

Isolated Subtalar Joint Fusion and Talonavicular Joint Fusion

A Glimpse at the Occurrences and Implications Applied to Adult Acquired Flatfoot and Posterior Tibial Tendon Dysfunction

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Abstract

The adult acquired painful flatfoot, a syndrome that has come to be known as posterior tibial tendon insufficiency, continues to pose a challenge for the foot and ankle specialist. Arthrodesis will likely continue to be a valuable procedure for treatment, particularly in older patients with significant deformity. The key question regarding arthrodesis is related to which, and how many joints, to involve in the procedure.

Literature Review

Arthrodesis has remained a means of correcting adult acquired flatfoot secondary to dysfunction of the tibialis posterior tendon. Owing to the entwined and diminutive motions of the subtalar, talonavicular, and calcaneocuboid joints, the flatfoot deformity should be thoroughly examined to ensure the fusion is tailored to the patient's precise needs. In the face of frequent studies of the subtalar, talonavicular, and calcaneocuboid joints, their meticulous biomechanical nature remains poorly understood. Comprehension of the precise, three-dimensional relationship possesses vast clinical implications as the drift toward selective arthrodeses, particularly of the talonavicular joint and subtalar joint, continues to gain popularity.

Conventionally, isolated subtalar joint arthrodesis was employed to treat paralytic pediatric flatfoot deformity and intraarticular calcaneal fractures. Wilson first described the procedure in 1927. Gallie, Chambers, Holmann, and Grice went on to revise the technique with varying practices of bone grafting and fixation. The goals of isolated subtalar joint fusion included elimination of pain, restoration of stability, and realignment of the hindfoot. Ogston first illustrated the isolated

talonavicular arthrodesis in 1884. Ogilvy, Elbar, and Dalziel would make use of the talonavicular fusion and achieve favorable results ⁸.

Previous imprecise *in vivo* studies of rearfoot motion motivated Wulker, et al. to conduct a study in which the linked movement of the rearfoot joints, following arthrodesis, could be more effectively quantified ²³. Movement at the subtalar and talonavicular joints were measured in eight non-pathological foot cadaveric specimens (age 20-87 years of age with a mean age of 43 years) utilizing the Zebris 100 ultrasonic motion analysis system developed in Germany. The specimens were denuded of skin and all soft tissue structures, the fibula was amputated, and ankle joint range of motion was eliminated utilizing two large partially threaded cancellous screws from medial to lateral. Isolated arthrodeses of the subtalar and talonavicular joints were performed and the resulting altered motion was measured at the unfused joint employing the talus as a point of reference. Arthrodesis of the subtalar joint was achieved by placing two partially threaded 6.5 mm cancellous screws through the calcaneus into the talar body, while the talonavicular joint was fused using two 15 x 25 mm metal bone staples in combination with a 3.5 mm partially threaded cancellous screw. Movement at the subtalar joint was drastically affected by fusion of the talonavicular joint; movement at the talonavicular joint was decreased by approximately one third with the subtalar arthrodesis; and movement at the calcaneocuboid joint was not considerably reduced by subtalar fusion; however, it was almost entirely eradicated in fusions involving the talonavicular joint. Wulker, et al. concluded that the talonavicular joint is the principle articulation of rearfoot movement ²³.

O'Malley, et al. ¹⁹ created a severe flatfoot deformity with considerable laxity at the transverse tarsal joint on five fresh-frozen cadaveric foot/ankle specimens. Fusions were performed at the subtalar joint, talonavicular joint, calcaneocuboid joint, and a triple arthrodesis was performed. The total amount of correction obtained with no osseous fusion, triple arthrodesis, calcaneocuboid arthrodesis, and fusions of the subtalar and talonavicular joints was measured radiographically utilizing radio-opaque beads impacted underneath the cortex of the talus,

navicular, and base of the first metatarsal. Calcaneal frontal plane motion was measured employing a screw inserted from medial to lateral. A sequential soft tissue release was performed utilizing Vitallium staples and a cannulated screw, respectively. Results showed that the talonavicular and triple arthrodeses were successful in correction of the severe flatfoot deformity that included adjustment of the hindfoot valgus. O'Malley concluded that the subtalar fusion was unsuccessful in correcting the severe flatfoot deformity. This experiment provided investigational substantiation that, while the subtalar and talonavicular joint worked concurrently; they diverged in their abilities to correct a flatfoot with substantial laxity through the tarsal joint. The results stated that the isolated talonavicular fusion was able to correct the flatfoot deformity to a similar degree as the triple arthrodesis. Conversely, the isolated subtalar joint fusion left motion in the transverse tarsus. Therefore, in patients whose flatfoot deformity confined itself to the subtalar joint, the isolated subtalar joint fusion could prove profitable.

Astion, et al.¹ conducted a study in which arthrodesis of the subtalar joint and talonavicular joint were simulated in 10 fresh-frozen cadaveric specimens. The soft tissue and cartilage of the cadaveric specimens were left intact, and the ankle joint was fused in neutral position. The range of motion of each joint uninvolved in the arthrodesis was measured with a three-dimensional Fastrak magnetic space tracking system previously employed to study the biomechanics of the wrist. The excursion of the posterior tibial tendon was also calculated under the same conditions, with the use of stainless steel wires sutured to the posterior tibial tendon and the peroneus brevis tendon. Astion, et al. believed that analysis of the excursion of the posterior tibial tendon aided in determining the applicability of tendon reconstruction as an adjunct to arthrodesis procedures. They concluded that any combination of simulated arthrodeses that included the talonavicular joint greatly limited the motion of the remaining joints to approximately 2 degrees and limited the digression of the posterior tibial tendon to 25 percent of the preoperative value. After simulated arthrodesis of the subtalar joint, a mean of 26 percent of the motion of the talonavicular joint, 56 percent of the motion of the calcaneocuboid joint, and 46 percent of the excursion of the posterior

tibial tendon was preserved. The talonavicular joint had the greatest range of motion, and the replicated arthrodesis of this joint reduced motion of the other joints of the triple-joint apparatus.

Mangone, et al. ¹⁴ conducted a retrospective review of isolated subtalar arthrodeses performed on 32 adults (34 fusions) between August 1990 and September 1993. Each fusion was performed using a single large cannulated lag screw through the talar neck. The American Orthopaedic Foot and Ankle Society standard clinical rating system for ankle and hindfoot was used to assess outcome. Patients answered subjective questions based on a scale developed by the authors. Follow-up examinations were performed to evaluate the procedure clinically and radiographically, according to another scale produced by the authors. Average patient age was 53 years (range, 27-80 years). Average follow-up was 30.8 months (range, 16-55 months). Twenty-four patients answered the subjective questions, and the average subjective score was 47 of a maximum 60 points (ranging from 0-60 points). Clinical data from 17 patients showed an average objective score of 30 of a maximum 34 points (range 25-34 points). Forty-two percent of the patients indicated a 100 percent improvement, 42 percent of 75% improvement, and 10 percent a 50 percent improvement. Eighty-three percent stated they definitely would have the procedure performed again. Results indicate that subtalar joint arthrodesis was an effective treatment for adult patients with pain and disability secondary to acquired planovalgus, posttraumatic, and inflammatory conditions of the hindfoot. In addition, the American Orthopaedic Foot and Ankle Society standard rating system of the ankle and hindfoot corresponded to clinical outcome ¹⁵.

Mann, et al. ^{15,16} studied 48 isolated subtalar arthrodeses in 44 patients with an average follow-up of 59.5 months. The study reviewed isolated subtalar joint arthrodeses for the diagnoses of talocalcaneal coalition, healed calcaneal fracture with subtalar arthrosis, acquired flatfoot because of posterior tibial tendon dysfunction, degenerative subtalar arthrosis, subtalar instability, and psoriatic arthritis aiming to further streamline the indications for subtalar fusions that would otherwise go to triple arthrodeses. Of the 48 subtalar fusions performed, eight of them had the

pre-operative diagnosis of adult acquired flatfoot secondary to posterior tibial tendon dysfunction. Ninety-three percent of the total number of patients was very satisfied or satisfied with their treatment. Pain and function improved significantly, and the American Orthopaedic Foot and Ankle Society ankle-hindfoot score at follow-up was 89. Transverse tarsal motion was diminished by 40 percent, dorsiflexion by 30 percent, and plantarflexion by 9 percent. There was a 36 percent and 41 percent incidence of mild radiographic progression of arthrosis in the ankle and transverse tarsal joint, respectively. The sole collection of patients to undergo radiographic angle changes was the patients with the pre-operative diagnosis of posterior tibial tendon dysfunction. In particular, they demonstrated near complete correction of their flatfoot deformities¹⁵. Isolated subtalar arthrodesis provided a highly successful result in the disease presented, and this study provides support for the use of a selected hindfoot fusion procedure for specific indications. While Mann, et al. believed that subtalar fusions increased stress in the surrounding joints, an advantage of the procedure was the preservation of the transverse tarsal joint which could go on to decrease the frequency of clinically significant arthrosis despite radiographic evidence of arthrosis. Technically, Mann et al. stated that excessive varus and valgus positioning of the hindfoot were not tolerated well. Specifically, disproportionate valgus can lead to calcaneofibular ligament impingement, unlocking of the transverse tarsal joint, decrease in arch height, struggles with shoe gear, and poor pedal cosmesis. They conclude that subtalar fusions in patients with posterior tendon dysfunction must be methodically selected for only those less active, older patients where rearfoot valgus, subtalar joint inversion, forefoot varus greater than 15 degrees, and transverse tarsal joint hypermobility were nonexistent.

Forty patients were treated with isolated subtalar joint arthrodesis, from 1994-2000⁴. These patients were retrospectively reviewed at the Western Pennsylvania Hospital. Among the preoperative diagnoses was posterior tibial tendon dysfunction. Subjective postoperative questionnaire results were obtained and classified as satisfied, satisfied with reservations, or dissatisfied. The aim of the study conducted by Catanzariti, et al. was to compare preoperative diagnosis with the postoperative outcomes. In addition, a subjective questionnaire was obtained

at the last follow-up visit to determine patient satisfaction. Patients were questioned about their level of pain, cosmesis, functional capacities, use of walking aids, and ability to wear shoes. The study evaluated minor and major postoperative complications, with minor complications consisting of postoperative symptoms that were resolved with nonoperative treatment. Major complications were defined as continued postoperative symptoms, which were not relieved with nonoperative treatment. Major complications also included patients who requested revisional surgery. Twelve of the 19 patients with posterior tibial tendon dysfunction had minor complications which included painful internal fixation, sural neuritis, delayed union, stress fracture at the tibial graft site, wound dehiscence, and residual postoperative pain. Two of the 19 patients with posterior tibial tendon dysfunction had major complications both of which had non-unions. Proponents of isolated subtalar joint arthrodesis agree that this arthrodesis will increase stress on the adjacent joints; however, they contend that the procedure preserves the majority of motion at the midtarsal joint⁴. Delayed unions occurred in two patients with a preoperative diagnosis of posterior tibial tendon dysfunction.

Since 1989, Harper¹¹ used the isolated talonavicular fusion and reported the results of 27 consecutive patients. All of the patients in this study were adults with a history of progressive painful flatfoot deformity. Patient ages ranged from 39 to 74 years, with an average of 57 years. All patients exhibited an asymmetrical planovalgus deformity. Cannulated screw fixation with compression was used in all cases. Initially, a 6.5 mm screw was used in three cases. Two 4.0 mm screws were used in the next three cases, followed by two 4.5 mm screws used in the remainder of the procedures.

At the time of final evaluation, patients were assessed for level of pain according to the pain scale created by the author, and they were also rated for subjective functional ability. Range of motion of both the ankle and hindfoot were recorded and an objective rating determined from those measurements. Radiographs of the foot and ankle were obtained and evaluated for fusion of the arthrodesis in addition to any arthrosis of the joints of the hindfoot and midfoot.

Ankle motion was decreased by an average of 10 degrees when compared to the opposite extremity, with the majority of the loss involving plantarflexion¹¹. Residual inversion and eversion of the hindfoot were variable, ranging from minimal to approximately 20 degrees, with the majority of patients retaining some clinical motion. Foot position was rated as relatively symmetrical in 23 patients and in mild valgus compared to the opposite extremity in three patients. In five patients, arthrosis was noted to have progressed in joints adjacent to the talonavicular joint. These included the ankle in one patient, the calcaneocuboid joint in one patient, and the naviculocuneiform joint in three patients. In four of the five, some degree of arthrosis was present before surgery. Although the subsequent development of arthrodesis in unfused adjacent joints was reported, the incidence seemed rather limited¹¹.

In 1990, Simmons et al. reported 12 patients with posterior tibial tendon insufficiency treated with talonavicular arthrodeses. All patients had successful fusions, and all but one patient had improvement in pain, with eight having no pain and four with mild pain¹¹.

Review of the literature indicated that there exist several methods of evaluating the applicability of isolated talonavicular and subtalar arthrodeses. These varying means of determining outcome made the evaluation of each study's individual results, and the comparison of outcome between studies, are challenging. The application of a standardized outcome measurement would aid in eliminating author bias and establish a standard method of evaluation for patients undergoing isolated arthrodesis. While the literature regarding isolated fusions remains meager, several keen observations and statements have been made.

It is understood that fusion of the talonavicular joint generates rearfoot stability and a component of medial column stability; however, the procedure may not remove the need to correct the navicular cuneiform joint and the first metatarsal cuneiform joint. Therefore, it may be necessary

to perform additional stabilizing procedures, such as a Young procedure, to achieve stability at other critical areas of instability⁸.

The advantage of an isolated arthrodesis of the talonavicular joint is that posterior tibial tendon abnormalities can be evaluated and addressed, and the foot positioned and stabilized using a single approach. This should result in lowered rates of postoperative morbidity when compared to double arthrodesis of both transverse tarsal joints, which require both medial and lateral incisions⁸.

The talonavicular arthrodesis offers an effective limitation of motion by obstructing nearly all midtarsal and subtalar joint motion. In theory, arthrodesis of the talonavicular joint affords maximum stability. Subtalar joint arthrodesis may be employed with favorable outcomes; however, a quantity of patients may receive inadequate correction in the transverse plane midtarsal joint deformity, perhaps due to the fact that the midtarsal joint is the principle joint stabilized by the tibialis posterior⁸.

The isolated subtalar joint fusion preserves approximately 50 percent of midtarsal joint motion relative to the triple arthrodesis. Talonavicular joint motion has been shown to decrease 13-45 percent *in vitro* and 40 percent *in vivo* following isolated subtalar joint fusions³. The subtalar joint fusion allows for motion at the midtarsal joint level thus allowing the foot to adapt to uneven terrain². The increased talar beaking associated with subtalar joint fusions is typically not associated with arthrosis, but rather traction from the dorsal ligaments of the talonavicular joint³. Isolated talonavicular fusions should be reserved for patients with symptomatic flatfeet that are still flexible with no arthritic changes within the subtalar joint¹¹.

The high rates of non-union associated with talonavicular fusions can often be attributed to the use of freeze dried allograft, saw resection of the joint, inadvertent resection of the incorrect joint, and employment of staple fixation⁵. The trend of fusing as few joints as necessary marks steps

forward in the surgical approach of the foot and ankle; nevertheless, this issue must be refined with further scrutiny.

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