# TALONAVICULAR JOINT ARTHRODESIS WITH SUBTALAR JOINT ARTHROEREISIS FOR CORRECTION OF ADULT ACQUIRED FLATFOOT DEFORMITY

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## INTRODUCTION

Adult-acquired flatfoot is a devastating condition that affects many older adults (Figure 1). There are many different treatments for this deformity, ranging from conservative care to surgical procedures as extensive as a triple arthrodesis. In geriatric patients, this condition tends to be chronic in nature rather than acute as would be in younger, more active patients. Surgical options trend towards arthrodesis of joints rather than reconstruction of tendons and soft tissue procedures because of the extent of the deformity, age of the patients and their soft tissues, and the limited activity levels of geriatric patients.

An isolated talonavicular joint fusion was originally described by Ogston to correct any midfoot deformities involving the talonavicular joint, including rheumatoid arthrosis, collapsing pes planovalgus, and post-traumatic arthritis in adults. Astion et al, in a cadaveric study, showed that an isolated talonavicular fusion limits the subtalar joint motion by 91% of its original range of motion. This procedure can be used as an isolated procedure. However, O'Malley et al state that there is a high incidence of nonunions of the talonavicular joint due to micromotion. Thus, it is often used in conjunction with other procedures. Other soft tissue and/or bony procedures work to help stabilize and eliminate micromotion at the talonavicular joint reducing the high nonunion rate.

Many of the above procedures are indicated for patients that have acute symptoms. In older geriatric patients that have an adult acquired flatfoot deformity, the treatment of choice is often a triple arthrodesis. However, to minimize the risks of surgery to the patients and decrease postoperative course, an alternative combination of procedures is proposed to correct collapsing pes planovalgus deformity. The risks and complications of the triple arthrodesis may be reduced by lowering the amount and time of the surgical procedures. A more precise method of positioning the rearfoot and the forefoot can be accomplished. The purpose of this study was to review the results of the talonavicular fusion with subtalar arthroereisis as an alternative procedure to triple arthrodesis in treating symptomatic collapsing pes valgoplanus deformities in geriatric patients. In addition, we also evaluated the quality of life improvement after the surgery and the potential nonunion rate at the talonavicular joint.

Figure 1. Adult acquired flatfoot (right.) Notice the left foot is pronated but not as severe as the right.

## MATERIALS AND METHODS

A thorough chart and radiographic review was conducted. The inclusion criteria was any patients that had a collapsing pes valgoplanus deformity with a talonavicular joint arthrodesis and a subtalar joint arthroereisis. The exclusion criteria were pes cavus foot type, rigid hindfoot deformity, and any radiographic signs of ankle arthrosis. Patients that had an isolated subtalar joint arthroereisis or an isolated talonavicular joint arthrodesis were not included in this study. Patients with any other adjunctive soft tissue procedure at the same time of the procedure were also excluded.

Twenty-one feet in 18 patients who had a talonavicular fusion with a subtalar arthroereisis with surgery dates from 1990 to 2007 were evaluated. Of the 18 patients, 16 were women and 2 were men. A total of 21 feet were evaluated in a retrospective radiographic analysis.. The average follow-up was 5.8 years. A total of 10 available patients (13 feet) returned for follow-up clinical examination.

The ACFAS (American College of Foot and Ankle Surgeons) Hindfoot Scoring Scale was used to evaluate patients preoperatively and postoperatively. This questionnaire was chosen for the study because it evaluated the 1) patient's subjective conditions (50 points) a. Pain – 30 points b. Appearance – 5 points c. Function – 15 points, 2) biomechanical evaluation (32 points) a. Range of motion 18 points b. Single heel raise - 9 points c. Bare foot limp – 5 points and 3) a radiographic evaluation (18 points) a. Lateral – 6 points b. Frontal – 6 points c. Sagittal – 6 points. All patients were asked if they were satisfied with the procedure, if they would have the procedure again, and if they would recommend the procedure to somebody else.

Radiographic measurements included on the dorsoplantar (DP) view the metatarsal adductus angle, the forefoot adductus angle, talocalcaneal (Kite's) angle, talar coverage, and cuboid abduction angle. On the lateral radiographic view, measurements include the calcaneal inclination angle, talar declination angle, the lateral talocalcaneal angle, lateral talar-metatarsal (Meary's) angle, and the position of the Cyma Line. The metatarsal adductus angle and the calcaneal inclination angles are structural angles while the rest of the angles are positional. Furthermore, radiographs were evaluated for any arthrosis or malunions at the talonavicular joint fusion site. The subtalar arthroereisis was evaluated for any displacement or malposition of the implant.

## SURGICAL METHOD

A thorough biomechanic examination was performed preoperatively, with attention paid to the position of the rearfoot with respect to the ground. The forefoot is also examined for any unmasking of any deformities with the rearfoot in the supposed corrected position such as metatarsus adductus. The tibial-calcaneal relationship and the calcaneus to the ground relationship were determined. The neutral stance position of the subtalar joint, and the relaxed stance position of the subtalar joint were marked preoperatively. The calcaneus was placed in a weight bearing position 2 to 4 degrees everted and was measured both from the neutral position and from the maximally pronated position for estimation intraoperatively (Figure 2). This becomes the desired position where the foot will end up once the surgery is finished. It is essential not to place the hindfoot in any inverted position.

The surgery takes place in 3 stages. This is necessary because the talonavicular joint should be fused after hind foot position is fixed. It is easier to prepare the talonavicular joint for fixation before you limit the subtalar joint.

### Stage 1

The talonavicular joint is isolated by using a dorsal medial linear incision over the talonavicular joint. The neurovascular structures, especially the saphenous nerve and vein, were identified and retracted inferiorly. A linear capsulotomy was made on the dorsomedial aspect of the joint and reflected. A mini-AO distractor was used to distract the joint. The cartilaginous surface of both the talar head and the proximal navicular was curetted (Figure 3). Subchondral drilling and/or osteotome "shingling" was utilized to obtain subchondral bleeding. Thus, the talonavicular joint is prepared for fusion.

### Stage 2

Attention was directed to the lateral aspect of the foot for the Flake-Austin subtalar arthroereisi technique with an ASI peg and disk implant (Figure 4). The intermediate dorsal cutaneous nerve and peroneous brevis tendon are identified. An Ollier incision was made between these two structures over the sinus tarsi parallel to the skin tension lines (Figure 5). The deep fascia (extensor retinacula) was incised and reflected in a "V" shape parallel to the leading wall of the posterior facet of the talus and the floor of the sinus tarsi (Figure 6). The soft tissue was freed from the floor of the sinus tarsi and the leading wall of the posterior facet of the talus was reflected or excised. A template for the Flake-Austin Angled Subtalar Implant was utilized to determine the correct size of the implant disk (Figure 7).

The position of the foot with the implant seated should be between neutral and maximally pronated position as measured preoperatively. Since tibial varum cannot be accounted for on the surgical table, a line is drawn on the anterior aspect of the leg. The line is extended onto the foot with the subtalar joint held in the neutral position. The foot is placed in the maximally pronated position and the leg line is once again extended onto the foot. By determining the neutral position and the maximally pronated position of the calcaneus intraoperatively, the two to four degrees of everted position of the calcaneus can be estimated from the preoperative biomechanical examination (Figure 8). Once the correct disk size was determined, various awls were used to create a hole for the stem of the implant. A trephin is used to finish the hole to the exact size of the stem (Figure 9). The appropriate implant is inserted at about a 45 degree angle so the disk is flush against the leading wall of the talus (Figure 10).

Figure 2A. Neutral subtalar joint stance position is inverted.

Figure 2B. Relaxed subtalar joint stance is maximally pronated and everted.

Figure 2C. Stance position with the calcaneus 2-4 degrees everted can be measured (estimated) from both the neutral position and the maximally pronated position.

Figure 3. Expose and prepare (curette) the taonavicular joint for fixation.

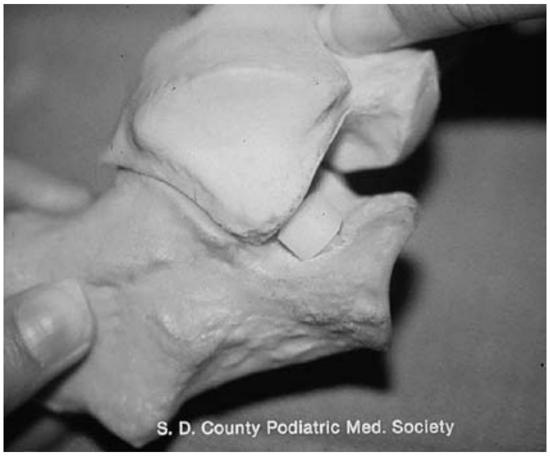


Figure 4. The Flake Austin technique inserting the peg and disk arthroereisis type implant.

Figure 5. The dotted line represents the course of the intermediate dorsal cutaneous nerve, the solid line above the heel represents the peroneus brevis tendon, and the oblique line over the sinus tarsi represents the Ollier incision.

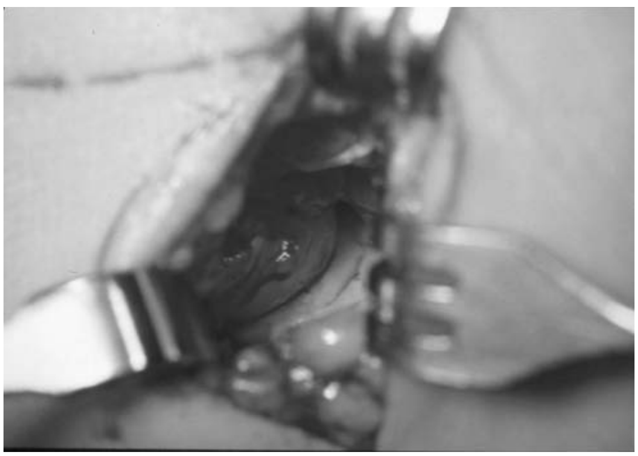

Figure 6. The posterior facet of the subtalar joint is identified. The talus is superior and the calcaneus is inferior.

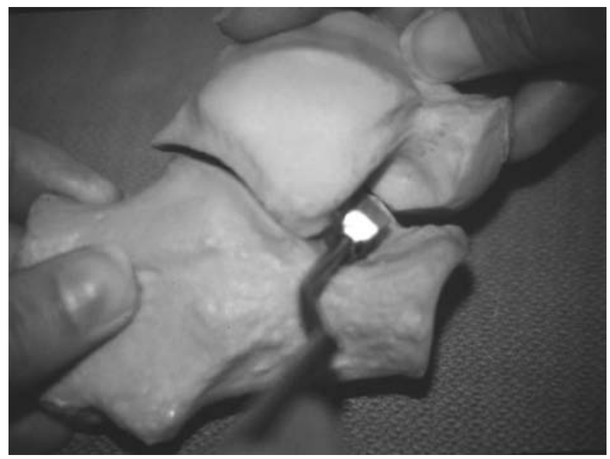

Figure 7. The various sized templates are inserted to determine the appropriate sized disk to be utilized

## Stage 3

With the hind foot stable against the implant in a maximally pronated position, the navicular is fixated on the talus to correct any sagittal, frontal, and transverse deformities of the forefoot. The joint was then fused using a 6.5 mm partially-threaded cancellous screw, or a compression staple. Bone graft can be inserted to facilitate fusion of the joint (Figure 11).

Postoperatively, the foot and leg were placed in a Jones Compression Dressing to prevent movement of the fusion site. The dressing was changed 2-3 days later when the swelling was reduced and the patient was placed in a short leg nonweight -earing cast. The patient is kept non-weight bearing in a short leg cast for approximately 4 to 6 weeks. Then the patients are transferred to an equalizer boot with weight bearing as tolerated for another four to six weeks, and physical therapy is initiated at this time. All patients were placed in a custom-made orthoses when they transition into a regular shoe.

# RESULTS

There were a total of 18 patients with 21 feet during a 20-year period from 1999 to 2008. Radiographic evaluation was performed on all 21 feet. A total of 10 patients with 13 feet returned the ACFAS questionnaire and were evaluated clinically. Statistical analysis was performed using the t-test of means.

The mean age of the patients when the procedure was performed was 68 years (range 44 to 81 years.) On the DP radiograph, the structural angle that was evaluated was the metatarsal adductus angle. The forefoot adductus angle, talocalcaneo angle, talar coverage, and the cuboid abduction angle were the positional angles that were

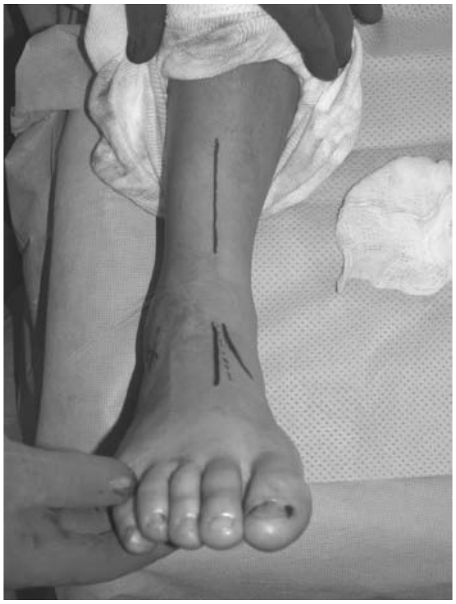

Figure 8A. Leg line extended onto the foot with the subtalar joint neutral.

Figure 8B. Leg line extended onto the foot with the subtalar joint maximally pronated.

Figure 8C. Dotted line is position of desired fixation of the subtalar joint as determined preoperatively.

Figure 9. A trephine is used to finish the hole in the calcaneus to fit the stem of the implant.

Figure 10. The ASI implant is seated in the calcaneus and pronated against the leading wall of the posterior facet of the talus.

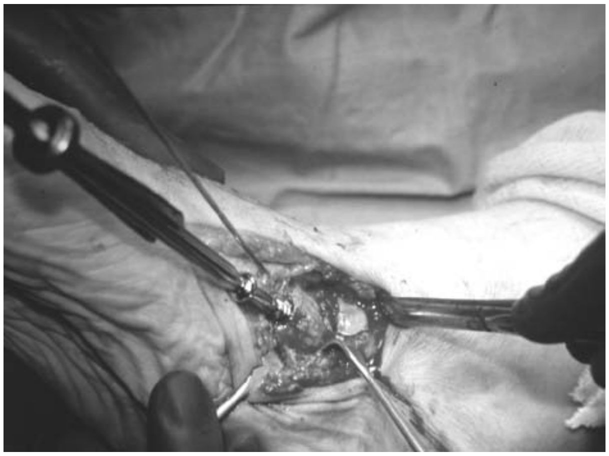

Figure 11A. The talonavicular joint is fixated with the subtalar joint maximally pronated against the implant and the forefoot held in its corrected position.

Figure 11B.

evaluated. The metatarsal adductus angle was 11.15 degrees preoperatively and 11.3 degrees postoperatively. The mean cuboid abductus angle preoperative and post-operative were 17.1 and 6.4 degrees, respectively. There were only 2 of 17 cases where the talar head was covered prior to surgery, Postoperatively, all talar heads were covered on the DP radiograph. The talocaneo angle decreased from 19.6 preoperatively to 13.4 post-operatively. Lastly, the forefoot adductus angle was actually a 10.6 degree abductus preoperatively which decreased to 6.0 degrees abducted postoperatively.

On the lateral radiograph, the structural angle was the calcaneo inclination angle and the positional angles were the Meary's Angle, talar declination angle, and the lateral talocalcaneo angle. Preoperatively the calcaneo inclincation angle was 16.35 degrees as compared with 17.4 degrees postoperatively. Meary's angle was 17.8 degrees pre-operatively and 6.25 degrees postoperatively. The talar declination angle was 43.15 degrees preoperatively and 30.35 degrees postoperatively. The talocalcaneal angle was 59.5 degrees preoperatively to 47.75 degrees postoperatively.

Radiographic evidence of pronation was not seen postoperatively. The Kirby Sign was not seen and the cuboid abduction angle was less than 5 degrees. The Cyma line was intact postoperatively with no deviations.

Using the Students' t-test for statistical analysis with $P$ values $< 0.05$ considered significant, the cuboid aduction angle, talocalcaneal (Kite's) angle, forefoot adductus angle, Meary's Angle, talo declination angle, and lateral talocalcaneal angle showed statistical significance. The changes in the 2 structural angles, metatarsal adductus angle and calcaneal inclination angle, were not statistically significant.

The ACFAS Hind foot score showed a marked improvement postoperatively. The score increased from 42 preoperatively to 73.25 postoperatively, and was statistically significant. However, 7 points in the ACFAS range of motion score were reserved to evaluate subtalar motion. Since the postoperative patients did not have any subtalar joint motion, we decided to modify the ACFAS score and eliminate the 7 points associated with subtalar joint motion. The modified ACFAS score was from a total score of 93 points instead of 100, and using the modified score, the postoperative score would be 78.8%.

All patients would have the surgery performed on them again if the foot was painful as before. All patients were able to perform a single heel rise. They all reported a significant decrease in pain and improvement in their quality of life. They are better able to perform functions of daily activity

Two patients had the cortical compression screw removed, and 2 patients had their ASI implant removed. Two patients had prominent screw head protrusion from the talar head. The reason for removal of the ASI implant was due to lateral pain anterior to the fibular malleolus. One patient had a delayed union at the talonavicular fusion site; however, the patient went on to heal uneventfully with a bone stimulator. All these obstacles and problems were resolved.

## DISCUSSION

Historically, subtalar joint arthroereisis has been used for flexible pes valgus deformities in children and to a somewhat lesser extent in adults. The concept of preventing excess pronation by limiting the motion of the subtalar joint was pioneered by Chambers. Many devices had been used over the years, ranging from iliac crest bone graft to different types of plugs with the materials made from fat, silastic, polyethylene, and metal. The goal is to prevent excess pronation of the subtalar joint; in effect, acting as an "internal orthotic." It also allows the surgeon to place the weight-bearing calcaneus in a precise location by manipulating the subtalar joint. Rarely patients do experience pain or discomfort in the sinus tarsi region if the implant is impinging on the normal motion of the subtalar joint, (i.e., if the implant is not sized correctly or if the implant was placed incorrectly). In those cases, the implant can be easily removed or replaced.

Arthrodesis of the subtalar, talonavicular, and calcaneocuboid joints (triple arthrodesis) is primarily used as salvage procedures for end stage arthritic joints and misalignment of the rearfoot. It was originally described by Ryerson in 1923 for treatment of neuromuscular diseases. However, triple arthrodesis procedure is not without its complications, including malunion and delayed union, shortening of the surgical foot, and iatrogenic malposition. Painful outcomes of this procedure have been reported to be as high as 55% by Saltzman in 1999. Alternative procedures had been devised in order to minimize these complications.

This report is a retrospective study of 18 patients with 21 feet that had a talonavicular joint arthrodesis with a subtalar joint arthroereisis for a collapsing pes planovalgus foot deformity. In patients that have an adult acquired flatfoot deformity, the patients are usually much older than patients that acutely develop a pes planovalgus deformity. Geriatric patients present the surgeon with new set of challenges. They have multiple medical comorbidities, are often obese, and cannot be fully nonweight bearing because they touch down weight bear when transferring. Since weight bearing creates a pronatory moment, having the subtalar joint fixed pronated against the implant should stabilize the rear foot even with some minor weight-bearing pressure.

Many surgeons are hesitant to perform extensive surgeries on geriatric patients because of their multiple medical comorbidities, even if the procedure of choice is the triple arthrodesis. The length of a triple arthrodesis procedure is typically 3 to 5 hours, depending on the skill and expertise of the surgeon. A longer operative time would expose patients to more risks. These include post-operative infections, increase stress on the body during and after surgery, thrombophebitis, possible acute renal failure, and a longer postoperative recovery time. All of these factors expose the patient to more complications during and after surgery. Inherently, these procedures have a shorter operating time than a triple arthrodesis procedure. With a shorter operating time, it decreases surgical trauma to the patient, decreases anesthesia time, and decrease risk of infection.

The 2 procedures work in concert to simulate the goals of the triple arthrodesis without performing one. The talonavicular joint arthrodesis eliminates the painful motion at the talonavicular joint. This is important because most of the patients describe pain at that joint. Instability at that joint was also eliminated. This is important because it allows the hindfoot to be more stable. During surgery, the talonavicular joint was placed in a more corrected position. The navicular was plantarflexed upon the talus; thereby, recreating a medial arch.

An isolated talonavicular joint arthrodesis has a high rate of nonunions secondary to micromotion. However, if the arthrodesis is combined with an arthroereisis, a second point of stabilization is created. The subtalar joint arthroereisis with the Flake-Austin ASI is able to more precisely place the weight-bearing calcaneus in a 2-4 degrees everted stance position. With proper bio-mechanical evaluation preoperatively and intraoperatively, the subtalar joint was placed accurately. Once the hindfoot was stabilized, attention can now be placed at the talonavicular joint, where the navicular is positioned so the forefoot is in a corrected position. With the hindfoot stabilized and the forefoot positioned to reduce any forefoot deformities, the goals of a triple arthrodesis were achieved.

The ASI implant also serves to neutralize the pronatory weight bearing forces on the hindfoot. When weight bearing, the ground reactive force is lateral to the axis of the ankle, subsequently causing the foot to have a pronatory moment. However, the foot is maximally pronated against the implant. Therefore, the pronatory ground reactive forces are against the implant, not the foot. This allows the hindfoot to be stable, which gives the talonavicular joint arthrodesis an improved chance of primary union.

## CONCLUSION

This was a retrospective study of 18 patients with 21 feet. The goals of a triple arthrodesis were accomplished without performing the triple arthrodesis. The positional angles of the foot seen on the DP and lateral radiographs were placed in a more neutral position. The overall patient satisfaction level improved and the patient's quality of life improved. However, the limits on this study were that it was a small patient population with some patients lost to follow up. There was no direct comparision with patients with the triple arthrodesis procedure. Future studies should include a control group with a larger patient base and direct comparison to patients that had the triple arthrodesis procedure.

The radiographic review of the study shows that the corrected foot is in a more neutral fixed position. The changes in positional angles on the DP view (cuboid abduction, talar head coverage, talocalcaneo, forefoot adductus) were statistically significant. The changes in the position angles on the lateral view (Meary's Angle, talar declination, talocalcaneo) were statistically significant. The changes in the structural angles, Metatarasal adductus and calcaneo inclincation angle, were statistically insignificant. Also noted was that the Kirby sign was not seen and the talar head was in a good position. The position angles all trend towards the foot having been fixated in a neutral position. Given that the changes were statistically significant, it shows that the foot is in a more neutral position after surgery.

Overall, the patients in this study were very happy with the results. They expressed satisfaction with the overall reduction of pain. Their quality of life improved in that they were able to perform their activities of daily living again. There was not a nonunion.

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