Surgical Treatment of Sanders Type 2 Calcaneal Fractures Using a Sinus Tarsi Approach

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Abstract

Background: Calcaneum is the most commonly fractured tarsal bone. The optimal treatment for displaced calcaneus fractures involving the posterior facet is surgical. The extensile lateral approach is commonly preferred because it provides sufficient exposure of the subtalar facet. However, this technique has the risk of complications such as wound necrosis and sural nerve injury. Various minimally invasive approaches, such as sinus tarsi approach, limited posterior approach, and percutaneous approach, have been introduced to reduce possible complications. This study was prospectively performed to evaluate the results of the sinus tarsi approach for Sanders Type 2 calcaneal fractures using postoperative computed tomography (CT). **Materials and Methods:** Between October 2012 and December 2013, 20 Sanders Type 2 calcaneal fractures were consecutively treated using a sinus tarsi approach and checked using CT preoperatively, immediately postoperatively, and at 12 months after surgery. Clinical evaluations were performed using the visual analog scale (VAS) and the ankle-hindfoot score developed by the American Orthopaedic Foot and Ankle Society (AOFAS). Radiographic evaluations were performed using calcaneus lateral and axial radiographs, hindfoot alignment radiograph, and CT. Changes in Böhler's angles and calcaneal widths were evaluated both preoperatively and at last followup. Reduction of the posterior facet was graded according to articular step, defect, and angulation of the posterior facet in CT. **Results:** VAS and AOFAS scores were significantly improved at 1 year after surgery but did not improve further. Böhler's angles and calcaneal widths were significantly improved after surgery. Böhler's angle was significantly smaller at the last followup than immediately after surgery, whereas calcaneal width was maintained. Reduction of the posterior facet was graded excellent in five feet (25%), good in ten (50%), and fair in five (25%) on immediately postoperative CT. Two feet (10%) had transient sural nerve injury which resolved within 3 months. Five feet (20%) had subfibular pain due to a prominent screw heads. **Conclusion:** Surgical management using a sinus tarsi approach produced good clinical and radiographic results and low wound complications for Sanders type 2 calcaneal fractures. It is important to have stable fixation and to achieve sufficient reduction of calcaneal width for the prevention of loss of reduction and lateral subfibular impingement.

Keywords: *Calcaneal fracture, computed tomography, sinus tarsi approach*
MeSH terms: *Calcaneus, prospective studies, bone screws, tarsal joint*

Introduction

Calcaneum is the most commonly fractured tarsal bone and is commonly results due to fall from height.[1] Comminuted and burst fractures are common because of the anatomic characteristics of the calcaneus, which consists of thin cortical and cancellous bone.[2] Therefore, the improper reduction of facets and calcaneal width can lead to complications, such as subtalar arthritis and lateral impingement.[3,4]

The optimal treatment for displaced calcaneus fractures involving the posterior facet is surgical.[5-7] Of the various surgical techniques, the extensile lateral approach is commonly preferred because it provides sufficient exposure of the subtalar facet and firm internal plate fixation.[8-10] However, this technique has the risk of complications such as wound necrosis and sural nerve injury due to extensive incisions and soft tissue dissection.[11,12] Therefore, various minimally invasive approaches, such as sinus tarsi approach, limited posterior approach, and percutaneous approach, have been introduced to reduce possible complications.[13-16]

The sinus tarsi approach is one of the minimal invasive methods which provides a direct view of the posterior facet. Sinus tarsi approach has been described to minimize trauma to the soft tissue envelope because reduction can be performed with minimal

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incision through the sinus tarsi.[17-20] Theoretically, Sanders Type 2 fractures which are not severely comminuted would be the most ideal indication for a sinus tarsi approach because of view limitations. However, most authors have used sinus tarsi approach for Sander Type 3 and 4 fractures, which have more severe comminution of the posterior facet, and majority of the literature is retrospective.[4,18,21,22] In addition, a few studies have evaluated the adequacy of reduction using immediate postoperative computed tomography (CT).[18]

This study analyzes clinical and radiological results and the incidence of associated complications in Sanders Type 2 calcaneal fractures treated by sinus tarsi approach.

Materials and Methods

This prospective study was approved by the Institutional Review Board of our hospital, and informed consent was obtained from all patients. 26 displaced calcaneal fractures involving the posterior facet were consecutively treated using a sinus tarsi approach by a single surgeon between October 2012 and December 2013. Five patients (five feet) with Sanders Type 3 and one patient with a concomitant severe head injury were excluded from the study. The remaining twenty patients (16 males, 4 females) were included in the study. The first eight fractures were fixed using Steinmann pins (S-pin group) and the latter 12 fractures were fixed using 7.0-mm cannulated screws (screw group). Mean patient age was 51.2 years (range 18–67 years), and the mean duration of followup was 14.3 months (range 13–21 months). Demographics of the two groups are listed in Table 1.

Clinical evaluation

Clinical results were assessed using the visual analog scale (VAS) and the ankle-hindfoot score developed by the American Orthopaedic Foot and Ankle Society (AOFAS).[23] These scores were evaluated preoperatively and at 4, 6, and 12 months after surgery and at last followup. Postoperative complications such as sensory deficit, wound problems, and tenderness around operation sites were evaluated by regular followup.

Radiographic evaluation

Radiographs were taken at the same facility using the same radiographic protocol for both injured and uninjured limbs. Radiographic images were retrieved using a picture archiving and communication system (PACS) (IMPAX; Agfa Healthcare, Mortsel, Belgium), and radiographic measurements were conducted using PACS software. Radiographic evaluations were performed using calcaneus lateral and axial radiographs, hindfoot alignment radiograph, and CT. Calcaneus lateral and axial radiographs were obtained at regular followup, and hindfoot alignment radiographs were obtained at 12 months after surgery. Böhler's angle, which was measured on calcaneus lateral radiographs, was used to assess sagittal reduction of the posterior facet, and calcaneal width was measured on calcaneus axial radiographs. Böhler's angles and calcaneal widths determined preoperatively, immediately postoperatively, and at last followup were compared and compared with those of uninjured sides at last followup. In addition, Böhler's angles, which were measured preoperatively, immediately postoperatively, and last followup, of the S-pin and screw groups were also compared. CT with multiplanar reconstruction was checked preoperatively, immediately postoperatively, and at 12 months after surgery to assess posterior facet reduction, which was evaluated in terms of articular step, defect, and angulation, as described by Kurozumi *et al*.[24] [Table 2].

Operative procedure

The procedure was performed under spinal anesthesia with the patient in the lateral position. The affected leg was exsanguinated with an elastic bandage, and a tourniquet was applied at the thigh.

Before making the skin incision, a 4.5-mm Steinmann pin (S-pin) was inserted into the posteroinferior portion of the calcaneal tuberosity. Distraction using varus and valgus stress was applied manually to overcome shortening of soft tissue. A 4-cm incision was made from the tip of the lateral malleolus to the level of the calcaneocuboid joint toward the fifth metatarsal. Dissection was performed carefully between the peroneal tendons and the sinus fat pad preserving the sural nerve. In two cases, to expose the posterior portion of the posterior

Table 1: Demographics and baseline data

Parameters	*n* (%)	Mean (range)
Gender		
Male	16 (80)	
Female	4 (20)	
Age (years)		51.2 (18-67)
Body mass index (kg/m^2)		23.4 (18.1-28.3)
Followup periods (months)		15.8 (14-27)
Time to surgery (h)		38.4 (5-140)
Smoker	12 (60)	
Diabetes	1 (5)	
Sanders classification		
IIA	12 (60)	
IIB	8 (40)	
IIC	0	

Table 2: Evaluation criteria using computed tomography images for the posterior facet reduction

Posterior facet	Step (mm)	Defect (mm)	Angulation (°)
Excellent	None	None	None
Good	<1	<5	<5
Fair	1-3	5-10	5-15
Poor	≥3	≥10	≥15

facet widely, the calcaneofibular ligament (CFL) was incised and repaired using a 2.7-mm suture anchor after fracture fixation [Figure 1]. After exposing the fracture site, hematoma and small fragments were evacuated and the impacted posterolateral fragment was elevated using a curette. After the posterolateral fragment had been reduced using the talus as a template, Kirschner wires were temporarily fixed to the medial fragment. Reduction was confirmed by C-arm fluoroscopy, and definite fixation was performed using two 4.0-mm cancellous screws. Gentle valgus and downward stress were then applied using Steinmann pin to correct varus alignment and restore calcaneal height, and calcaneal width was restored by laterally compressing the heel. Once good reduction had been achieved, fixation between the anterior process and posterior facet fragment was performed using four to five 2.2-mm Steinmann pins. When cannulated screws were used, two or three 7.0-mm cannulated screws were inserted from the posterior heel to the anterior process [Figure 2]. An additional screw was inserted toward the posterior facet to support the posterior facet when the stability of fixation was inadequate [Figure 3]. Joint alignment was confirmed on C-arm fluoroscopy, and wound closure was performed with interrupted sutures.

Postoperative care

Patients were placed into short leg splints for 6 weeks postoperatively with passive and active motion exercises of the ankle and subtalar joint to commence the day following surgery, without weight-bearing. Patients remained non-weight-bearing for 8 weeks, and this was followed by gradual protected weight-bearing. Steinmann pins and screws inserted from the posterior facet fragment to the anterior process were generally removed at 12 weeks after surgery.

Statistical analysis

Continuous data are expressed as means and standard deviations. All dependent variables were tested for distribution normality and equality of variances and were analyzed using nonparametric tests because they showed non-normal distribution. The Mann–Whitney U-test was used to compare the postoperative radiographic results of the S-pin and screw groups and of injured and uninjured limbs. Wilcoxon's signed rank test was used to compare pre- and postoperative scores. For all tests, $P < 0.05$ was considered statistically significant.

Results

VAS and AOFAS scores were significantly improved at 12 months after surgery but did not improve any further [Table 3].

Böhler's angles and calcaneal widths improved significantly after surgery. At last followup, Böhler's angles were significantly smaller than at immediately after surgery, whereas calcaneal widths were maintained. Böhler's angles immediately after surgery were no different from those of uninjured sides but were significantly smaller at last followup. Calcaneal width was significantly more immediately after surgery and at last followup than that of uninjured sides [Table 4]. The S-pin group showed significant reduction loss till last followup, whereas the screw group showed no loss of reduction. Calcaneal widths did not change over subsequent followups in either group [Table 5].

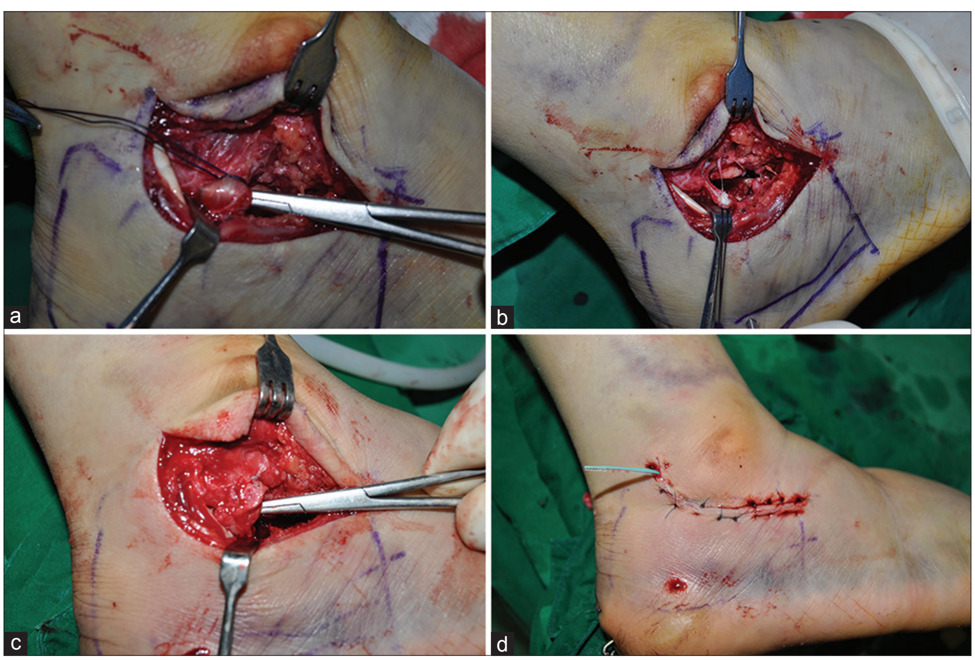

Figure 1: Peroperative photographs of extended sinus tarsi approach. (a) Skin incision extends along a fibular posterior border. Photograph shows a CFL across a subtalar joint. (b) After incising a CFL at fibular attachment, subtalar joint is exposed widely at fibular attachment. (c) A CFL is repaired using a 2.7-mm suture anchor. (d) Photograph showing an incision line after wound closure. CFL = Calcaneofibular ligament

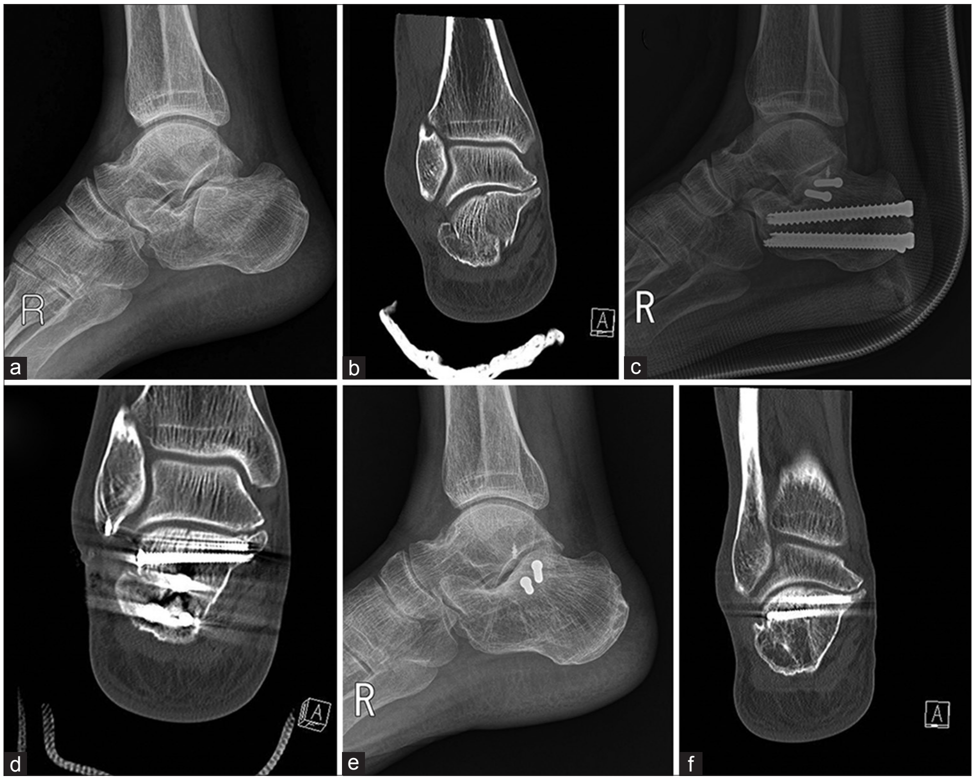

Figure 2: A case of a 60-year-old male patient. (a) Preoperative radiograph of ankle joint lateral view showing a calcaneal fracture with joint depression. (b) Preoperative computed tomography showing calcaneal fracture with Sander's Type 2A. (c) Immediately postoperative radiograph lateral view showing a well-reduced calcaneal fracture using 7.0-mm cannulated screws. (d) Immediately postoperative computed tomography showing an anatomical reduction of a posterior facet. (e) Postoperative radiograph of ankle joint lateral view taken at 1 year after surgery showing complete bony union. (f) Postoperative computed tomography taken at 1 year after surgery showing complete bony union

Table 3: Clinical results after surgery

Clinical results	Mean±SD			
	4 months after surgery	6 months after surgery	12 months after surgery	Last followup
VAS	5.5±0.9	3.9±1.0	2.4±1.1	2.0±1.1
P		<0.001*	<0.001†	0.008‡
AOFAS score	62.9±11.6	80.8±7.8	89.1±6.2	90.2±6.2
P		<0.001*	<0.001†	0.043‡

*Comparison of values between 4 and 6 months after surgery, †Comparison of values between 6 months and 12 months after surgery, ‡Comparison of values between 12 months after surgery and last followup. SD=Standard deviation, VAS=Visual analog scale, AOFAS=American Orthopaedic Foot Ankle Society

Table 4: Radiographic results after surgery

Radiographic results	Mean±SD			
	Preoperation	Immediate postoperation	12 months after surgery	Uninjured side
Böhler's angle (°)	4.0±11.0	22.2±6.3	20.7±7.5	27.6±2.5
P		<0.001*	0.002†	<0.001‡
Calcaneal width (mm)	51.0±5.0	45.1±3.8	45.3±3.9	40.0±3.0
P		<0.001*	0.052†	<0.001‡

*Comparison of values between preoperation and immediate postoperation, †Comparison of values between immediate postoperation and 12 months after surgery, ‡Comparison of values between 12 months after surgery and uninjured side. SD=Standard deviation

Reduction of the posterior facet was graded excellent in 5 (25%), good in 10 (50%), and fair in 5 (25%) feet on immediately postoperative CT. On CT obtained at 12 months after surgery, grade of reduction changed from good to excellent in one foot and from fair to good in another because bony defects of the posterior facet had recovered.

Two feet (10%) had transient sural nerve involvement which resolved within 3 months. Five feet had subfibular pain due to a prominent screw head and pain subsided after

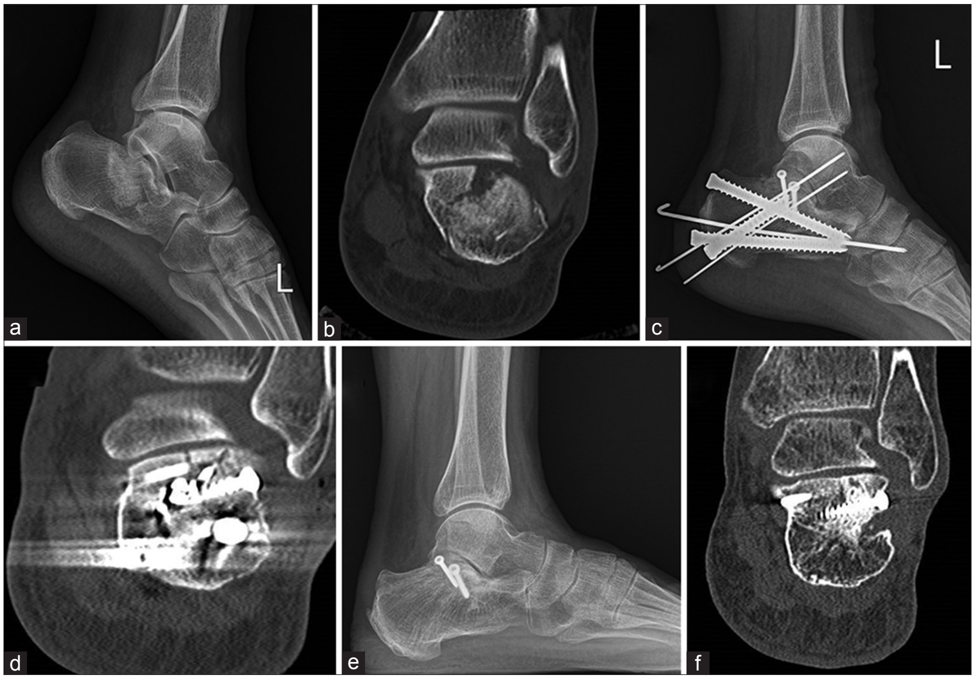

Figure 3: A case of a 50-year-old female patient. (a) Preoperative radiograph of ankle joint lateral view showing a calcaneal fracture with joint depression. (b) Preoperative computed tomography showing calcaneal fracture with Sander's Type 2B. (c) Immediately postoperative radiograph of ankle joint lateral view showing a well-reduced calcaneal fracture using 7.0-mm cannulated screws. (d) Immediately postoperative computed tomography showing an anatomical reduction of a posterior facet. (e) Postoperative radiograph of ankle joint lateral view taken at 1 year after surgery showing complete bony union. (f) Postoperative computed tomography taken at 1 year after surgery showing complete bony union

Table 5: Radiographic results of the S-pin and screw groups

Radiographic results	Mean±SD		
	Preoperation	Immediate postoperation	12 months after surgery
S-pin group			
Böhler's angle (°)	5.4±11.6	22.8±9.4	18.3±11.9
P		0.011*	0.018†
Calcaneal width (mm)	53.0±6.0	46.0±3.5	46.4±3.4
P		0.012*	0.18†
Screw group			
Böhler's angle (°)	3.4±10.9	22.0±4.8	21.7±4.7
P		<0.001*	0.059†
Calcaneal width (mm)	50.2±4.4	44.7±4.0	44.9±4.1
P		<0.001*	0.157†

*Comparison of values between preoperation and immediate postoperation, †Comparison of values between immediate postoperation and 12 months after surgery. SD=Standard deviation

screw removal. There were no cases of nonunion, wound complication, or lateral ankle instability due to CFL repair.

Discussion

Anatomic reduction of the calcaneus is difficult because its three-dimensional structure is difficult to understand and calcaneal fractures are commonly accompanied with severe comminution.[2] Thus, non-surgical treatments, such as closed reduction, cast splint, and traction, have been widely adopted in the past.[7,25] However, malunion of greater than 1 mm in the posterior facet of the calcaneus can result in traumatic subtalar arthritis because it causes altered forces at the subtalar joint.[26] Anatomical studies of the calcaneus and the development of surgical techniques mean that now, despite controversies surgical management has recently gained popularity for obtaining anatomical reduction of displaced calcaneus fractures involving the posterior facet.

Since it is difficult to expose the posterior facet of the calcaneus and because of the nature of blood supply to lateral soft tissues, a well-considered surgical approach is crucial for the treatment of calcaneus fractures.[8-10] The extensile lateral approach is universally used for calcaneus fractures involving the posterior facet because it can provide a broad operative field and a firm fixation using plates, which can restore calcaneal width and prevent varus and valgus deformities. However, it has been reported that the incidence of soft tissue necrosis and the risks of infection and sural nerve injury are high when an extensile lateral approach is used.[11,12] Furthermore, malreduction of the posterior facet commonly occurs after surgery because the medial part of the posterior facet is difficult to expose.[26,27] Therefore, several recent studies have focused on minimally invasive procedures that enable reduction and minimize soft tissue injury.[13,14,16]

The sinus tarsi approach involves an incision being placed from the sinus tarsi along the subtalar joint to expose the posterior facet and was designed to provide a direct view of the posterior facet and reduce soft tissue and neurovascular injuries. Several authors have reported good clinical and radiographic results for this approach and a low incidence of complications although studies vary with respect to approach site, length of incision, and fixation method.[4,17-22,28-32] In addition, in the majority of studies, the accuracy of posterior facet reduction was evaluated using Böhler's and Gissane's angles in plain radiographs. However, Böhler's angle does not reflect degree of facet reduction and are irrelevant to clinical results in studies that compare plain radiographs with CT to evaluate degree of calcaneus fracture reduction,[24,26] although there is still controversy. Furthermore, the only significant factors found to be related to clinical results in these studies was degrees of reduction of posterior facet and calcaneocuboid joint as determined by CT.[24] Although CT is essential for the evaluation of posterior facet reduction after surgery, a few studies have evaluated the accuracy of reduction status by immediately postoperative CT after surgery using the sinus tarsi approach.[18] In the present study, CT was performed immediately postoperatively and at 1-year followups for all patients. Immediately postoperatively, posterior facet reduction was graded good or excellent in 15 of the 20 cases (75%). In CT obtained at 12 months after surgery, two feet showed bone formation in osseous defects.

While the extensile approach can offer the facility of applying an overall compressive force to the lateral calcaneus using anatomical plates, it can be challenging to restore calcaneal width when the sinus tarsi approach is used because of limited exposure of the subtalar facet. Furthermore, if calcaneal width is not restored to its normal extent, the distance between the fibular epiphysis and calcaneus narrows and introduces the risk of lateral impingement. To date, Some studies have compared the extensile approach and the sinus tarsi approach, but no study compare the calcaneal widths achieved using the two techniques.[4,32,33] Weber *et al*.[4] reported that pain in the subfibular area presented in 5 of 24 cases treated using the sinus tarsi approach, and this was attributed to impingement by screws, and in all cases, the pain disappeared after screw removal. In the present study, we compared the calcaneal widths of injured and uninjured side, and the widths of injured side were significantly greater at the last followup. Five of our 20 cases (25%) complained of pain in the subfibular area after weight-bearing, but in all cases, the pain disappeared after removing screws. Therefore, when the sinus tarsi approach is chosen, it should be taken into consideration that the symptoms induced by lateral impingement may occur and should be properly treated.

Steinmann pins[19,21] or cannulated screws[16,31,32] are generally used for fixation of anterior and posterior bone fragments when the sinus tarsi approach is used; mini-plates have also been used in recent studies.[18,22] Fixation using Steinmann pins is simple surgically, but the fixation strength achieved is weak and their use is accompanied by the risk of pin site infection. Cannulated screws of diameter of 6.5 or 7 mm are more commonly used and have been reported to have satisfactory fixation strength.[34] Recently, the fixation using plates has prodeuced better results with the development of low-profile plates.[18] However, the fixation using plates has the disadvantages of greater soft tissue injury than the percutaneous method and weak fixation strength due to the use of small plates and 2.7-mm screws. According to a recent biomechanical study, two cannulated screws to the medullary cavity shows same to better biomechanical strength than plates.[34] In the present study, Steinmann pins were used to fix anterior and posterior bone fragments in the first eight cases and we have experienced collapse of Böhler's angle in some cases. After that, we changed fixation device to 7.0-mm cannulated screws in the later ten cases. Statistically, those fixed using Steinmann pins demonstrated significantly greater loss of Böhler's angle than those fixed using cannulated screws (P = 0.001) although the number of subjects included was not large. Because these results are only subgroup analysis not main purpose of this study, we believe this is prospective study for Sanders type 2 calcaneal fractures using sinus tarsi approach in spite of changing fixation devices during performing study. In addition, we consider cannulated screw fixation to be the best choice for fixing anterior and posterior bone fragments from the perspectives of minimizing soft tissue injury and obtaining sufficient fixation strength.

The strengths of this study induces its prospective nature, the use of the same operative technique and single surgeon and postoperative followup protocol, and the inclusion of only patients with Sanders Type 2 calcaneus fractures. CT was performed on all patients immediately after surgery and at 12 months postoperatively to evaluate degree of posterior facet reduction. Nevertheless, the study also has its limitations. First, the number of subjects enrolled was small and the followup period was relatively short. Second, VAS and AOFAS hindfoot scores were used to evaluate clinical results and quality of life was not evaluated. Finally, no comparative group treated using the extensile lateral approach was included. Therefore, we recommend that a comparative, randomized, and prospective study be undertaken to compare the sinus tarsi approach and the extensile approach for the treatment of Sanders Type 2 calcaneal fractures.

Conclusion

We conclude that surgical management using a sinus tarsi approach produces acceptable clinical and radiographic results for Sanders Type 2 calcaneal fractures. The study also shows it is important to achieve stable fixation for prevention of reduction loss and to achieve sufficient reduction of calcaneal width to prevent lateral impingement.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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