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Primary Subtalar Joint Arthrodesis for Comminuted Fractures of the Calcaneus

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ABSTRACT

Severely comminuted intra-articular calcaneal fractures often culminate in subtalar arthrosis and stiffness even after operative reduction. In some instances, subtalar arthrodesis is necessary to reduce the symptoms. Primary subtalar arthrodesis for these fractures has gained acceptance in recent years. However, few definite predictors of functional outcome after primary fusion have been found. A series of 17 patients with highly comminuted fractures were studied to determine which radiographic parameters were predictive of functional outcome. The American Orthopaedic Foot and Ankle Society Ankle-Hindfoot scale score was obtained at an average of 34 (range 12 to 157) months after arthrodesis. Radiographic measurements included the talocalcaneal, calcaneal inclination, talo-first metatarsal, and Böhler's angles, and the height of the tibial plafond, width of the calcaneus, and the presence of a medial step-off on the injured and uninjured foot. The mean Ankle-Hindfoot scale score was 78 (range 56 to 92), and the mean visual analog score was 1.9 (0 to 4). Statistically significant associations were noted between greater postoperative function and increasing age ($p = .028$), the quality of restoration of Böhler's angle ($p = .038$), and the talocalcaneal angle ($p = .049$). No patient had nonunion. The results of the present study suggest that the outcomes after primary arthrodesis of the subtalar joint are favorable, in particular, when the radiographic relationships of the hindfoot have been restored.

The treatment of severely comminuted intra-articular calcaneal fractures remains controversial (1–6). Although open reduction and internal fixation (ORIF) has become commonplace for displaced calcaneal fractures, more favorable outcomes have been reported in those patients with less comminuted fracture patterns (7–9). The primary utility of ORIF seems to be restoration of the articular congruity, height, and morphology of the fractured calcaneus (10,11). Improvements in fixation technology and less-invasive surgical exposures have improved the functional outcomes (12–16). Despite these advances in surgical technique, an evolving body of evidence has shown that patients with highly comminuted fracture patterns often develop subtalar joint (STJ) arthrosis, poor hindfoot function, and symptoms that culminate in arthrodesis (9,17–19). In the past several decades, many surgeons have discovered that despite anatomic reduction, little hindfoot motion was appreciated at the STJ. Subsequently, many studies validating primary arthrodesis for the treatment of acute intra-articular calcaneal fractures have been published (20–25).

From empirical observations of patients with highly comminuted fracture patterns, our experience has paralleled that of these other published reports (20–25). The purpose of the present investigation was to report our results after primary arthrodesis of the STJ in severely comminuted intra-articular calcaneal fractures and contribute to the growing body of data on this surgical strategy. The quality of restoration according to radiographic parameters and the correlation with the clinical scores of 17 patients with highly comminuted calcaneal fractures are presented.

Patients and Methods

An institutional review board exemption was granted for the present study at one of the institutions, and the institutional review board at the other institution approved the study. A retrospective analysis was performed of the medical records and radiographic images of the 17 patients with comminuted intra-articular calcaneal fractures classified as Sanders type IV (Fig. 1) that had been treated with primary STJ arthrodesis. These cases were taken from the personal series of each of the senior authors (S.E.L., J.M.S.) at the medical centers of each of these surgeons from January 1998 to December 2012. Only the patients who had been followed up for a minimum of 1 year were included. The exclusion criteria were open fractures, concomitant fractures in the other

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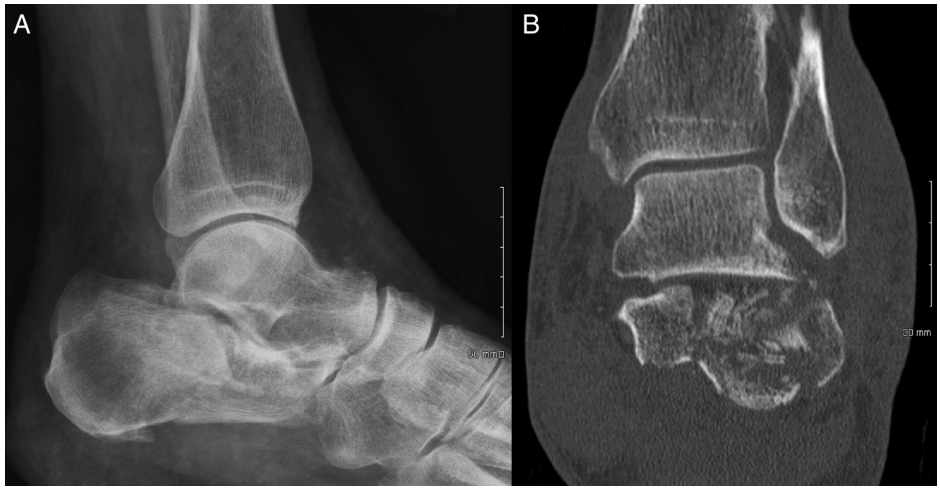

Fig. 1. (*A*) Lateral radiograph and (*B*) coronal computed tomography image of the posterior facet of the subtalar joint in a highly comminuted (Sanders type IV) calcaneal fracture.

lower extremity or spinal anatomic locations, and the unavailability of the complete radiographic file.

The medical records were reviewed, and data were excerpted independently by each of the surgeons (S.E.L., J.M.S.). Each surgeon reviewed only their own individual patient information and data. The descriptive variables included age at the injury, gender, weight, mechanism of injury, interval from the injury to the index operation (in days), fixation construct, the use of biologic agents or bone graft, and whether hardware was removed. The radiographic data included measurements of the injured and uninjured feet. Contralateral images served as the reference to evaluate the level of restoration of the normal anatomy and to identify any residual postoperative deformity. Radiographic measurements were done in accordance with standard techniques (26,27). On the lateral view, the measurements included the calcaneal inclination angle, talar declination angle, talocalcaneal angle, Böhler's angle, and the height of the tibial plafond in relation to the weightbearing surface (hindfoot height). On the calcaneal axial view, the width of the calcaneus at the level of the posterior facet was measured. When available, digital software (Stentor Intelligent Informatics, I-Site, version 3.3.1, Phillips Electronics, Andover, MA) was used to determine these values. Otherwise, they were determined manually. Routine computed tomography scans as a part of the preoperative evaluation were used to determine the Sanders classification (9).

The evaluation of functional outcomes consisted of a modified American Orthopaedic Foot and Ankle Society Ankle-Hindfoot scale (AHS) score and visual analog scale (VAS) pain score obtained prospectively for all patients at the most recent follow-up visit. As discussed by other investigators, the maximum possible score for the American Orthopaedic Foot and Ankle Society scale for patients with STJ arthrodesis is 94 (22).

Statistical analysis was performed to determine which demographic, radiographic, and anatomic parameters would correlate with better outcomes. Linear regression models were calculated to determine whether any of the relationships were meaningful. The level of statistical significance was set at $p \leq .05$.

Operative Technique

The operative technique consisted of placing the patient under general or spinal anesthesia in a lateral decubitus position or supine with an ipsilateral beanbag under the hip. A lateral incision was made over the sinus tarsi long enough to expose the posterior facet of the STJ and critical angle. The posterior facet fragments, if large enough, were elevated to disimpact the fracture. The calcaneal tuber was repositioned to align with the superomedial fragment using either a Schanz pin or an external fixator and then temporarily fixated to the sustentacular fragment with small caliber Steinmann pins or 2.0 mm Kirschner wires. The cartilaginous surfaces from the calcaneal articular fragments and posterior facet of the talus were sharply debrided down to raw cancellous bone. If the fragments of the posterior facet were large enough, they were reduced to the sustentacular fragment and fixated with small caliber screws. Smaller fragments were saved in a bath of lactated Ringer's solution. The morphology of the calcaneus was checked using fluoroscopy such that the height and width were restored and the medial step-off was minimal. Definitive fixation of the fusion mass was then completed (Table 1 and Fig. 2). In some cases, the resultant void was back-filled with crushed cancellous allograft or autogenous bone from the tibia (Table 1). When indicated, additional fixatives were added to secure the fracture fragments and attain stability (Fig. 2). Patients remained non-weightbearing for a minimum of 8 weeks and then progressed to weightbearing as tolerated in a brace or short leg walking cast until they could transition to a conventional shoe.

Results

A total of 21 patients had undergone primary subtalar fusion after intra-articular calcaneal fracture. Of the 21 patients, 17 (17 fractures) met the inclusion criteria. The results for the descriptive variables are listed in Table 1. Of the 17 patients, 9 (52.9%) were male and 8 (47.1%) were female. The mean age at injury was 53.8 (range 30 to 75) years. The mean weight at injury was 165.8 (range 119 to 260) lb. Of the 17 patients, 11 (64.7%) had fallen from a height and 6 (35.3%) had been involved in a motor vehicle collision. The mean interval from injury to surgery was 14.8 (range 7 to 42) days (Table 1). None of the patients in the series required subsequent revision surgery; however, 5 patients (29.4%) required partial or complete hardware removal. Aside from cancellous allograft chips and autogenous bone, no osteobiologic materials were used in any of the cases.

Two of the fractures (11.8%) were temporarily stabilized with external fixation before placement of definitive internal fixation. Definitive fixation of the arthrodesis consisted of large fragment screws in 16 of the fractures (94.1%) and Kirschner wires with a delta-frame external fixator in 1 fracture (5.9%). When fracture patterns dictated the need for additional stabilization, supplemental plates or screws were used (Table 1 and Fig. 2). Osseous union was achieved in all patients. The mean follow-up duration was 34 (range 12 to 157) months.

The results of the radiographic measurements are listed in Table 2. The mean percentage of restoration of the radiographic parameters compared with those from the uninjured foot is presented in Table 3. The calcaneal inclination was restored to within 5% of the uninjured side, and the talar declination and talocalcaneal and Böhler's angles were fully restored, with a slight overcorrection. The width of the calcaneus on the injured side was slightly larger than that of the normal foot.

The most recent AHS and VAS scores for all patients are listed in Table 4. The mean AHS score for the series was 78.4 (range 56 to 92). The mean 10-point VAS score for the series was 1.9 (range 0 to 4). A comparison of these scores with those of other demographic and radiographic variables revealed a statistically significant association between greater postoperative function (AHS) and increasing age ($p = .028$), improved restoration of Böhler's angle ($p = .038$), and