The Journal of Foot & Ankle Surgery 55 (2016) 513–521

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Comparison Between Sinus Tarsi Approach and Extensile Lateral Approach for Treatment of Closed Displaced Intra-Articular Calcaneal Fractures: A Multicenter Prospective Study

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ARTICLE INFO

Level of Clinical Evidence: 4

Keywords:
calcaneus
posterior facet
Sanders classification
subtalar joint
surgery

ABSTRACT

The purpose of our investigation was to prospectively review and compare the early outcomes of Sanders II and III closed displaced intra-articular calcaneal fractures (DIACFs) in a group of patients treated by open reduction and internal fixation with plate and screws using the extended lateral approach or the sinus tarsi approach (STA). Thirty-eight patients with DIACFs were prospectively enrolled and operatively treated using either the extended lateral approach or the STA. Patients underwent a careful clinical and radiographic examination and were evaluated according to the American Orthopaedic Foot and Ankle Society score, visual analog scale, and the Foot Function Index. The results from our study showed similar clinical and radiographic outcomes between the 2 groups. In our series, Sanders II and III DIACFs were sufficiently exposed using the STA to achieve anatomic reduction and stable fixation. The STA group had a lower incidence of wound complications ($p \geq .05$), the surgical procedure was faster, and the waiting time to surgery was shorter ($p \leq .05$). Despite the limited number of patients and the short follow-up period, our results suggest that the STA is a useful method for the treatment of DIACFs, with a low incidence of complications and results comparable to those for patients treated using the extended lateral approach.

Displaced intra-articular calcaneal fractures (DIACFs) are disabling injuries that occur more often in young, active, individuals performing manual labor and thus have a high socioeconomic impact (1–3). Historically, most surgeons have favored nonoperative treatment because the surgical outcomes were unpredictable (4). A better understanding of the debilitating nature of these injuries, combined with improvements in surgical techniques and implants, has renewed interest in operative fixation in the past 15 to 20 years (5–8). Operative reduction and fixation is now routinely recommended (with some exceptions) for DIACFs. Studies have demonstrated a decrease in the incidence of late consequences and the socioeconomic burden of these injuries when treated by open reduction and internal fixation (ORIF) (3,5–8).

The currently available data provide strong support for the use of the extensile lateral approach (ELA) for ORIF of DIACFs (9–13). However, the ELA comes with the risks of a variety of potentially serious complications, including wound dehiscence and deep infection. To overcome these disadvantages, several investigators have suggested alternative techniques involving percutaneous or minimally invasive fracture reduction and fixation with screws and/or external fixators (14–19). However, it has been reported that these methods might not be able to successfully achieve and/or maintain adequate reconstruction of the fracture (1,17,18,20,21). This could be a serious problem because evidence from published data supports the concept that anatomic reduction and stable fixation of DIACFs will lead to the best possible outcomes (4,5,22–26). To maintain the ability to accurately reduce and strongly fix the fracture fragments, overcoming the risks of the ELA, the sinus tarsi approach (STA) has been proposed. Despite limited exposure, the STA enables direct reconstruction of the posterior facet and anterior process, percutaneous reduction of the posterior tuberosity, and strong fixation of the fracture with plate and screws. Good or excellent functional results have recently been presented to support ORIF of DIACFs through the STA (1,17,27–31).

The purpose of our investigation was to review and compare the early outcomes of Sanders II and III closed DIACFs in a group of patients treated

Financial Disclosure: None reported.
Conflict of Interest: None reported.

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http://dx.doi.org/10.1053/j.jfas.2015.11.008

operatively through the ELA or STA, with plate and screw fixation. To the best of our knowledge, this is the first report of such a comparison. Our hypothesis was that no outcome differences would be detected.

Patients and Methods

We performed a multicenter prospective study of patients affected by DIACFs who had been treated operatively from January 2012 to December 2012. The patients were enrolled in the study consecutively and divided into 2 groups. Group 1 was treated at Ospedale San Camillo-Forlanini di Roma (hospital 1) and had undergone ORIF of the DIACF through the ELA. Group 2 was treated at Ospedale Civile di Bracciano (hospital 2) and had undergone ORIF of the DIACF through the STA. The protocols were different in the 2 hospitals. In hospital 1, all the patients had been treated through the ELA and in hospital 2, all the patients had been treated through the STA. The 2 surgeons who performed the procedures (A.B., hospital 1, all operations through the ELA; and F.A., hospital 2, all operations through the STA) had been trained at the same academic institution (Università di Roma "Tor Vergata") and have the same level of experience in trauma and foot and ankle surgery (>15 years in practice). The third surgeon involved in the study (A.G.V.), who did not participate in any of the operations, performed all the final follow-up evaluations and statistical analyses. The institutional review boards approved the present study, and all the patients provided informed consent to participate in the study. The fractures were categorized according to the Sanders classification (32).

The entry criteria for all the patients enrolled in the present trial were as follows:

1. Patients aged 18 to 65 (≥18, ≤65) years affected by isolated intra-articular fractures that were displaced >2 mm from the anatomic position, as demonstrated by axial coronal and sagittal computed tomography (CT) scan (excluding Sanders type IV fractures and all open fractures)
2. No previous involvement of the ipsilateral foot and/or ankle by surgery, fractures, osteoarthritis, or inflammatory arthritis
3. No major underlying medical comorbidities (ie, uncontrolled hypertension, previous myocardial infarction, cancer, history of stroke or transient ischemic attacks, chronic obstructive lung disease, cardiac arrhythmias, morbid obesity, diabetes mellitus, peripheral vascular diseases, peripheral neuropathies)
4. Nonsmoking status or nonsmoking status at the operation and had remained nonsmoking for the next 12 weeks
5. At the injury, full-time employment (working ≥38 hours weekly) and/or participation in moderate to strenuous recreational activities (e.g., walking, jogging, golfing, tennis, bowling, weight lifting, cycling, other active sport)
6. A minimum follow-up period of 24 months

A total of 45 patients fulfilled the enrollment criteria. Of the 45 patients, 38 (85.5%) were willing to participate. The remaining 7 patients (15.5%) either did not wish to participate in the study or were lost to follow-up (3 patients [6.7%] in group 1 and 4 [8.9%] in group 2). The final percentages were calculated considering the 38 study participants (100%). The mean age of the 38 patients who completed the study was 42.73 ± 13.70 years; 28 were males (73.7%) and 10 females (26.3%). The injury mechanisms were falling or jumping from a height for 28 patients (73.7%) and motor vehicle accidents for 10 (26.3%; Table 1). Of the 38 patients, 20 (52.6%; 15 males [39.5%] and 5 females [13.1%]) were treated through the ELA (group 1) and 18 (47.4%; 13 males [34.2%] and 5 females [13.1%]) through the STA (group 2). According to the Sanders classification, 7 were type II fractures (18.4%) and 13 were type III fractures (34.2%) in group 1 and 7 were type II fractures (18.4%) and 11 type III fractures (28.9%) in group 2. The calcaneocuboid joint (CCJ) was involved in 15 patients (39.5%) in group 1 (5 [13.1%] with Sanders II fracture and 10 [26.3%] with Sanders III fracture) and in 12 patients (31.6%) in group 2 (3 [7.9%] with Sanders II fracture and 9 [23.7%] with Sanders III fracture).

Table 1
Comparison of demographic data between groups (Wilcoxon rank sum test and Fischer's exact test for dichotomous variables)

Variable	ELA (n = 20)	STA (n = 18)	*p* Value
Age (y)	39.55 ± 13.19	41.89 ± 11.59	>.05
Sex			>.05
Male	15 (39.5)	13 (34.2)	
Female	5 (13.1)	5 (13.1)	
Sanders type			>.05
Sanders II	7 (18.4)	7 (18.4)	
Sanders III	13 (34.2)	11 (28.9)	
Etiology			>.05
Fall from a height	8 (21)	7 (18.4)	
Motor vehicle accident	12 (31.6)	11 (28.9)	
CCJ involvement	15 (39.5)	12 (31.6)	
Böhler angle			>.05
Uninjured side	40.00 ± 4.30	37.67 ± 6.43	
Preoperatively	7.00 ± 8.07	6.61 ± 7.62	

Abbreviations: CCJ, calcaneocuboid joint; ELA, extensile lateral approach; STA, sinus tarsi approach.
Data presented as mean ± standard deviation or n (%).

The objective and subjective data for the 2 treatment groups were analyzed and compared at the 24-month follow-up endpoint. The follow-up radiographic assessment consisted of serial radiographs and CT scans. The specific radiographs views included the lateral, 30° Broden, Saltzman, and Harris projections, which were taken postoperatively (T0), at 6 (T1) and 12 (T2) weeks, and at 12 (T3) and 24 (T4) months after surgery. CT scans were obtained using 1-mm cuts in 3 planes and were taken preoperatively to assess the fracture characteristics, postoperatively (T0) to check the articular reduction, and 24 months after surgery. A series of radiographic parameters were registered.

The Böhler angle was measured using a handheld goniometer placed over the lateral plain film. The values for this angle were obtained at the patient's initial presentation and at subsequent follow-up visits. These were compared against the same angle measured in the uninjured foot. This method of angle measurement has previously been shown to provide reliable results (5,33,34).

The quality of reduction of the posterior subtalar joint (PSJ) facet was classified as anatomic (no joint surface step-off), nearly anatomic (joint surface step-off <2 mm), or nonanatomic (joint surface step-off >2 mm), in accordance with the method described by Janzen et al (35) on the postoperative CT scan. Hindfoot alignment was categorized as varus, valgus, or neutral, according to the orientation of the long axis of the calcaneus relative to the long axis of the leg. Subtalar arthrosis was graded as mild (diminished joint space), moderate (diminished joint space and subchondral sclerosis), or severe (markedly diminished or no joint space) (4).

Subtalar joint motion was measured using the method described by Morrey and Wiedeman (36) and reported on by other investigators (23,35). Passive inversion and eversion of the calcaneus were evaluated with the patient supine and the ankle in a neutral position. The subtalar joint motion of the injured foot was recorded and compared with the motion of the uninjured foot.

The physician also enquired whether the patients had undergone any additional foot and ankle surgery because of complications after ORIF of the calcaneus (soft tissue procedures, hardware removal, hindfoot fusion, and/or other procedures for alignment, nonunion or malunion correction). The physician also queried whether the patients had required a custom-made orthosis or shoe modification for painless ambulation. The complications were categorized as minor or major. Minor complications were defined as those managed nonoperatively, and major complications were those that required surgical intervention for resolution.

The patients were evaluated using region-specific functional questionnaires to assess the severity of disability. The American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score (37), Foot Function Index (FFI) (38), and 10-cm visual analog scale (VAS) (39) were used as a quantification of the clinical evaluations. The AOFAS ankle-hindfoot score has 2 sections: a subjective division completed by the patient and an objective division completed by the surgeon.

The FFI was developed to measure the effect of foot pathology on function in terms of pain, disability, and activity restriction. The FFI is a self-administered index consisting of 23 items divided into 3 subscales. The possible score range for FFI is 0 to 100, with lower scores denoting better outcomes.

Operationally, the VAS is a horizontal line, 100 mm in length, anchored by word descriptors at each end (0 mm, no pain; 100 mm, very severe pain). The score was determined by measuring in millimeters from the left (no pain) of the line to the point marked by the patient.

The objective component the AOFAS score, although not validated, is widely used in the published data to assess patient outcomes (40). The subjective component of the AOFAS score and the FFI and VAS scoring systems have been validated in several trials (33,39–41).

Standard descriptive statistics were calculated, including percentages and the mean ± standard deviation. The baseline characteristics between the 2 groups were analyzed using the Wilcoxon rank sum test (Mann-Whitney *U* test), and Fisher's exact chi-square test was used to determine the differences for all dichotomous variables. The unpaired Student *t* test (for continuous data) and the 2-tailed Fisher test (for categorical data) were used to compare the results between the patient groups. Statistical significance was defined at the 5% level ($p \leq .05$). We used Microsoft Excel® for Windows® XP software (Microsoft, Redmond, WA) for statistical analysis. These analyses were performed by 1 of us (A.G.V.)

Operative Procedure

A standard antibiotic prophylaxis regimen with a second-generation cephalosporin was performed in both hospitals for all patients (first dose, 30 minutes before inflation of the tourniquet and then every 8 hours, 3 times).

Group 1 (ELA)

The interval between injury and surgery was an average of 19.4 ± 7.5 (range 7 to 37) days. Complete resolution of the post-traumatic swelling and the wrinkle sign were used to judge when the soft tissue envelope was ready for surgery. The patients were