

Clinical application of the sinus tarsi approach in the treatment of intra-articular calcaneal fracture

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Abstract

To observe the clinical outcome of the sinus tarsi approach in the operative treatment of intra-articular calcaneal fractures.

Forty-nine intra-articular calcaneal fractures in 45 patients were managed surgically with sinus tarsi approach. The anatomical plate and compression bolts were applied in 14 feet. The anatomical plate and screws were applied in 35 feet. Maryland foot score system was used to evaluate the function of the hindfoot at the followup.

The reduction of the posterior facet was graded as nearly anatomical (less than 2 mm articular displacement) in 46 feet (93.9%). The width, height, and Böhler angle were significantly improved in all patients ($P < .01$). After a mean follow-up period of 18.7 months (14.5–29 months), the Maryland foot scores were: 34 feet scored 90–100 points (excellent), 6 feet scored 80–90 points (good), 6 feet scored 70–80 points (fair), and 3 feet scored 60–70 points (poor). Incision-edge necrosis occurred in 2 cases. One case suffered from incomplete medial plantar nerve injury. One case suffered from heel pad branch of the tibial nerve injury. Six cases suffered from sural nerve injury, and 4 cases sustained a lateral wound dehiscence due to a hematoma. No case suffered from lateral impingement syndrome. Up to now, no patient had to accept subtalar arthrodesis.

Sinus tarsi approach provides good exposure to the subtalar joint. Open reduction and internal fixation of calcaneus fractures through a sinus tarsi approach allows adequate reduction with low risk of wound-healing complications.

Abbreviation: DIACFs = displaced intra-articular calcaneal fractures.

Keywords: calcaneus, intra-articular fractures, open reduction and internal fixation, sinus tarsi approach

1. Introduction

Calcaneus fractures comprise 1% to 2% of all fractures of the human body, and 60% of all tarsal bones injuries.^[1] High-energy axial traumas, such as fall from height or motor accidents, are the common causes for calcaneal fractures. There are 2 types of calcaneal fractures: extra-articular and intra-articular. 60% to 75% of calcaneal fractures are displaced intra-articular calcaneal fractures (DIACFs).^[2,3] DIACFs can cause hindfoot deformities and long-term disability due to pain and chronic stiffness. The treatment of displaced intra-articular calcaneal fractures remains challenging and controversial due to their complexity.

Treatments options, such as Cotton mallet, the Harris traction, percutaneous pins, primary fusion, open reduction, and total excision, have been used for DIACFs in the past. However, the clinical outcomes of these treatments are far from satisfactory. With

improved understanding of the fracture, more surgeons have recommended open reduction and internal fixation with conventional plate via an extensible lateral L-shaped approach as a standard treatment for DIACFs.^[4] This approach provides excellent exposure of the fracture and allows direct reduction of the depressed posterior facet fragment. However, several studies report high postoperative wound complications rate of using this method, including wound dehiscence, hematoma, flap necrosis, deep infection, is high.^[5–7]

In attempt to limit these complications, various alternative surgical approaches have been developed, including limited lateral, obtuse-angled, the medial, combined lateral and medial, plantar, Kocher approach, U-incision, and limited posterior approach. The limited lateral approach includes Palmer approach, Smile-incision, Ollier approach, and the sinus tarsi approach. Using a much smaller incision, sinus tarsi approach allows visualization of the articular reduction while limiting soft tissue dissection.^[8–10] The purpose of this study is to assess the clinical outcomes and the wound complications of the sinus tarsi approach in the operative treatment of DIACFs.

2. Materials and methods

2.1. Patients

From September 2006 to July 2009, 49 intra-articular calcaneus fractures in 45 patients were managed surgically with sinus tarsi approach. Among the 45 patients included in this study, 42 were men and 3 were women. Their average age was 42.7 (32–59). The left side was involved in 19 cases, right side in 22 cases, and both sides in 4 cases. The mechanism of injury was a fall from height, including low (<1m) in 2 cases, intermediate (1m–2m) in 19 cases, and high height falls (>2m) in 24 cases. According to the Sanders classification system, there are 26 feet of type II fractures, 19 feet of type III fractures, and 4 feet of type IV fractures. In

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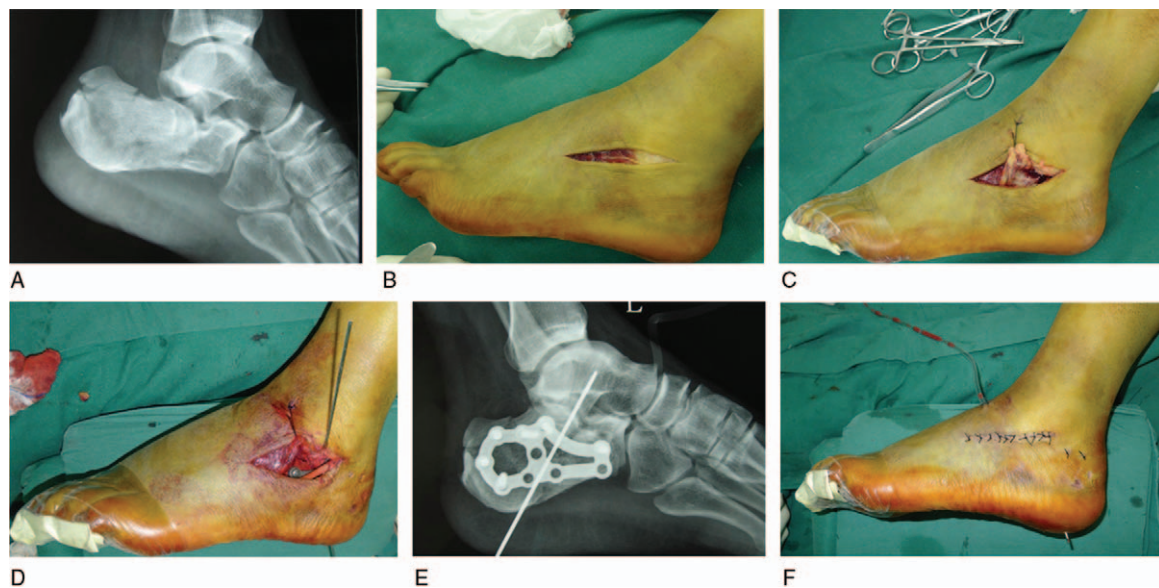


Figure 1. Open reduction and internal fixation with anatomical plate via sinus tarsi approach. A, Preoperative lateral X-ray showed that calcaneal height, Böhler's angle, and Gissane's angle were significantly reduced. B, Incision was made through sinus tarsi approach. C, Exposure of sinus tarsi. D, Internal fixation with an anatomical plate. E, Postoperative lateral X-ray showed that the placement of anatomical plate. F, Postoperative view of the foot after wound closure.

addition, 3 cases had associated injuries of the lumbar spine fracture, 2 cases with tibial plateau fracture, and 1 case with Pilon fracture. Informed consent was obtained from all patients for being included in this study.

2.2. Surgical procedure

Surgery was performed from 3 to 22 days (average, 7.9 days) after injury. Complete resolution of the swelling and the wrinkle sign were used to judge when the patients were ready for surgery. The patients associated with lumbar spine fracture received general anesthesia, all the other patients received spinal anesthesia. A standard antibiotic prophylaxis regimen with a first-generation cephalosporin was performed for all patients at 30 minutes before inflation of the tourniquet. The patients were placed in a prone position for bilateral fractures or in a lateral decubitus position for unilateral fractures.

An incision is made from the tip of the lateral malleolus toward the base of the fourth metatarsal bone. The incision lies in a plane between the superficial peroneal nerve and the sural nerve. Care is taken to bluntly dissect after the skin incision to protect the sural nerve or branches of the superficial peroneal nerve. By mobilizing the sinus tarsi fat pad dorsally, the incision was deepened. The extensor digitorum brevis muscle is sharply elevated off of the anterior process with the lateral root of the inferior extensor retinaculum, and reflected dorsally and distally. The peroneus brevis and peroneus longus tendons are split, allowing exposure to the sinus tarsi and visualization of the posterior facet of the subtalar joint. A 3.0 mm Steinmann pin was inserted into the calcaneus tuberosity for traction. The posterior facet of the talus was used as a template by pushing the depressed fragment against it into proper alignment with the supero-medial fragment. Temporary fixation was performed with K-wires ranging in size from 1.5 to 2 mm according to the size of the displaced fragment. The wires were driven through the calcaneum to the talus for provisional fixation. The K-wires

were removed after the application of the plate or at 4 weeks after the surgery. Heel width was corrected by forceful manual impaction with the surgeon's hands placed along the lateral and medial tuber (Fig. 1).

For the fractures with involvement of the calcaneocuboid joint, the skin incision was extended anteriorly, and the extensor brevis muscle was elevated as far as calcaneocuboid joint. With this approach, the calcaneocuboid joint could be clearly visualized and reduced. In some cases, the patients had dislocated calcaneocuboid joint. After being reduced manually, the calcaneocuboid joint was stabilized by K-wires for 4 weeks (Fig. 2).

After the calcaneus was reduced satisfactorily under C-arm fluoroscopy, an anatomical plate was inserted into the incision subcutaneously. Screws were inserted directly through the sinus tarsi approach for visible screw holes and percutaneously for those inaccessible holes.

If the reduction of the calcaneal fractures were not satisfying, one compression bolt can be drilled directly to the sustentaculum tali, which lies beneath the posterior articular surface. Another 2 compression bolts were inserted to the calcaneal tuberosity. The nut was tightened on the screw after confirmation of the reduction of the calcaneal fractures. The distal part of the compression bolt was broken off at the constricted area.

Following the plate and screw were well fixed under C-arm fluoroscopy, the rubber drains were inserted into incision, and the incision was closed in a layered fashion followed by compression bandaging.

If the patients had dislocated peroneal tendons, these must be addressed before wound closure. The incision is started at the tip of the lateral malleolus and extended 4 cm along the lateral malleolus. The peroneal tendons are manually relocated (Fig. 3).

All surgical procedures were all reviewed and approved by the Medical Ethics Committee of the Third Hospital of Hebei Medical University.

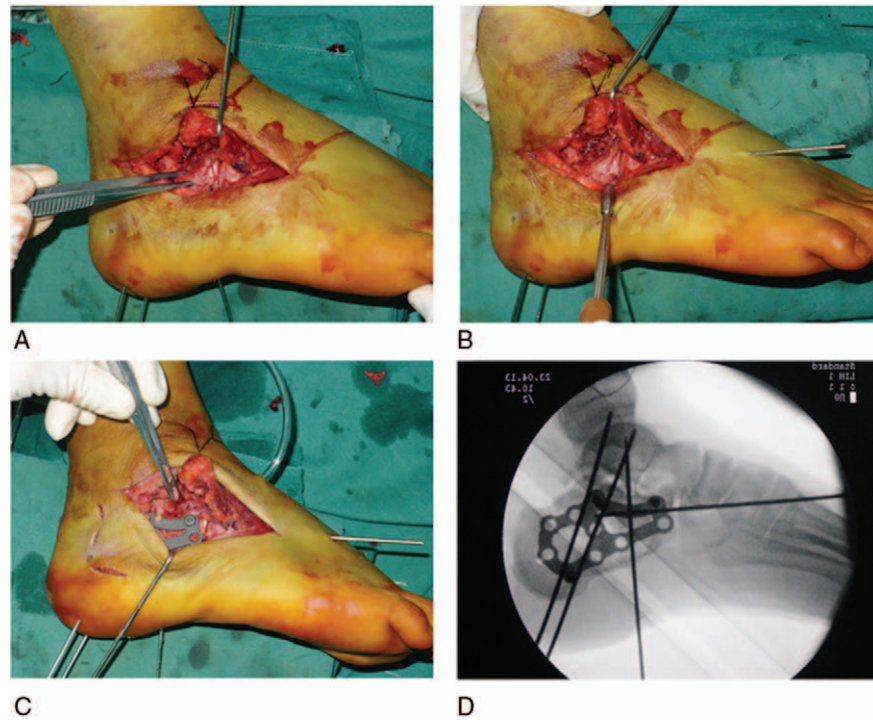


Figure 2. DIACFs with involvement of the calcaneocuboid joint. A, The skin incision was extended anteriorly to expose the calcaneocuboid joint. B, The relocated calcaneocuboid joint was stabilized by K-wires. C, Internal fixation with an anatomical plate. D, Postoperative lateral X-ray showed that calcaneus was reduced satisfactorily and the placement of anatomical plate. DIACFs = displaced intra-articular calcaneal fractures.

2.3. Postoperative management

Radiographs were taken postoperatively to measure the calcaneal anatomical parameters, including height, width, and Böhler angle. The suction drain was removed 24 hours postoperative

day. Sutures were removed at 2 weeks. In some cases, K-wires were removed at 4 weeks. Progressive weight bearing was allowed at 8 weeks, and full weight bearing was permitted at 12 weeks. Using the 100 points Maryland foot scoring system,



Figure 3. DIACFs with dislocated peroneal tendons. A, Finishing view of sinus tarsi approach. B, Temporary fixation was performed with K-wires. C, The restoration of Böhler angle and the reduction of the posterior facet were confirmed under C-arm fluoroscopy. D, The incision is extended about 4 cm along the lateral malleolus to expose the dislocated peroneal tendons. E, Sutures of tendinous sheath of peroneus longus and brevis. F, Postoperative view of the foot after wound closure.

patients were given a clinical assessment at final visit. An overall rating of excellent (90–100), good (80–89), fair (70–79), and poor (<69) was assigned to each fracture.

2.4. Statistical analysis

All data were analyzed by SPSS 17.0 statistical software and expressed as mean ± standard deviation. The preoperative and postoperative calcaneal anatomical parameters were compared by the paired *t* test. Comparisons were considered to be significant at *P* < .05.

3. Results

Forty-nine intra-articular calcaneal fractures in 45 patients were included in this study. Three cases had associated injuries of the lumbar spine fracture, 2 cases with tibial plateau fracture, and 1 case with Pilon fracture. Two of the 3 patients with associated injuries of the lumbar spine fracture received general anesthesia, all the other patients received spinal anesthesia. The anatomical plate and compression bolts were applied in 14 feet. The anatomical plate and screws were applied in 35 feet. There were 6 cases with calcaneocuboid joint fractures, and 2 cases with dislocated peroneal tendons. All of the cases had follow-up from 14.5 to 29 months (averaged 18.7 months). No case had wound infection. Two cases had incision-edge necrosis and treated by dress-changing and direct suture at the second stage. One case suffered from incomplete medial plantar nerve injury. One case suffered from heel pad branch of the tibial nerve injury. To these cases, the injured nerves were released when the plate and compression bolt was removed 3 months postoperation. They obtained relief and recovered half a year postoperation. Six cases suffered from sural nerve injury and got relief half a year postoperation. Four cases sustained a lateral wound dehiscence due to a hematoma. It healed after surgical drainage. No case suffered from lateral impingement syndrome. Up to now, no patient had to accept subtalar arthrodesis.

According to Sanders classification, there were 26 type II fractures, 19 type III fractures, and 4 type IV fractures. The reduction of the posterior facet was graded as nearly anatomical (less than 2 mm articular displacement) in 26 feet (100%) of type II fractures, 18 feet (94.7%) of type III fractures, and 2 feet (50%) of type IV fractures (Table 1). The width, height, and Böhler angle were improved significantly in all patients (Table 2). According to Maryland foot score, 34 fractures resulted excellent, 6 good, 4 fair, and 3 poor (Table 3).

4. Discussion

Various alternative open approaches have been developed in treating DIACFs, including extensile lateral approach, medial approach, combined lateral and medial approach, limited posterolateral approach, and sinus tarsi approach.^[11] In 1948, Palmer^[12] originally introduced a laterally based approach through the sinus tarsi for direct visualization of the articular

Table 1
Postoperative anatomical reduction of the patients.

Sanders type	Feet	Anatomical reduction
II	26	26 (100%)
III	19	18 (94.7%)
IV	4	2 (50.0%)
Total	49	46 (93.9%)

Table 2
Preoperative and postoperative radiographic measurements of calcaneal dimensions and angular measurements.

Radiographic parameter	Preoperative	Postoperative	<i>P</i> value
Böhler angle, degrees	7.11 ± 23.19	29.76 ± 6.12	<.01
Calcaneal height, cm	32.24 ± 6.12	44.57 ± 4.87	<.01
Calcaneal width, cm	35.81 ± 7.12	28.19 ± 3.07	<.01

surface for reduction. He and other authors proved this approach to be useful and reasonably safe.^[13] In 2005, Holmes described the minimally invasive sinus tarsi approach for DIACFs. He reported that the sinus tarsi approach proves adequate exposure to achieve successful reduction and fixation without any wound infection, wound dehiscence, or osteomyelitis over 18 years.^[14] In 2008, Hospodar et al studied 16 consecutive cases using minimally invasive sinus tarsi approach. No major wound complications were found in those cases. The posterior facet joint was successfully reduced to less than 2 mm of displacement in 14 patients.^[15] In 2016, Wang et al^[16] used a self-designed combined plate through a minimally invasive sinus tarsi approach to study 18 cases and proved sinus tarsi approach may be safe and effective for type II and type III calcaneal fractures.

There are different methods for fixation of calcaneal fractures. Some authors used only pin, others preferred screws, staples, and pins, or screws and plates. In this study, the anatomical plate and compression bolts were applied in 14 feet, and the anatomical plate and screws were applied in 35 feet. However, there is no significant difference with functional outcomes of these 2 methods.

Abdelazeem et al used limited open sinus tarsi approach and fixation by screws only technique to manage 33 cases of DIACFs. Marked improvement in Böhler angle was noticed in all patients. The mean preoperative angle was 2.8°, and postoperatively it was 19.4°.^[17] In 2015, Yeo et al^[18] reported successful improvement in Böhler angle from 17.0° to 26.5° using sinus tarsi approach. In this study, we achieved sufficient exposure of the posterior facet. There was a significant improvement in Böhler angle from 7.11° to 29.76° (*P* < .01), which is within the 20° to 40° recommended in Rockwood and Green. Our results compare favorably with the previous study, which showed that restoration of the Böhler's angle leads to better functional outcomes.^[19]

Twenty-six Sanders II, 19 Sanders III, and 4 Sanders IV calcaneal fractures were included in this study population. Most authors only included Sanders II and Sanders III fractures.^[20] There are very few studies that included Sanders IV fractures.^[9,21] The reduction of the posterior facet was graded as nearly anatomical (less than 2 mm articular displacement) in 26 feet (100%) of type II fractures, 18 feet (94.7%) of type III fractures, and 2 feet (50%) of type IV fractures. Our outcome correlated with the Sanders classification.

It has been reported that wound complications ranged from 0% to 15.4%.^[8] In this study, there are 2 cases (4.08%) with incision-edge necrosis, 1 case (2.04%) suffered from incomplete medial plantar nerve injury, 1 case (2.04%) suffered from heel pad branch of the tibial nerve injury, 6 cases (12.24%) with sural nerve injuries, and 4 cases (8.16%) with a lateral wound dehiscence due to a hematoma. No case suffered from lateral impingement syndrome. Up to now, no patient had to accept subtalar arthrodesis. Weber et al^[22] report 7.69% of sural nerve injuries. Yeo et al^[18] reported 5% of sural nerve injuries using sinus tarsi approach. Compared with previous studies, our sural nerve injuries are significantly higher due to some unknown reasons.

Table 3**Postoperative Maryland foot score.**

Sanders type	Feet	Excellent (90–100)	Good (80–89)	Fair (70–79)	Poor (60–69)	Excellent and good rate (%)
II	26	22	3	1	0	96.2
III	19	12	3	3	1	78.9
IV	4	0	0	2	2	0
Total	49	34	6	6	3	81.6

In conclusion, sinus tarsi approach is a less invasive method for treatment of calcaneal fractures. It permits good visualization of the fracture, and allows anatomic reduction of articular surfaces. It is a valid option of treatment for displaced intra-articular calcaneal fractures.

Author contributions

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Funding acquisition: Q. Wang.

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Project administration: A. Peng.

Resources: Q. Wang.

Supervision: Q. Wang.

Validation: Q. Wang.

Writing – original draft: Q. Meng.

Writing – review & editing: A. Peng, X. Wu.

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