

8 Rearfoot Surgery

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Femoral Tunnel Position on Conventional Magnetic Resonance Imaging after Anterior Cruciate Ligament Reconstruction in Young Men: Transtibial Technique versus Anteromedial Portal Technique

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Introduction—Anatomic single-bundle anterior cruciate ligament (ACL) reconstructions are commonly utilized to treat ACL injuries. Despite the consensus for use of the anteromedial portal technique over the transtibial technique for better positioning of the femoral tunnel, there is little research that compares the clinical outcomes of the two. To assess the position of the femoral tunnel, available research has used computed tomography (CT) that exposes the patient to large amounts of radiation or cadavers, which are not readily available. This study aims to compare the clinical outcomes of the transtibial and anteromedial portal techniques of ACL reconstruction and quantify the difference in femoral tunnel position between the two methods using magnetic resonance imaging (MRI).

Methods—Sixty-four young (< 45) male patients who underwent single-bundle ACL reconstruction with an Achilles allograft were divided into two groups of 32. Group 1 utilized the transtibial technique and group 2 employed the anteromedial portal technique. The same surgeon performed all reconstructions, and all participants underwent the same postoperative rehabilitation regimen. Clinical outcomes were evaluated using the Lachman test, pivot shift test, International Knee Documentation Committee (IKDC) classification, Lysholm score, Tegner activity scale, and single leg hop (SLH) test both preoperatively and at the last follow-up visit. MRI and radiographic images were used to measure side-to-side differences (SSD), assess the position of the femoral tunnel aperture, and evaluate the posterior cruciate ligament (PCL) index.

Results—The two groups showed no significant difference when evaluated with the Lachman test, pivot shift test, IKDC classification, Tegner scale, and SLH test. Group 2 exhibited more favorable outcomes with the Lysholm score and SSD compared to Group 1 ($p < 0.001$). Group 2 also had a more posteriorly positioned femoral tunnel and a smaller degree of change in the PCL index ($p < 0.001$).

Discussion—The more posteriorly positioned femoral tunnel achieved by the anteromedial technique may be more beneficial because a more anteriorly positioned femoral tunnel may cause stretching or tearing of the graft during flexion and extension of the knee. The PCL index indicates buckling associated with residual knee laxity following ACL reconstruction due to graft stretching. The transtibial group showed significant changes in the PCL index during follow-up, which may be a result of a more vertically positioned femoral tunnel causing graft impingement. A major concern of the anteromedial technique is that the femoral tunnel may be too short; however, this study showed the average length of the femoral tunnel to be long enough to adequately fix the graft in both techniques.—*C. Stucke*

◆ The authors of this article compared the clinical outcome after ACL reconstruction using free Achilles tendon allograft via one of two portal techniques: transtibial or anteromedial. The design of the study was a prospective randomized comparative study. There were two study groups, each with 32 subjects for a total of 64 subjects, all of which were “young male patients.” The diagnosis of ACL rupture was made via physical examination and MRI and confirmed by arthroscopy. While the authors may have arrived at definitive results for this study, which showed that the anteromedial portal technique yielding a more stable knee construct, the functional outcome did not prove to be statistically significant. Another point to consider is that the study group, though it may have represented that sector of the population which would most likely suffer ACL injury, it is not representative of the whole of the population. The fact that the subjects in the study were all “young male patients” poses a considerable limitation when it comes to generalization of the results. One might want to know what results would be seen for females and also for a broader age range that includes middle-aged adults and the elderly. Furthermore, the authors noted four key limitations to their study, which could have affected the outcome. They are as follows: (1) position of femoral tunnel aperture which was used, disqualifies it from being interpreted in light of prior studies of a similar nature; (2) no investigation was made between the position of the femoral tunnel aperture and the clinical outcomes; the aim was comparison of the position of femoral tunnel aperture and the related clinical outcomes; (3) there is a question of intraobserver reliability as it pertains to clinical evaluation; (4) follow-up was only for 2 years; a longer follow-up time would be more ideal to yield more information regarding long-term outcome. Considering all of the aforementioned, it appears that there can be advantages or disadvantages to the use of either technique in ACL reconstruction when the matter is viewed from a case-by-case basis. In general are several factors which determine the choice of surgical procedures, including but not limited to: type of injury, patient’s age,

patient's activity level, presence of comorbidities, availability of surgical equipment and resources, physician experience, etc. There can be legitimate grounds for either approach.—L. A. DiDomenico, D.P.M., and L. Lowe, D.P.M.

Comparison of Transfer Sites for Flexor Digitorum Longus in a Cadaveric Adult Acquired Flatfoot Model

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Background—Adult-acquired flatfoot is a common disorder accompanied by a collapse of the medial longitudinal arch, forefoot abduction, and rearfoot eversion. Posterior tibialis tendon dysfunction (PTTD) is often associated with adult-acquired flatfoot, although the exact role of the dysfunction is not completely understood. Stage II PTTD is generally treated with a soft tissue repair, such as a flexor digitorum longus (FDL) tendon transfer (FDLTT), and an osseous procedure. It was hypothesized that an FDLTT would result in a lateral shift of peak pressure, a lateral shift of center of pressure (CoP), an increase in medial-lateral range of the CoP, and joint kinematics demonstrating inversion, adduction, and plantar flexion. It was also hypothesized that there would be no difference between FDLTT sites.

Methods—Seven cadaveric limbs were transected mid-tibia and induced with a flatfoot through ligamentous attenuation and cyclical loading to mimic PTTD. The limbs were mounted on a robotic gait simulator, and stance phase simulations were performed. Data was collected for peak pressure, CoP position, and CoP range. Range of motion, maximum angle during stance of the talonavicular, and three naviculocuneiform joints were also measured. The FDL was then transferred to three sites including the navicular, medial cuneiform, and the distal residuum of the posterior tibialis tendon (PTT). The same data collection was performed for each FDLTT site.

Results—Peak plantar pressures on the medial side of the foot were reduced by an FDLTT. The largest reduction of pressure on the hallux and first metatarsal was achieved by transfer to the medial cuneiform and to the navicular, respectively. Non-statistically significant trends suggest that transfer to the residual PTT increased the pressure on the second metatarsal. All of the FDLTT failed to produce a difference in CoP. Only the navicular transfer produced a kinematic difference from the flatfoot model in the max dorsiflexion of the navicular medial cuneiform joint. No differences existed between FDLTT locations.

Discussion—Surgical treatment of PTTD is often accomplished by a soft tissue correction and an osseous adjustment. The present study shows that while a FDLTT is able to produce a significant difference in medial peak pressures, it is

not sufficient to cause significant decreases in CoP or changes in joint kinematics. Clinical correction of the biochemical abnormalities caused by PTTD is unlikely to be achieved by an FDLTT without addressing osseous structures.—A. *Rusher*

◆ The authors designed a study to investigate whether there are any differences with regard to kinetics and kinematics with FDL transfer to residuum of degraded PTT (rPTT), navicular (NAV), or medial cuneiform (CUN) in the treatment of stage II posterior tibial tendon dysfunction (PTTD). The study was designed using cadaveric models, which were prepared via surgical induction of stage II PTTD and then surgical repair using the three techniques of FDL transferred described. The authors noted that the PTT was not attenuated during flatfoot preparation. Furthermore, the specimens did not have any other pathological abnormalities such as hallux valgus. The various models were compared against a flatfoot constant and between themselves under subsection to simulated near physiological biomechanical stresses. The results showed a general decrease in peak plantar pressure medially after FDL transfers (rPTT, NAV, CUN) compared to flatfoot constant, but with regard to magnitude of peak plantar pressure, statistically insignificant differences were seen between the three transfer sites (rPTT, NAV, CUN). Secondly, increased lateral pressure was observed for all transfer sites. A key point that was mentioned by the authors, which is quite noteworthy, is that flexor digitorum longus tendon transfer by itself will not be sufficient for changing bony kinematics in stage II PTTD; a concomitant osseous procedure is warranted to have a better outcome. While the results of this study provide helpful information, there are many factors which can influence surgical outcome in the actual live, moving, biomechanically complex patient. Often, PTTD presents with other lower extremity pathology, which must also be taken into consideration (i.e., hallux abductovalgus, equinus, MTJ/STJ/ankle arthritis and pathomechanics, etc.). Therefore, the surgeon's decision-making process regarding procedure of choice in FDL transfer for stage II PTTD will always have to be guided by a thorough assessment of each case with its distinctive presenting characteristics.—L. A. *DiDomenico, D.P.M., and L. Lowe, D.P.M.*

Single-Incision Medial Approach for Double Arthrodesis of Hindfoot in Posterior Tibialis Tendon Dysfunction

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Background—Triple arthrodesis with a two-incision approach has been the primary salvaged produce for symptomatic severe or rigid flatfoot due to posterior tibialis dysfunction. The two-incision approach although effective, has complications such as calcaneocubiod nonunion. This study will look at a single-incision medial double arthrodesis approach to preserve the calcaneocubiod joint

from a nonunion occurring, while also generating the same amount of effectiveness as the two-incision approach.

Methods—The study population included 18 feet in 17 patients, which included five men and 12 women. The mean age of the population was 65 years old, with the average follow-up occurring at 24 months. The patients reported as having a rigid or severe deformity, which had been unresponsive after 6 months of conservative treatment, with no prior arthrodesis surgery.

Results—The single medial incision method showed statistically significant improvement in the radiographic and physical component score. The results illustrated an 89% union rate for the studied subjects. One patient sustained varus malunion due to overcorrection and another patient sustained valgus malunion due to undercorrection. There were no wound-related complications while performing the study. The overall satisfaction rate was 78%.

Discussion—Posterior tibialis tendon dysfunction is the most common cause of planovalgus deformity in adults. The single medial incision to correct this dysfunction was studied to attempt to reduce calcaneocuboid joint nonunion and to limit the amount of shortening of the lateral column. The results of the single-incision double arthrodesis, with posterior tibialis tendon dysfunction did not achieve the desired results of other studies. Therefore, the results were not encouraging enough to suggest the single-incision medial approach, for posterior tibial tendon dysfunction, for daily surgical operation of the deformity.—*J. Watson*

◆ This retrospective study was focused on investigating the benefits of a double arthrodesis (STJ, TNJ) using single medial incision approach versus a triple arthrodesis (STJ, TNJ, CCJ), using double-incision approach in case of posterior tibial tendon dysfunction (PTTD) with rigid/severe pesplanovalgus deformity. The authors stated that their approach provided at least two main benefits: (1) sparing of calcaneocuboid joint (CCJ) and thus avoidance of nonunion at CCJ postoperatively and its related symptoms; (2) avoidance of lateral wound dehiscence by avoiding a lateral incision. In general, these are quite relevant and important concerns for the performance of double and triple arthrodesis, and the goal is to minimize their occurrence. In total, 18 cases of patients who underwent STJ and TNJ fusion using single medial incision approach (slightly posterior to medial malleolus to slightly distal to navicular bone) were reviewed—five men and 12 women with mean age of 65. The measured parameters included union rate, time to union, complications, radiographic assessment, and subjective assessment. Overall union rate was 89%. Solid union at both sites of fusion (STJ, TNJ) was achieved in 83% of patients within 6 months. No wound-related complications were noted, but there were other complications which included varus malunion, valgus malunion, symptomatic hardware requiring removal, and valgus ankle deformity. As far as radiographic assessment is concerned, statistically significant improvement was noted in the following measurements: AP talocalcaneal angle, talo-second metatarsal angle,

lateral talocalcaneal angle, and lateral talo-first metatarsal angle. With regard to the subjective assessment, 22% of subjects had no pain, 44% had mild pain presenting occasionally, and 17% had severe pain on a daily basis. There was an overall satisfaction rate of 78%. Only 28% deemed their feet of better appearance after surgery versus before surgery. The results of this study did show that a one-incision approach is beneficial for avoiding the occurrence of the stated complications; however, there are many other potential complications that can present, as evidenced by their results. Therefore, the decision to choose one method over the other has to be determined on a case-by-case basis. Based on the outcome of this retrospective analysis, the authors concluded that though favorable in support of their claims, their results did not provide strong enough evidence compared to prior studies, to advocate a single medial incision double arthrodesis as the procedure of choice over that of triple arthrodesis. Furthermore, they noted several limitations, including a small study group, short follow-up time, associated procedures performed on several of the subjects (potentially confounding for results), and a lack of a triple arthrodesis comparison group. A prospective randomized study for further analysis of this alternative approach was suggested, and rightly so, as this would be needed to yield more information to advocate the general use of one technique over another.—L. A. DiDomenico, D.P.M., and L. Lowe, D.P.M.

Safety and Efficiency of a 2-Portal Lateral Approach to Arthroscopic Subtalar Arthrodesis: a Cadaveric Study

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Introduction—Arthroscopy offers a safer and more efficient approach to subtalar arthrodesis than open techniques (48% complication rate). However, there is variation among the different arthroscopic subtalar approaches and their safety regarding the surrounding anatomical structures. The purpose of this study is to investigate the safety and I bevlieve this shoud be efficacy of a two-portal lateral (anterior and middle) approach to arthroscopic subtalar arthrodesis.

Methods—This study utilized 30 cadaveric feet with a mean age of death of 78 ± 6.7 years. The middle sinus tarsi portal was made just inferior and anterior to the tip of the fibula on the equator of the sinus tarsi soft point, and the anterior portal was placed a half centimeter above the anterior process of the calcaneus on the sinus tarsi equator. A 4-mm arthroscope was used along with a 3.5-mm full-radius synovial shaver for soft tissue debridement and a 4.5-mm shielded-bur for joint surface freshening of the posterior subtalar joint. Metal rods were placed in the two portals following joint freshening and the feet were carefully dissected for viewing any compromised structures. The distance between the superficial peroneal

nerve and the anterior portal was measured along with the distance between the sural nerve and middle portal. The resected areas of the posterior subtalar facets were also measured using digital photographs.

Results—The mean distance between the lowest branch of the peroneal nerve and the anterior portal was 16.7 ± 8.4 mm and the mean distance between the highest branch of the sural nerve and the anterior portal was 12.2 ± 5.3 mm. An average resection greater than 90% was obtained for both the posterior talar and calcaneal subtalar joint facets. The lateral sinus tarsi arterial network was found to be intact in 28 of 30 cases. Two cases exhibited incomplete lesions of the calcaneofibular ligament. Lesions were found on the peroneal tendon sheath and peroneus brevis tendon in three cases. No lesions were identified to the remainder of the surrounding nerves, vessels, ligaments, and tendons.

Discussion—Despite the lack of evidence on the amount of joint freshening needed to achieve bone fusion, this study shows that the two-portal lateral approach to arthroscopic subtalar arthrodesis appears to be safe and efficient with a mean freshening of posterior talar and calcaneal subtalar joint facets greater than 90%. The two portals are positioned as close to the sinus tarsi equator as possible to avoid superficial peroneal and sural nerve risks experienced in previous studies. The two-portal lateral approach also protects the anterior tibial, peroneal, and sinus tarsi arteries, which prevents avascular necrosis of the talus by placing the portals plantar to each of these vessels.—*C. Stucke*

◆ In this cadaveric study the safety and I believe this should be efficacy of the use of a lateral two-portal approach to arthroscopic subtalar joint (STJ) arthrodesis was investigated. The authors used two portals; middle portal placed just distal and anterior to tip of fibula, and anterior portal, placed opposite to the middle portal 0.5 cm above tip of anterior process of calcaneus. In utilizing this technique the authors were able to achieve their primary and secondary objectives. Primarily, they sought to obtain a high percentage of resected STJ surface both on the calcaneal and talar aspect of the joint. This was achieved with resected percentages being 91.2% for calcaneal portion and 93.9% for talar portion. Secondarily, the authors were able to avoid lesions to sural nerve, superficial peroneal nerve, and tibial nerve; avoid disruption to lateral sinus tarsi vascular network; avoid lesions to cervical and interosseous talocalcaneal ligament; and avoid injury to the following tendon sheaths: peroneal (except minor breach), posterior tibial, flexor hallucis longus, and flexor digitorum longus. They reported distances of the portals from neural structures as a significant benefit in the use of this technique, with the smallest measured distance to sural nerve and superficial peroneal nerve being 4 mm for both middle and anterior portals, respectively. The objectives outlined in this study are generally desirable in the performance of any STJ arthrodesis and thus the results of this study can prove beneficial in the decision-making process with regard to use of an arthroscopic technique over an open technique and in particular, to portal placement. However, as noted by the authors, there are limitations to application of the results of this study in live patient scenarios, in which other factors may be encountered, which is certainly not present in the cadaveric

model. Furthermore, there is no way of measuring clinical, functional, and long-term radiographic outcome of this fusion technique in a cadaveric model; therefore, its application is limited in that respect when considering live patient cases.—L. A. DiDomenico, D.P.M., and L. Lowe, D.P.M.

Subtalar Fusion for Pes Valgus in Cerebral Palsy: Results of a Modified Technique in the Setting of Single Event Multilevel Surgery

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J Pediatr Orthop. 2013 Jun;33(4):431-438.

Background—Equinovalgus is a common deformity in children with cerebral palsy that has an abnormal biplanar relationship between the talus and navicular. This relationship has been radiographically termed as dorsolateral peritalar subluxation (DLPTS). Extra-articular subtalar arthrodesis that addresses the unstable valgus hindfoot has succeeded in evolving, leading to a subtalar internal fixation technique by Dennyson and Fulford designed to accurately realign the subtalar joint. The purpose of this study is to describe a modification of Dennyson and Fulford technique in the correction of DLPTS in children with bilateral spastic cerebral palsy, quantify the radiographic corrections, and examine the change in functional measurements post-surgery.

Methods—This retrospective cohort study examined 46 children from a children's tertiary care hospital between January 1999 and December 2004. The children were diagnosed with bilateral spastic cerebral palsy and underwent single-event multilevel surgery (SEMLS) procedure. A review of the patients' radiographs, sagittal gait pattern, Gross Motor Functional Classification System (GMFCS) level, surgical prescription, and Functional Mobility Scale (FMS) was performed. Surgery proceeded with a modified Ollier incision over the sinus tarsi and reduction of the subtalar joint. The joint was fixed with a fully threaded cannulated 7.3-mm cancellous screw, and the precut cortico-cancellous dowel was "press fit" into the sinus tarsi. Fusion rates were evaluated with radiographs, and the corrections were measured using the lateral talocalcaneal angle (LTCA), the lateral talo-first metatarsal angle (LTMtA), and navicular cuboid overlap (NCO).

Results—The patients were identified as 22% GMFCS II, 46% GMFCS III, and 33% GMFCS IV. Postoperative radiographic indices revealed significant improvement in all three measurements. LTCA improved by an average of 20 degrees ($p < 0.001$), LTMtA averaged a 21-degree improvement ($p < 0.001$), and NCO improved by 29% decrease in overlap ($p < 0.001$). Additionally, FMS

exhibited statistical significance in improvements at distances of 5 m, 50 m, and 500 m, with no decrease in function postoperatively.

Conclusion—The modified Dennyson and Fulford technique demonstrated significant improvements in structural alignment and function for children with spastic cerebral palsy. The dowel allograft avoids harvesting of the iliac crest, and its design improves stability while simultaneously lessening the risk of nonunion. This study confirms that the graft and fusion technique are effective for single-event multilevel surgery to correct dorsolateral peritalar subluxation in children with cerebral palsy.—*W. D. Garner*

◆ In this study the authors assessed the outcome of a bilateral STJ arthrodesis with press fit corticocancellous allograft for correction of bilateral “dorsolateral peritalar subluxation.” The study subjects were children, 46 in total, all with spastic cerebral palsy. The mean age was 12.9 years. A modified Ollier incision was utilized to gain exposure to STJ. The method of fixation was with a 7.3-mm fully threaded cancellous screw traversing STJ in an oblique to vertical dorsal to plantar orientation. Three radiographic angles were measured preoperatively and postoperatively, which showed significant improvement, namely: lateral talocalcaneal angle, lateral talo-first metatarsal, and navicular cuboid overlap; the reported improvement was 20 degrees, 21 degrees, and 29 degrees, respectively. Other parameters relating to functional outcome showed improvement as well. The average follow-up time of the subjects in this study was 55 months, which is satisfactory for meaningful assessment of long-term results. Overall, this study is relevant in helping to guide surgeons as it pertains to surgical correction of this type of deformity (“dorsolateral peritalar subluxation”) related to cerebral palsy in pediatrics, or similar pathology. Pediatric reconstructive surgery can be challenging given skeletal immaturity and various other factors that may be present and must be taken into consideration, thus, having a technique which yields predictably good results for the patient is certainly desirable.—*L. A. DiDomenico, D.P.M., and L. Lowe, D.P.M.*

Isolated Subtalar Arthrodesis through Minimal Incision Surgery

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Introduction—When a patient has an isolated pathology of the subtalar joint, isolated subtalar arthrodesis (ISA) is an acceptable choice for treatment. The most common indication for this procedure is painful post-traumatic talar osteoarthritis after a fracture of the calcaneus or talus. Using large incisions in patients who require subtalar arthrodesis has an increased risk of infection, neurovascular

damage, and delayed wound healing. Many of the patients who require this procedure have compromised soft tissues that increase the previous-mentioned risks. There are contraindications with arthroscopic surgery, which include gross malalignment of the hindfoot and significant bone loss of the talus or calcaneus, and this technique is more demanding on the skill of the surgeon.

Methods—Seventy-seven feet on 76 patients had the ISA procedure; the mean follow-up was 50 months. All patients had conservative treatment for at least 6 months before the procedure. There were 36 retrospective and 47 prospective cases in this study. The patients' conditions included complex calcaneal fractures, previous failure of subtalar arthrodesis, tarsal coalition, primary subtalar osteoarthritis, inflammatory osteoarthritis, and other neuromuscular dysfunctions. Fusion was determined by two Brodens and one lateral radiograph showing complete bridging with absence of radiolucencies.

Results—Four months after the procedure, 92.2% of patients had fusion. Six of the 77 patients had delayed radiological consolidation with pain. Fifty-seven achieved "good" results, 13 were "fair," and seven were "poor"; this was based on Angus and Cowell criteria. There was a mean increase in the AOFAS score at 47.6 points; 74% of the patients who required daily analgesia before surgery no longer needed it after. Fifty-seven percent of the patients who required insoles returned to normal shoes after 1 year. Eighty-eight percent of the patients obtained proper alignment with a plantigrade and stable foot. Ninety-one percent of the patients stated that they would undergo the operation again if given the choice to or not.

Discussion—The main goal of using ISA was to eliminate pain and to maintain hindfoot function, which would allow patients to return to normal activities relatively early. The authors had many patients with high-risk complications associated with large skin incisions, which is why those chose ISA; however, the technique most surgeons use is a large skin incision, since they want to avoid poor fusion by having adequate visualization. It is stated that one limitation of this minimally invasive approach is that it doesn't allow for the use of bone graft when there is bone loss; it is also stated that the most common complication in the study was screw protrusion. The authors also state that since they had very small numbers, they do not recommend MIS for revision surgery.—A. Kamery

◆ These authors conducted a retrospective and prospective case review of patients who underwent isolated subtalar joint arthrodesis through minimal incision surgery. The authors stated their reasons for performing this type of procedure, which include the following: (1) containing bleeding biological material within the joint; (2) avoiding periosteal stripping and thus favoring vascularity and bone healing; and (3) avoiding incisions over tissue, which is devitalized, scarred, or poorly vascularized, thus reducing incidence of poor scarring, wound dehiscence, and infection of soft tissue. The authors performed the STJ arthrodesis through a 1-cm incision over sinus tarsi and a posterolateral portal lateral to Achilles tendon slightly above tip of lateral malleolus. Their choice of internal fixation was one 8.5-mm cannulated screw or two screws in case of poor bone stock directed from plantar calcaneus to dorsal talus. While the

authors reported generally good outcome with regard to several parameters: pain, function, alignment, quality of life, complications, and patient satisfaction, limitations of the study were also noted. A key limitation is the inability to perform bone grafting in the event of bone loss with this type of arthrodesis technique. In light of this, consideration should be given by the operating surgeon on a case-by-case basis to the likelihood of needing a bone graft if this technique is to be used. There also appears to be a learning curve associated with this technique; therefore, those attempting it would have to ensure that they are properly trained to achieve good results. In cases of revisional surgery, this technique is not recommended by the authors because their study group was very small, and furthermore, the follow-up period was relatively brief, being 15 months. In light of these factors, as is noted by the authors, further study is warranted before it can be advocated on a broader scale. However, given the proper patient selection, minimal incision surgery in the case of isolated STJ arthrodesis does afford for several clinically and functionally desirable outcomes.—L. A. DiDomenico, D.P.M., and L. Lowe, D.P.M.

Subtalar Distraction Osteogenesis for Posttraumatic Arthritis Following Intra-Articular Calcaneal Fractures

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Foot Ankle Int. 2013 Mar;34(3):398-402.

Introduction—Calcaneal fractures, which account for 1%-2% of all fractures, are a common clinical finding. Frequently, the calcaneal fractures are accompanied by fractures into the subtalar joint. Accompanying severe soft tissue injury delays the early reduction and internal fixation of the fractures; the result may be arthritis and severe deformity. Subtalar *in situ* arthrodesis and subtalar distraction bone-block arthrodesis with or without osteotomy are the currently employed treatment modalities for these types of fractures.

Methods—This study includes seven patients whose ages range from 16 to 54 years. Epidural anesthesia was utilized along with a pneumatic tourniquet on the thigh in the supine position. Prominent lateral calcaneal bone fragments and all cartilaginous surfaces of the subtalar joint were removed. An external fixator was placed using fluoroscopy along with two screws in the posterolateral calcaneus and two screws in the lateral, middle-lower part of the tibia. The external fixator was left in place for 7 to 10 days, followed by 1 millimeter per day of distraction across the subtalar joint for 2 to 3 weeks. This process was monitored by weekly serial radiographs. The external fixator was then removed and the patients were able to resume bearing weight on the affected feet.

Results—Calcaneal height increased by 12.5 mm on average among the seven

patients. The average American Orthopaedic Foot and Ankle Society hindfoot score increased from 25.3 preoperatively to 76.3 postoperatively. The average time to subtalar joint fusion was 4.9 months.

Discussion—The procedure was novel and successful among the seven patients involved in the study. One patient experienced severe pain during distraction of the subtalar joint. This problem suggests that further research of the procedure itself is necessary. The number of patients in the study was small; therefore, a future study with a larger number of patients is needed to support the authors' findings.—*S. M. Erman*

◆ These authors performed a level IV retrospective case series of a surgical treatment, consistent with gradual subtalar distraction using external fixation and attempting to restore the calcaneal height and an assessment of its efficacy. The articular surfaces and subchondral bone of the posterior facet of the subtalar joint were surgically removed. An external fixator, attached with two pins in the tibia and two pins in the posterolateral calcaneus was used. The subtalar joint was compressed for 7 to 10 days followed by gradual subtalar distraction at 1 mm/day. The lengthening procedure was stopped when the calcaneal height was restored according to radiography. Seven cases of old calcaneal fractures accompanied by severe subtalar joint injury (8 feet) were treated using this method. Average follow-up was 14.3 months (range, 7-36 months). In all seven cases (1 case bilateral feet), the postoperative wound healed primarily. The calcaneal heights of all eight feet were partially restored. Subtalar joint bone fusion was completed within 4 to 6 months after the surgery. The average preoperative American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot score was 25.3, and the average postoperative AOFAS score was 76.3. Subtalar distraction osteogenesis with external fixation is an effective alternative method for the treatment of old calcaneal fractures with secondary severe subtalar joint arthritis in a small group of patients, resulting in a level IV retrospective series. The article does not express the surgical experience the surgeon should have prior to embarking with this technique. Additionally, it does not get into the potential complications that one can encounter with the use of external fixation as well as the length of time it takes to obtain a union.—*L. A. DiDomenico, D.P.M.*

Subtalar Distraction Arthrodesis Using Fresh-Frozen Allogeneic Femoral Head Augmented with Local Autograft

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Foot Ankle Int. 2013 Apr;34(4):550-556.

Introduction—Calcaneal malunions can lead to complications that include subtalar arthritis, a decrease in arch height, and a weakened Achilles tendon, along with many other structural and functional problems. Subtalar distraction arthrodesis

(SDA) using tricortical autograft is commonly indicated for severe calcaneal malunions with positive outcomes. Structural allograft with orthobiological agents has also been used to enhance the results of such a procedure. This study set out to determine the effectiveness of performing an SDA using fresh-frozen allogeneic femoral head without the use of orthobiological agents.

Methods—The study was performed using a retrospective review of 15 SDA procedures conducted on 13 patients. The same surgeon performed all surgeries that were chosen for the study. Fresh-frozen allogeneic femoral head grafts were used in all SDAs reviewed. Success of the surgery was described by using the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score, as well as a visual analogue scale (VAS) pain score. Along with the clinical evaluation of the results, radiographic analysis was conducted, and the following measurements were determined and compared: talar declination angle (TDA), calcaneal inclination angle (CIA), lateral talocalcaneal angle (LTCA), and heel height. Union of the arthrodesis was determined by visualizing bridging trabeculations on lateral X-ray. Dorsiflexion, plantarflexion, and ankle range of motion was also objectively evaluated. SDAs were performed by creating an incision posterolaterally at the level of the ankle and distracting the posterior facet of the subtalar joint. Fresh-frozen allogeneic femoral head from a bone bank was then shaped to size and impacted into the space created by the distraction. Patients were instructed to remain non-weight-bearing for 10 weeks after surgery.

Results—In the clinical evaluation, there was statistically significant improvement in the AOFAS and VAS pain scores. Likewise, all radiographic angles significantly improved. Also, the median increase in heel height was 8.6 mm. However, range of motion at the ankle joint did not exhibit a significant difference.

Conclusion—While the study showed a 100% union rate and a 93.3% satisfaction rate, there were some complications from the SDAs performed including varus alignment of the hindfoot, sural neuralgia, and irritation from hardware. The most significant limitation to the study was the small sample size. The study proved that the use of fresh-frozen allogeneic femoral head without orthobiological agents was comparable to other types of grafts commonly used for calcaneal malunion. However, this method is also more cost-effective and lacks the added complication of morbidity at the autograft site.—*E. Athanasoula*

◆ This study was a retrospective analysis of cases of subtalar distraction arthrodesis (SDA) for calcaneal malunion using fresh-frozen allogeneic femoral head supplemented with local autograft from calcaneus (lateral wall). All cases of SDA were performed by the same surgeon over a 2-year period. A total of 13 patients (15 feet) were reviewed and evaluated according to several parameters. AOFAS score, SF-12 physical and mental health summary, radiographic measurements: calcaneal inclination angle (CIA), lateral talocalcaneal angle (LTCA), talar declination angle (TDA), heel height,

calcaneal length, and union time were all evaluated. Statistical analysis demonstrated significant improvement in the majority of measured parameters. An overall patient satisfaction rate of 93.3% (14 feet) was reported. As it pertains to the radiographic analysis, average improvement was seen for the following: TDA (16.9 degrees to 20.7 degrees); CIA (9.2 degrees to 17.2 degrees); LTCA (29.0 degrees to 40.7 degrees). Heel height displayed an average increase from 66.9 mm to 75.0 mm. Fusion was reported in 100% of cases by a median of 13 weeks postoperative. It appears that the use of fresh allogeneic femoral head augmented with local calcaneal autograft is a viable option for STJ distraction arthrodesis in cases of calcaneal malunion. However, given that the follow-up time of this study was an average of 3 years, the question still remains regarding the outcome over a longer time period. Furthermore, the study had a relatively small number of cases and no control group, as noted by the authors. Having a greater number of cases is certainly important for the advocacy of this technique and any surgical technique in general. The procedure, though showing overall good results, is not without complications as reported by the authors (varus alignment of hindfoot, chronic regional pain syndrome, hardware irritation, and sural neuralgia); also, collapse of femoral head, though minimal, was noted after 3 months. Therefore, these factors, potential drawbacks, must be kept in mind and carefully weighed against the benefits of the procedure. Surgeon skill, experience in performing procedure, and modification of the surgical technique (such as varying fixation method, etc.) can also influence the overall outcome.—*L. A. DiDomenico, D.P.M., and L. Lowe, D.P.M.*

Predictive Risk Assessment for Major Amputation after Tibiotalocalcaneal Arthrodesis

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Introduction—Tibiotalocalcaneal (TTC) arthrodesis with the use of an intramedullary nail is an effective method of limb salvage and deformity correction. However, due to risk of amputation in revision ankle fusion treated with TTC fusion with internal fixation, patients and physicians would both benefit from the ability to provide an educated and realistic estimation of the risk of limb loss after TTC fusion. This study used a large database of TTC fusions and statistical methods to build a model to determine risk factors for amputation, and thereby devised a formula to predict the risk of amputation.

Methods—One hundred seventy-nine patients from a single center database treated with an intramedullary arthrodesis nail had a comprehensive chart and radiographic review performed. The primary endpoint was amputation. Patients were divided into two groups: those who eventually went on to major amputation and those who did not. Regression modeling was used to find notable variables that

affected the eventual salvage or loss of limb, and these variables were evaluated for differences between the groups. A model was built to determine the odds ratio of risk of amputation for each significant variable, and these results were simplified in a formula devised to represent patients' amputation risk.

Results—Eventually, 21 of the 179 patients went on to amputation. Through regression modeling, age, diabetes, revision surgery, and preoperative ulcer were found to be important risk factors in determining amputation. The highest risk factor was diabetes with an odds ratio of 7.01 (95% confidence interval, $p = 0.002$), followed by revision surgery and presence of a preoperative ulcer. The probability of amputation could be calculated by the equation: $e^x/(1+e^x)$ where variable x is determined as a factor of age, diabetes, revision surgery, and presence of preoperative ulceration. A spreadsheet formula Web page was constructed to simplify risk calculation.

Conclusion—This study presents a model to help predict the risk of amputation in patients requiring a TTC with an intramedullary nail. The large cohort and statistical methods make this study a good objective estimation of risk for major amputation and may assist clinicians and patients in preoperative consultation. The model and formula provided may also aid future studies as a method to compare results.—*M. M. DeArmon*

◆ Tibiotalocalcaneal (TTC) arthrodesis using a nail has been shown to be an effective salvage technique. This paper reviews the risk of major amputation associated with a tibiotalocalcaneal arthrodesis. An understanding of the relative risk of amputation after TTC fusion and the influencing factors could help understand the rate of limb salvage. One hundred seventy-nine limbs were treated with TTC fusion with an intramedullary nail. A chart and radiographic review was performed. Patients were divided into two groups: those who went on to eventual amputation and those with successful salvage of their limb. There were 21 limbs that were eventually treated with major amputation. This represents a salvage rate of 88.2% (158/179 patients). Age was a factor in amputation risk, and the highest risk factor for amputation was diabetes with an odds ratio of 7.01 and 95% confidence, $p = 0.0019$. The odds of amputation were 6.2 times and three times greater for patients undergoing revisions and those with preoperative ulcers, respectively. The probability of amputation could be found preoperatively by using the derived equation: $e^x/(1 + e^x)$ where x is a factor of age, diabetes, revision, and ulceration. TTC arthrodesis with a retrograde intramedullary nail has a high rate of limb salvage across a wide range of indications and medical comorbidities. In this patient cohort, diabetes was the most notable risk for amputation, followed by revision surgery, preoperative ulceration, and age. A model has been built to help predict the risk of amputation. This paper is very helpful in determining preoperative risk for patients undergoing a TTC fusion. This formula could possibly be applied to other surgical procedures with similar circumstances. The extracted risk factors listed above are detailed in order for the treating surgeon to be cognizant of when approaching these high-risk patients and increased awareness of risk with TTC fusions. This information may be very helpful

and possibly be applied in similar circumstances in reconstructive foot and ankle surgery.—L. A. DiDomenico, D.P.M.

Extraosseous Talotarsal Stabilization Using HyProCure®: Preliminary Clinical Outcomes of a Prospective Case Series

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Introduction—Stability of the talotarsal joint (TTJ) is paramount to the function of the foot and ankle complex. Misalignment of this articulation, termed recurrent talotarsal dislocation (RTTD), causes severe biomechanical abnormalities and possible pathologic deformity secondary to abnormal subtalar joint pronation. Extraosseous talotarsal stabilization (EOTTS) with the HyProCure® stent is a minimally invasive procedure for attaining stabilization of the TTJ. By inserting this device into the sinus/canalis tarsi, the surgeon is able to restore normal alignment of the TTJ articular facets. The purpose of this prospective study was to evaluate the efficacy of the HyProCure® stent as a stand-alone procedure for correction of RTTD and associated pathologies.

Methods—The diagnosis of RTTD was determined through clinical observation and radiographic analysis. An approximately 1.5-cm linear incision was made obliquely over the sinus tarsi, 1 cm from the distal aspect of the fibula. A path to the sinus tarsi was created via blunt dissection. Soft tissues within the sinus tarsi were transected to accommodate the HyProCure® device. Stent placement was confirmed with fluoroscopy and range of motion was assessed (goal 3°-5° pronation). The incision was closed by subcuticular suturing technique.

The Maryland Foot Score (MFS) questionnaire facilitated subjective evaluation of preoperative/postoperative pain, foot function, and appearance.

Results—From March 2010 to November 2011, 35 patients, 71.43% female with a mean age of 41, underwent EOTTS. Postoperative MFSs fell below the preoperative scores 1 week post EOTTS, then quickly surpassed the preoperative scores at week 3. Postoperative MFSs showed statistically significant improvement compared to preoperative scores at 4 weeks, with continued gradual improvement through one year. One-year follow-up scores revealed a 36.97% decrease in pain, 14.39% increase in foot function, and 29.49% improvement in appearance. The mean postoperative MFS for the 21 patients compliant with the trial after 1 year was 89.17 ± 14.41 points, a significant improvement from 71.57 ± 17.58 points preoperatively. No clinically significant complications were observed during the study.

Conclusions—Measurement of patient pain, foot function, and appearance preoperatively showed statistically significant improvement postoperatively with stand-alone HyProCure® device implantation. The subgroup of patients with foot conditions secondary to RTTD showed similar results to the entire patient population, suggesting that treatment of underlying RTTD has a positive effect on the progression of secondary deformities. EOTTS may therefore be indicated to improve patient outcomes in conjunction with other procedures to correct for pathologies associated with excessive subtalar joint pronation.—C. A. Brush

◆ This was a prospective study which examined the preliminary subjective outcomes of extraosseous Talotarsal Stabilization with use of a HyProCure implant. The implant was used in pediatric and adult patients for treatment of recurrent talotarsal dislocation (RTTD). A total of 46 feet in 35 patients (10 males and 25 females) were included in the study. Three primary criteria were used to evaluate outcome of procedure subjectively via Maryland Foot Score (MFS) Questionnaire: pain, foot function, and appearance. The follow-up interval for the subjects in the study was structured as follows: 1, 2, 3 weeks; 6 months; 1 year. Overall, the authors reported statistically significant improvement across all of the categories evaluated. At the 1-year postoperative mark, mean pain score was 37.67 ± 10.81 compared to preoperative value of 27.5 ± 12.78 (scale 0-45: 0 = disabling pain; 45 = no pain). The mean score for function at 1 year postoperative mark was 42.13 ± 4.13 versus preoperative value of 36.83 ± 5.34 . With regard to appearance, mean score at 1 year postoperative mark was 9.37 ± 1.5 versus preoperative value of 7.23 ± 2.93 . The physical and functional design of HyProCure adds much credibility to its use in several ways. The implant is shaped in such a way as to afford for anatomic compatibility within the sinus tarsi and also biomechanical compatibility with motion about the subtalar joint axis. It is designed to fit in the sinus tarsi in an anterior-lateral-distal to posterior-medial-proximal orientation, which is the same as the normal configuration of the sinus tarsi. It functions by facilitating normal alignment of the articular facets of the talotarsal joint, in addition to preventing abnormal and excessive motion (i.e., hyperpronation with subsequent prolonged unlocking of midtarsal joint and delay in subtalar joint resupination during gait cycle). Furthermore the physical construct of the implant affords for stability in the sinus tarsi (having a lateral conical portion and medial cylindrical portion, essentially to fit the shape of the sinus tarsi, while also being threaded to allow for tissue on-growth, thus enhancing its stability). The minimally invasive technique required for implantation of HyProCure is also another added benefit (with sizers to ascertain exact size needed, and the implant being cannulated, allowing precise placement). Minimizing surgical incision size, number of incisions, soft tissue dissection, and bony debridement are all desirable ends toward achieving a good outcome for this procedure. An implant that is anatomically compatible restores and maintains normal anatomic alignment, restores normal biomechanical function, and is stable and durable all at the same time; these are key features which are needed in advocating its use. From the general results of this study, HyProCure is one which deserves its due consideration in the treatment of RTTD.—L. A. DiDomenico, D.P.M., and L. Lowe, D.P.M.

QUESTIONS

- 8-1. Carranza-Bencano, et al. found that which of the following was not a complication of performing isolated subtalar arthrodesis with a minimal incision?
- A. Does not allow for bone graft if there is bone loss
 - B. Screw protrusion
 - C. Poor patient satisfaction
 - D. Fusion not achieved
- 8-2. Which of the following is not a complication of the subtalar distraction arthrodesis procedure using fresh-frozen allogenic femoral head discussed by Chiang, et al.?
- A. Morbidity at autograft site
 - B. Hardware irritation
 - C. Varus alignment of the hindfoot
 - D. Sural neuralgia