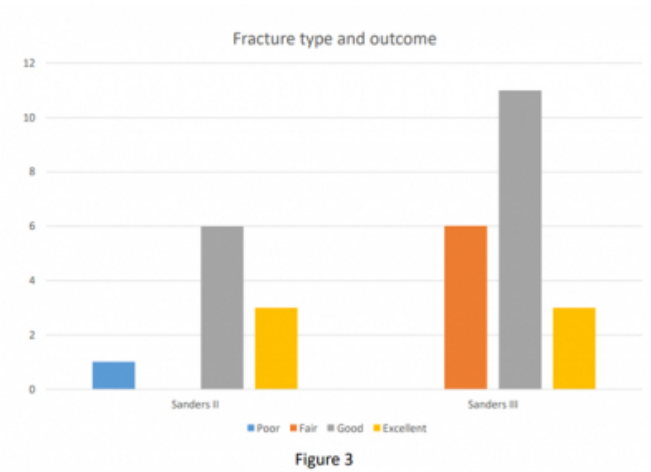


Photo 2



Photo 1



Photo 2

Photo 1

Photo 3



Photo 3

Photo 4

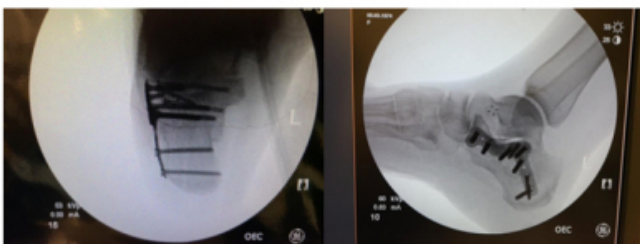


Photo 4

Photo 5



Photo 5

DISCUSSION:

Displaced intra-articular calcaneal fractures can be difficult to manage. They are usually the result of high-energy trauma and can be associated with multiple injuries¹. The optimal treatment remains controversial. Treatment options include non-operative, percutaneous fixation, and open reduction and internal fixation (ORIF). The prognosis following calcaneal fractures is related to the degree of intra-articular displacement, and anatomical restoration of the subtalar joint should be the goal of operative treatment^{3, 4, 5, 6, 7}. Patients with Sander I and IV fractures should be treated conservatively. Type I fractures are non-displaced and operations offer no additional benefit. Type IV fractures are comminuted and often difficult to obtain anatomical reduction. They are associated with poor outcomes and a high rate of subtalar arthritis requiring arthrodesis. These fractures should be managed conservatively, or in selected cases, primary subtalar fusion may be considered. For Sanders type II and III fractures, surgery should be considered to achieve anatomical reduction of the subtalar joint. A meta-analysis by Jiang et al 2012 supported operative treatment in management of DIACF despite a high rate of wound complications. Most of the fractures were treated using the extensile lateral approach. They demonstrated that surgical treatment was superior to non-surgical treatment in the recovery of Bohler's angle, calcaneal height, and calcaneal width. Patients treated operatively had less problems with shoe wear and a higher rate of return to work³. However, in the UK Heel Fracture Trial, Griffin et al concluded that operative treatment was associated with a high risk of complications, and there was no differences in outcomes

between non-operative and operative treatments²¹. In this multicenter RCT, operations were performed by 27 surgeons via the extensile lateral approach. Limitations of this study included a low recruitment rate (only 7.5% of patients with calcaneal fractures were recruited), and that each of the 27 surgeons only operated on a median of 2 cases. In another multi-centre RCT, Buckley et al demonstrated that certain factors were associated with better outcomes with operation. Subgroup analysis revealed that young patients, females, light to moderate workload, and non-workers compensations were associated better outcomes after surgery²⁰.

The extensile lateral approach is associated with a high rate of post-operatively wound infection, which may lead to lower functional scores^{3,4,7}. In addition, one of the most dreaded complication using this approach is flap necrosis. A possible explanation is that the posterior vertical portion of the extensile lateral incision lies in close proximity to the lateral calcaneal artery, which if injured, may compromise the perfusion to the wound and lead to increased wound complications rates⁸. Other factors include shorter operative time, smaller incision, and less extensive soft tissue dissection⁶. Less invasive techniques have been developed in order to avoid the high risk of wound complications. In particular, the sinus tarsi approach has been gaining popularity. This smaller incision placed well away from the lateral calcaneal artery offers direct visualization of the subtalar joint. Earlier studies demonstrated favorable results in operations performed using the sinus tarsi approach. The sinus tarsi approach was associated with satisfactory reduction, good functional outcomes, and a lower rate of wound complications^{6, 11, 12, 13}. However, a recent meta-analysis by Yao et al showed that there was no difference in clinical efficacy between the two approaches³⁰. Results from 15 randomized controlled trials were reviewed and there was no significant difference in terms of radiographic outcome and complication rates.

Results from this study showed that patients who received operation via the sinus tarsi approach achieved satisfactory radiological outcome and functional outcome. Bohler's and Gissane's angle were restored 28 out of 30 patients. Broden's view showed no significant gap or intra-articular stepping >2mm of the subtalar joint in all patients. Post-operative CT would be useful to better illustrate the quality of reduction. Functional outcome was assessed using the American Orthopaedic Foot and Ankle Society Ankle-Hindfoot Score. There was no statistically significant difference in the average AOFAS score between Sanders II

and III patients. Moreover, fracture severity did not correlate with the rate of return to work. Overall, our results were promising and consistent with previous studies showing good functional outcomes with operation using the sinus tarsi approach. However, our results failed to show that smoking was associated with lower AOFAS scores.

Three patients developed post-operative infections in this study. The rate of post-operative wound infection from this study (10%) was slightly higher than results from other studies using the sinus tarsi approach, which ranged from 0-6%⁶. However, it is important to note that all three patient had risk factors we believe directly contributed to wound infection. One patient suffered from uncontrolled diabetes, which is a recognized risk factor for wound complications. Other risk factors for wound complications include smoking, bone graft, absence of drain, open fracture, and fracture severity^{15, 22}. On the other hand, the other two patients who developed wound infections were non-compliant to wound care and rehabilitation protocol and started full weight-bearing walking within weeks after the operation. Further study is needed to determine whether non-compliance and early return to full weight bearing are risk factors for wound complications.

The optimal timing of surgery for DIACF remains unclear. In calcaneal fractures, the thin layer of soft tissue covering the heel is at risk to formation of fracture blisters. Fracture blister are sub-epidermal vesicles consisting of transudative fluid. If ruptured, the underlying de-epithelialized tissue can be rapidly colonized by pathogens, predisposing to wound infection¹⁶. Therefore, it is common practice to either avoid incision at the blister site or to delay operation until re-epithelialization. While early surgery allows for shorter hospital stay and earlier rehabilitation, it may lead to increase wound complication rates. A retrospective study by Al-Mudhaffar et al¹⁷ demonstrated that surgery within 7 days of injury was a risk factor for wound complications. On the other hand, Ho CJ et al¹⁴ concluded that surgery timing may not affect post-operative infection rate and suggested early surgery may be helpful. In our study, the mean duration to operation was 9.3 days. 2 out of 8 patients who received surgery within 7 days developed wound infections, compare to 1 out of 22 patients who received surgery after 7 days (OR 7, P = 0.1655). This seems to favor the traditional belief that early surgery was associated with increased risk of infection, however our results were not statistically significant.

There are some limitations to the sinus tarsi approach. In

particular, medial comminution is difficult to deal with. Often times, medial fractures are harder to visualize and reduction of these fragments can be difficult. In future studies, we may consider routine post-operative CT to see if there are any differences between the qualities of reduction of medial vs lateral fractures. Another limitation of this approach is that additional wounds for percutaneous insertion of Schanz screws are usually needed to achieve correction of extra-articular deformities.

There are some limitations in this study. First, the sample size was small and inadequate to provide significant statistical power. Based on our data, it seemed that poor compliance and early full-weight bearing could be associated with wound infections. A larger sample size would be helpful to demonstrate statistical significance. Second, this was single cohort prospective study. There was no intervention, no randomization, and outcomes were purely observational.

CONCLUSION:

The optimal treatment for displaced intra-articular calcaneal fractures remain controversial. The Sanders classification is prognostic. In DIACF, operation should aim to achieve anatomical reduction of the subtalar joint. Factors such as diabetes mellitus, smoking, peripheral vascular disease, and non-compliance may be associated with wound complications. In these patients, the risks of surgery may outweigh the benefits. Other factors to consider include young age, female sex, light to moderate workload, and non-worker's compensation. Operation should be considered in these patients as they are associated with better outcome after surgery.

Many studies cite wound complications as a major risk of surgical treatment. However, the majority of these studies were done using the extensile lateral approach. While there are mixed evidence comparing the STA and the ELA, many studies have shown that the STA can achieve similar functional outcomes with less wound complications compare with the ELA.

Based on the results of this study, we believe that patients with DIACF should receive operation using the sinus tarsi approach if they were managed operatively with open technique. The STA allows anatomical reduction of the subtalar joint and restoration of the calcaneal anatomy with a low complication rate. Only 3 out of 30 patients developed wound complications and all 3 patients had significant risk factors. It is also important to note that none of our patients

developed flap necrosis, which can occur after operation using the extensile lateral approach. Most patients were able to achieve good to excellent functional outcome.

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