



Isolated subtalar arthrodesis

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The aim of this study is to review the results of isolated subtalar arthrodesis in adults and to make a comparative analysis of the clinical outcomes between the patients with posttraumatic subtalar arthritis and the ones with other etiologic factors, and to evaluate the effects of grafting.

This study included 19 men and 12 women. The mean postoperative follow-up was 36.8 months. The mean AOFAS hindfoot score improved from a mean of 46 preoperatively to a mean of 77.3 postoperatively. Thirty-one of 33 arthrodeses achieved bony union at a mean time of 15.7 weeks. The mean increase in the talocalcaneal height was 3.8 mm in the feet operated without grafting, whereas it was 8.1 mm in the feet for which grafting was performed. Improvement in talocalcaneal angle was significantly better in the feet operated with bone grafting. The feet with posttraumatic subtalar arthritis were more prone to Reflex Sympathetic Dystrophy.

Key words : Subtalar joint ; Arthrodesis ; Calcaneal fracture ; Hindfoot.

INTRODUCTION

Human foot is composed of various complex anatomic structures which have unique biomechanical features to function in a perfect harmony. Degenerative joint disease, which occurs due to many different etiologies, may be diagnosed in different parts of the foot and ankle. Main complaints are pain, progressive restriction of range of motion and difficulty in weight bearing ; which are also the factors

causing significant disability (15). Arthrodesis is a common operative procedure indicated in the treatment of end-stage degenerative joint disease of the foot and ankle (25). Isolated subtalar joint arthrodesis is a commonly used technique in the management of hindfoot pathologies including posttraumatic arthritis, valgus or varus deformity, talocalcaneal coalition, inflammatory conditions of the subtalar joint and tibialis posterior tendon dysfunction (1,10, 11,16,20,27). It has gained popularity because subtalar arthrodesis preserves some hindfoot motion and does not increase the risk of arthritis in the adjacent joints (17). Operative procedures for subtalar fusion include joint resection, bone grafting, and osteosynthesis with screws (13). In the literature, the rate of union and patient satisfaction are generally reported as high (3).

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The purpose of this study is to review the results of isolated subtalar arthrodesis in adults. To make a comparative analysis of the clinical outcomes between the patients with degenerative subtalar arthritis secondary to calcaneal fracture and the ones with other etiologic factors, and to evaluate the effects of grafting.

MATERIALS AND METHODS

Between January 2007 and January 2012, 33 feet of 31 patients underwent isolated subtalar arthrodesis surgery were included in our study. Patients who had degenerative changes of the ankle or other intertarsal joints, who had previous arthrodesis procedure for any joint of the foot, and who had any osteotomy to correct coronal plane hindfoot deformity during the same surgery with subtalar arthrodesis, were excluded. None of our patients had degenerative talonavicular arthritis preoperatively. General indications for arthrodesis were severe pain that did not respond to conservative treatment and/or impairment of daily activities and walking. All patients had failure of conservative treatment including activity modification, use of nonsteroidal anti-inflammatory drugs, physical therapy, intra-articular injection, and bracing. The study included 19 men and 12 women with a median age of 44 (range : 19 to 70) years at the time of surgery. The mean postoperative follow-up time was 36.8 ± 16.5 (range : 24 to 74) months. Degenerative subtalar arthritis secondary to calcaneal fracture was the indication for surgery in 18 feet (Fig. 1), whereas in the other 15 feet



Fig. 1. — Subtalar arthritis secondary to a previous calcaneal fracture.

the indications were nontraumatic arthritis due to hind-foot valgus deformity (6 feet), talocalcaneal coalition (5 feet), subtalar instability as a sequela of neurovascular conditions (2 feet), and flatfoot secondary to tibialis posterior tendon dysfunction (2 feet). Grafting of the joint space following the removal of chondral surfaces was applied in 19 feet (iliac crest autograft in 16 feet and cancellous allograft in 3 feet), whereas in 14 feet the procedure did not include any kind of grafting. Tibiocalcaneal alignment was established and the arthrodesis procedure was completed by compressive fixation using two cannulated screws for each case. Weight bearing was not allowed for the following six weeks postoperatively. Partial weight bearing was permitted with crutches for an additional six weeks. Radiographic control images were obtained at 3 weeks intervals. Rehabilitation protocol was administered and full weight bearing was allowed according to union status by the end of the third month postoperatively. Informed consent was obtained for all participants of this study.

Data collection

The American Orthopedic Foot and Ankle Society (AOFAS) hindfoot scoring system was used for clinical assessment pre- and postoperatively. The range of motion (ROM) in the sagittal plane was clinically measured by two of the authors and the average degrees of plantar and dorsiflexion were noted for each foot at the latest follow-up. Correlation coefficient of repeated ROM measurements was 0.93. Union status was determined according to anteroposterior and lateral X-rays obtained at each follow-up visit. Time period from surgery to union, that was evident on the radiographic images, was recorded in all cases. Measurements of talocalcaneal height (TCH) and talocalcaneal angle (TCA) on the standing lateral X-rays preoperatively and also at the latest follow-up visit were performed. All complications were recorded.

Statistical analysis

SPSS 22.0 (SPSS Inc, IBM, Chicago, IL, USA) was used to analyse data that we acquired in this study. Statistical analysis was made by using Wilcoxon signed-rank test to compare related data of preoperative and postoperative periods, and nonparametric Mann-Whitney U test to compare independent interval data. The level of significance was set at $p < 0.05$.

RESULTS

The mean AOFAS hindfoot score improved from a mean of 46 ± 8.3 (range : 26 to 57) preoperatively to a mean of 77.3 ± 7.5 (range : 64 to 88) postoperatively ($p < 0.001$). The improvement in the mean AOFAS hindfoot score did not significantly differ between the patients with a medical history of calcaneal fracture and the ones with other etiologic factors ($p > 0.05$). The mean dorsiflexion in the sagittal plane was 10.9 ± 3.6 (range : 5 to 18) degrees, and mean plantar flexion was 30.4 ± 3.5 (range : 24 to 35) degrees at the latest follow-up visit. With the numbers available, no significant difference could be detected between the patients with degenerative arthritis secondary to calcaneal fracture and the ones with other etiologic factors according to range of motion in the sagittal plane at the latest follow-up ($p > 0.05$). Thirty-one of 33 arthrodeses (93.9%) achieved bony union at a mean time of 15.7 (range : 12 to 25) weeks postoperatively (Figs. 2A and 2B). The difference in mean time from surgery to radiographic bony union between the patients with a medical history of calcaneal fracture and the ones with other etiologic factors was not significant ($p > 0.05$). The mean time to union was 14.4 ± 1.7 (range : 12 to 18) weeks in the feet for which grafting of the subtalar joint space was performed during the arthrodesis procedure, whereas it was 17.5 ± 2.8 (range : 14 to 25) weeks in the feet operated without grafting ($p < 0.05$). At the latest follow-up, mean in-

crease in the TCH was measured as 3.8 ± 2 (range : 2 to 7) mm in the feet operated without grafting, whereas it was 8.1 ± 2.1 (range : 4 to 12) mm in the feet for which grafting of the subtalar joint space was performed during the arthrodesis procedure ($p < 0.05$). The mean TCA was 21 ± 3.8 (range : 15 to 28) degrees preoperatively in the feet operated without grafting, and it was measured as 26.6 ± 2.9 (range : 22 to 32) degrees at the latest follow-up. The mean TCA improved from 21.9 ± 4.3 (range : 14 to 32) degrees preoperatively to 31.5 ± 3.2 (range : 26 to 40) degrees postoperatively in the feet with grafting. Improvement in TCA was significantly better in the feet operated with bone grafting ($p < 0.05$).

Complications

Two nonunions (6%) were diagnosed during the clinical follow-up. One of these nonunions was a patient with nontraumatic subtalar arthritis due to chronic hindfoot valgus deformity in whom the surgery was performed without grafting. The other one with the etiology of degenerative subtalar arthritis secondary to calcaneal fracture was from the grafted group. Nonunion was due to infection in this case. Three infections (9%) were diagnosed in our study group. Two of these cases were treated with vacuum-assisted wound care, and union was achieved without persistent osteomyelitis. The other case that resulted in nonunion was treated by surgical debridement, intravenous antibiotics and implant



Fig. 2A. — Preoperative roentgenogram of isolated subtalar arthritis.



Fig. 2B. — Bony union by the end of 14th week postoperatively.

removal. There was no malunion case in our series. Reflex sympathetic dystrophy (RSD) was diagnosed in 5 feet (15.1%). Four of them were among the cases of degenerative subtalar arthritis secondary to calcaneal fracture. This means that, isolated subtalar arthrodesis applied for the feet with posttraumatic subtalar arthritis was significantly more prone to RSD ($p < 0.05$). Physical rehabilitation protocol including Transcutaneous Electrical Nerve Stimulation (TENS), oral / transdermal medications, and encouraging the use of the extremity were applied as the treatment of RSD. No neurovascular complication was detected in this series. Degenerative arthritis in the adjacent talonavicular joint was diagnosed in 7 feet (21.2%) at the latest follow-up. Two of them had previous calcaneal fracture, whereas the other 5 feet were among the ones with other etiologies like talocalcaneal coalition, tibialis posterior tendon dysfunction, or nontraumatic subtalar arthritis due to hindfoot deformity. This difference was statistically significant ($p < 0.05$).

DISCUSSION

Arthrodesis is a salvage procedure applied in the operative treatment of degenerative disorders of the joints. Several indications for subtalar joint arthrodesis have been described in the literature (1,3,10,11,16,27). Different studies advocated this intervention as a selected hindfoot surgery for specific indications (17,18). Dahm *et al* reported that isolated talocalcaneal arthrodesis was an effective treatment and had a high rate of union, a low rate of complications, and a low rate of progressive arthritis of adjacent joints (9). On the other hand, Easley *et al* emphasized that according to the results of their study, subtalar arthrodesis was associated with a less favorable outcome and a higher rate of complications than had been previously reported (11). The main objective of the present study was to evaluate the clinical results of isolated subtalar joint arthrodesis in adults.

The American Orthopaedic Foot and Ankle Society scoring system has been accepted as a valid tool for clinical assessment of the patients with the pathologies of hindfoot. The mean AOFAS score following subtalar arthrodesis was reported between

64 to 77.8 points in different clinical trials (1,2,11,14,20,22,23,24,26). In a systematic review evaluating subtalar arthrodesis for the late complications of calcaneal fracture, average modified AOFAS score (maximum 94 points) was found as 73 (range : 64-83) points at the final follow-up, and it was also mentioned that six studies reported pre- and post-reconstruction AOFAS outcome scores with an average increase of 44.2 points (24). Although, mean AOFAS score improved significantly from 46 points to 77.3 points in our study group similar to the results reported in the literature, it did not significantly differ between the patients with a medical history of calcaneal fracture and the ones with other etiologic factors. Similarly no significant difference in the mean AOFAS score could be detected between the feet grafted during operation and the ones without grafting.

Savva and Saxby evaluated the range of motion in saggital plane postoperatively in patients who had subtalar arthrodesis for the sequela of calcaneal fracture (23). They reported that dorsiflexion and plantar flexion capacity was nearly 80% of the healthy side. Myerson and Quill reported a mean improvement in dorsiflexion of 15° in 8 patients, no change in 4 and a mean loss of 10° in 2 patients (21). Another study demonstrated reduction in the mean dorsiflexion from 13 degrees to 11 degrees. Rammelt *et al* reported an improvement in the mean postoperative dorsiflexion but at the same time a reduction in the mean plantar flexion (22). We did not apply a healthy side comparison in the present study but the range of motion in the saggital plane was clinically measured and noted for each foot at the latest follow-up. Mean dorsiflexion was 10.9 degrees, and mean plantar flexion was 31 degrees. As far as we know, there is no study comparing the range of motion following subtalar arthrodesis with respect to the etiologic factors. The difference according to range of motion in the saggital plane between the patients with degenerative subtalar arthritis secondary to calcaneal fracture and the ones with other etiologic factors was not statistically significant in our study group ($p > 0.05$).

The rate of bony union and the mean time from surgery to union are also important parameters when evaluating the clinical results of such cases.

The overall rates of bony union following subtalar joint arthrodesis were reported between 84 to 100% by different authors in the literature (3,4,7,8,9,11,14). Schepers mentioned that the average fusion rate was 96% (range : 83 to 100%) in systematically reviewed studies evaluating patients operated for the late complications of calcaneal fracture (24). Another literature review was performed by Tuijthof *et al* for papers that presented subtalar arthrodesis operative techniques and they found weighted percentage of nonunion as 12% (27). Joveniaux *et al* reported bony union in a median time of 13 weeks (14). In a study using fresh-frozen femoral head allograft for subtalar arthrodesis, Chiang *et al* also reported median time of union as 13 weeks (8). Boffeli *et al* emphasized that a retrospective review of radiographs taken 10 weeks postoperatively indentified a 100% fusion rate in their study group (3). In the present study, 31 of 33 arthrodeses (93.9%) achieved bony union at a mean time of 15.7 (range : 12 to 25) weeks postoperatively. In the present study, the difference in mean time from surgery to radiographic bony union between the patients with posttraumatic arthritis and the ones with other etiologic factors was not statistically significant ($p > 0.05$). However, mean time to union was significantly shorter in the feet for which grafting of the subtalar joint space was performed during the arthrodesis procedure ($p < 0.05$). Therefore, our findings demonstrate that grafting is an important factor accelerating union time in subtalar arthrodesis.

Talocalcaneal relationship is primarily affected in the pathologies of hindfoot. Talocalcaneal height (TCH) and TCA are useful tools for radiological assessment of the patients who have had surgery for the hindfoot disorders. The decrease in the TCH was demonstrated to lead the lengthening of the Achilles tendon (6,12). The improvement in TCH varied between 4 to 7 mm postoperatively (5,16,21,22). Chiang *et al* reported that the median increase in heel height was 8.6 mm in their study (8). The mean postoperative TCH was measured as 77.7 mm by Savva *et al* (23). The mean postoperative TCA was reported between 11.6 to 37 degrees in the literature (5,19,22,23,26). According to Dahm *et al*, the mean TCA did not significantly change postoperatively (9). In our study, improvement of both the TCH

and TCA were significantly better in the feet for which grafting of the subtalar joint space was performed during the arthrodesis procedure.

The rates of nonunion and infection were similar to the literature in our patient group (3,4,7,8,11,14,19,23). According to our data, isolated subtalar arthrodesis procedures, performed in patients with degenerative subtalar arthritis secondary to calcaneal fracture were significantly more prone to RSD postoperatively. This may be due to incongruent micro-architectural reconstruction of the osseous tissue following calcaneal fracture. Degenerative arthritis in the adjacent talonavicular joint was significantly more common in patients with other etiologies such as talocalcaneal coalition, tibialis posterior tendon dysfunction, or nontraumatic subtalar arthritis due to hindfoot deformity.

This study has some limitations. First, it was a retrospective study evaluating the data of prospectively followed patients. Second, the cohort was limited. Third, the follow-up is not long term. On the other hand, comparative analysis of the clinical outcomes between the patients with different etiologic factors and the evaluation of the effects of grafting were the strength of our study.

In conclusion, isolated subtalar arthrodesis is an effective surgical intervention with significant clinical improvements in some patients with disorders of the hindfoot. Grafting of the joint space should be considered as a determinant factor affecting the postoperative time to union and the restoration of the talocalcaneal relationship. A medical history of calcaneal fracture is a predisposing factor for the increased rate of postoperative RSD ; but not for the degenerative changes in the adjacent joints.

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