Calcaneal Reconstruction for the Late Complication of Calcaneal Fracture

KI WON YOUNG, MD; KYUNG TAI LEE, MD; YOUNG KOO LEE, MD; MUN SUK JANG, MD; JUN HEE YOON, MD; JUN HO KIM, PHD

abstract

Calcaneal fracture is the most common fracture in the tarsal bones. Treatment is difficult because the patterns of fracture are various and complications occur frequently. The purpose of this study was to evaluate the clinical results of calcaneal reconstruction for chronic complications after calcaneal fracture.

From September 2001 to November 2004, calcaneal reconstruction was performed in 24 patients (25 feet). We reviewed 21 patients (22 feet) who could be followed up >2 years postoperatively. Patients who underwent subtalar arthrodesis and simple bone resection were excluded. Patients who underwent calcaneal sliding osteotomy were included. Nineteen men and 2 women ranged in age from 27 to 54 years (mean, 44.4 years). The mean interval between the first operation and reconstructive operation was 11.2 months (range, 3-31 months). The mean follow-up period after calcaneal reconstruction was 29.8 months (range, 24-38 months). Böhler angle, calcaneal pitch, and talocalcaneal height were checked pre- and postoperatively.

The most common patient report was pain on the inferior aspect of the lateral malleolus (16 patients) and calcaneal tuberosity (3 patients). All the mean values of talocalcaneal height, calcaneal pitch, and Böhler angle improved, which was statistically significant. In the postoperative period, 10 patients were very satisfied, 9 were satisfied, and 3 were not satisfied. Although pain did not completely resolve, all patients were satisfied postoperatively.

Dr Young is from the Foot and Ankle Service, Department of Orthopedic Surgery, Gangnam Eulji Hospital, Eulji University, College of Medicine, Seoul, Dr Lee (Kyung Tai) is from the Foot and Ankle Clinic, KT Lee’s Orthopedic Hospital, Seoul, Drs Lee (Young Koo), Jung, and Yoon are from the Department of Orthopedic Surgery, Soonchunhyang University, Bucheon Hospital, Gyeonggi-Do, and Dr Kim is from RNC Sports Center, Seoul, Republic of Korea.

Drs Young, Lee (Kyung Tai), Lee (Young Koo), Jung, Yoon, and Kim have no relevant financial relationships to disclose.

Correspondence should be addressed to: Young Koo Lee, MD, Department of Orthopedic Surgery, Soonchunhyang University 4 Jung-Dong, Wonmi-Gu, Bucheon-Si, Gyeonggi-Do, 420-767, Republic of Korea (brain0808@hanmail.net).

doi: 10.3928/01477447-20110826-03
Calcaneal fractures are regarded as a considerable challenge to orthopedists due to low patient satisfaction and persistent postoperative subtalar arthritis and malunion pain. The loss of calcaneal height and the widening of the calcaneus resulting from malunion cause the talus to transform into a banana talus, progress the change to the midfoot and forefoot, and lead to peroneal tendon impingement syndromes, decompression and shoe resection. Consequently, 21 patients (22 feet) were included. Nineteen men and 2 women ranged in age from 27 to 54 years (mean, 43.1 years). The mean interval between the first operation and reconstructive operation was 11.2 months (range, 3-31 months). The mean follow-up after calcaneal reconstruction was 29.8 months (range, 24-38 months). This study was approved by the institutional review board of our institute, and informed consent was obtained from all patients.

The inclusion criteria for this prospective clinical trial were as follows: a diagnosis of malunion of calcaneal fracture, prior surgery for calcaneal fracture, and symptoms of postoperative pain. A priori power analysis was conducted to determine the sample size using the PS program. Based on the clinical data of previous studies, it was assumed that the minimum clinically significant difference between baseline and follow-up mean American Orthopaedic Foot & Ankle Society (AOFAS) ankle-hindfoot scores was 8 and standard deviations ranged between 6 and 10. We calculated the sample size to detect a minimum clinically significant difference with 80% power and an alpha error of 5%. The sample sizes ranged from 7 to 15 depending on the outcome variables.

From September 2001 to November 2004, calcaneal reconstruction was performed in 24 patients (25 feet). We reviewed 21 patients (22 feet) who could be followed up >2 years postoperatively. Three patients were excluded because they underwent subtalar arthrodesis or simple bone resection. Consequently, 21 patients (22 feet) were included. Nineteen men and 2 women ranged in age from 27 to 54 years (mean, 43.1 years). The mean interval between the first operation and reconstructive operation was 11.2 months (range, 3-31 months). The mean follow-up after calcaneal reconstruction was 29.8 months (range, 24-38 months). This study was approved by the institutional review board of our institute, and informed consent was obtained from all patients.

Patient medical histories were examined by interview. Physical examination included bending patients’ knees in the prone position and checking their ankle motion. For radiological examination, weight-bearing anteroposterior (AP) and lateral radiographs of the foot and calcaneal axial radiographs were taken to measure calcaneal pitch, talocalcaneal height, and Böhler angle. Conservative therapies were given to symptomatic patients with radiological abnormality for 6 months; symptom improvement was expected through medication, shoe modification, and insole. Patients whose symptoms had not resolved after 6 months were classified according to Stephens and Sanders classification and underwent surgical treatment.

Lateral exectomy was performed in patients with suspected lateral impingement or patients whose calcaneal height was not significantly lost, while calcaneal reconstruction was performed in the other patients. A short-leg splint was applied for 2 weeks postoperatively, followed by short-leg casting for 2 weeks. Then postoperative shoes were worn for 2 months, after which full weight-bearing exercises were done. Subtalar fusion was performed in patients who had no symptom improvement during follow-up or who reported persistent pain at the subtalar joint and had low degrees of improvement. The AOFAS hindfoot-ankle score and foot wear difficulty were measured preoperatively, after which calcaneal reconstruction was performed. Postoperatively, the AOFAS score and foot wear difficulty were measured. The patients were asked about the most remarkable improvements postoperatively and whether they would recommend the procedure to others.

**SURGICAL TECHNIQUE**

A patient is placed in the lateral decubitus position on a beanbag, with the normal leg down and in front of the injured extremity. A thigh tourniquet is placed. After preparation and draping, the leg is exsanguinated with use of an Esmarch bandage. The tourniquet is inflated to 350 mm Hg. A standard lateral extensile approach to the calcaneus is used. The vertical limb of the incision should be made just anterior to the Achilles tendon, and thus posterior to the sural nerve, allowing the nerve to be elevated with the full-thickness flap posteriorly. However, care must be taken to avoid violation of the nerve at the terminal portion of the horizontal limb of the incision. Three 1.6 mm Kirschner wires are placed, 1 in the distal part of the fibula, another in the talar neck, and the other in the cuboid, for retraction of the peroneal tendons and the subperiosteal flap. If there are entrapment syndromes, decompression is done by lateral wall osteotomy. The calcaneal tuberosity is osteotomized, and a downward oblique sliding osteotomy is made (Figure 1). Finally, two 5.0-mm cannulated screws are used to fix the osteotomy site.

**RESULTS**

The most common patient reports were pain on the inferior aspect of the lateral malleolus (10 patients), calcaneal tuberosity (3 patients), diffuse pain (6 patients), and medial pain (3 patients). Chronic complications included subtalar arthritis (all patients), depression of the lateral aspect of the calcaneus (16
patients), varus deformity (9 patients), and lateral impingement (6 patients), Haglund’s deformity (6 patients), and valgus deformity, inferior and medial depression, and nonunion (1 patient).

Stephens and Sanders types I, II, and III calcaneal malunions were observed in 3, 15, and 4 patients preoperatively, respectively, and in 9, 13, and 0 patients postoperatively, respectively, which suggests a statistically significant improvement ($P < .0154$) (Table 1).

In addition, preoperative Zwipp types I, II, and III were observed in 4, 8, and 10 patients preoperatively, respectively, and in 15, 3, and 4 patients postoperatively, respectively, which also suggests a statistically significant improvement ($P < .0036$) (Table 2).

Mean Böhler angle increased from 24.1$^\circ$ to 35.4$^\circ$ postoperatively ($P < .0001$), and the mean rate of the difference of the talocalcaneal height between the fracture site and noninvolved site from 68.4% to 73.6% ($P < .0001$). Calcaneal pitch increased from 12$^\circ$ to 16.8$^\circ$ postoperatively ($P = .0001$). Talocalcaneal angle also increased from 15.5$^\circ$ to 19.6$^\circ$ postoperatively ($P = .02$).

In the postoperative period, 10 patients (45.4%) were very satisfied, 9 (40.9%) were satisfied, and 3 (13.6%) were not satisfied. Although pain did not completely resolve, all patients were satisfied postoperatively. Sixteen patients intended to undergo reoperation, and 17 intended to recommend calcaneal reconstruction to others. Mean AOFAS score improved from 63.9 (range, 52-82) preoperatively to 78.7 (range, 62-92) postoperatively ($P < .0001$).

### DISCUSSION

In the past, various reports have discussed whether calcaneal fractures should be surgically treated. In 1908, Cotton and Wilson reported that following closed reduction of calcaneus fracture, they performed delayed treatments for malunion. In 1935, Conn described the traumatic flatfoot with its associated pathology and championed the triple or double arthrodesis to correct the deformity. In 1985, Braly et al reported that lateral wall exostectomy for subfibular impingement and addressed peroneal pathology is required in the light of a significant amount of pain from the lateral wall exostosis and peroneal tendon pathology.

However, as surgical techniques have advanced, the concept of calcaneal malunion reconstruction was introduced, and Romash reported this concept in 1993 for the first time. He checked the widening of the heel, lateral impingement, and the scar of the primary fracture line through coronal and axial computed...
Computed tomography (CT) scans preoperatively; performed osteotomy to restore the fracture line to the innate form followed by anatomical reconstruction; and intended to achieve union through subtalar fusion, as the calcaneus acts as a pedestal or platform that supports the talus at the proper height, inducing the appropriate talar inclination angle, which is important to ankle motion. In 1996, Hansen reported multiple osteotomy to resolve some problems such as lateral displacement and the shortening of the lateral column, and he corrected varus or valgus deformity through medial or lateral translation.

Several approaches are intended to evaluate calcaneal malunion. Of them, Böhler’s angle on the lateral view, talocalcaneal angle, and height of the calcaneus are the most commonly used. Since malunion leads to decreased talocalcaneal angle and talar inclination angle, increasing deformity of the calcaneus occurs, indicating tibiotalar impingement. Similarly, all results of this study also suggest statistically significant increases.

Computed tomography is used to assess surgical techniques or outcomes. In 1993, Crosby and Fitzgibbons reported the effectiveness of CT scan for the assessment of the displacement of the posterior facet and determining its prognosis value. Stephens and Sanders attempted to evaluate this through coronal images at the levels of the posterior facet on CT scan, which is one of the most commonly used methodologies for classifying calcaneal malunion. Clare et al reported the availability of Stephens and Sanders classification and described that intermediate- to long-term results depend on classification through subjective satisfaction and radiologic assessment. Our study also used Stephens and Sanders classification for all patients, and all postoperative outcomes were statistically significantly improved.

Of several problems that may occur either postoperatively or after any conservative therapy, malunion is the most common. In the event of malunion, anterior impingement occurs radiologically due to talar horizontal, dorsiflexed position with a radiographic decreased talar declination angle, resulting in ankle arthritis. Moreover, it leads to shoe wear problems caused by the loss of hindfoot height as well as a decrease in push-off power caused by leg-length discrepancy and shortening of the lever arm of the gastrocsoleus complex. Additionally, varus hindfoot may cause locked Chopart’s joint and stiffness in the foot, lateralization of the center of pressure progression and increased pressure under the head of the fifth metatarsal, and eccentric loading of the ankle and knee joints; consequently, the affected patient develops ankle joint arthritis with walking difficulty. In our study, 4 patients with type III larger angles experienced more difficulty, and 2 patients with larger angles underwent sliding valgus osteotomy followed by bone graft using the iliac bone (Figure 2).

Some researchers suggest that there are several etiologies depending on the site of pain. Lateral pain is often caused primarily by lateral impingement and also by peroneal tendon pathology, which is characterized by resisted eversion aggravating pain. It is known that anterior pain usually results primarily from either talar neck impingement or scar tissue in the ankle. Plantar pain secondary to plantar exostosis is the most common, while poorly localized pain is caused primarily by nerve-related problems or complex regional pain syndrome. In our study, lateral pain was the most common (10 patients) and 6 patients reported diffuse pain. Fusion was achieved in 2 patients. Three patients reported medial pain and 3 reported posterior pain.

Several treatments exist for patients with calcaneal malunion, including the Romash’s multiplane calcaneal...
reconstruction. Some studies report that lateral decompression is effective primarily for Stephens and Sanders type I, and in situ subtalar arthrodesis is helpful mainly for Stephens and Sanders type II, which has been frequently used in cases with apparent arthritic changes in the subtalar joint and persistent symptoms. Similarly, in our study, this treatment was given secondarily to 9 patients who presented with subtalar arthritic changes after calcaneal reconstruction with persistent symptoms. Another treatment applied in this study was distraction bone block arthrodesis reported by Chandler et al., who mentioned that the main causes of calcaneal malunion are the loss of hindfoot height and symptomatic anterior ankle impingement resulting from horizontal talus, and distraction and subsequently bone block arthrodesis are necessary to treat them.

Huang et al. reported vertical sliding corrective osteotomy with the subtalar fusion technique. When they compared clinical results between in situ fusion and sliding osteotomy with subtalar fusion, the former showed better results than the latter. In their study, osteotomy was performed at the level of the posterior facet, and sliding to the inferior was followed by subtalar fusion. In our study, a similar technique was used for surgical treatments; however, subtalar fusion was not performed regardless of Stephens and Sanders classification. The principal reason is that the known main causes of calcaneal malunion are the loss of hindfoot height and hindfoot widening rather than subtalar arthritis. Performing lateral ostectomy and sliding osteotomy led to good or satisfactory outcomes in 13 of 22 patients.

REFERENCES