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A Comparison of Split Peroneus Brevis Tendon and Semitendinosus Allograft Tendon for Lateral Ankle Ligament Reconstruction

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ABSTRACT

Lateral ankle instability is a debilitating condition that is often unresponsive to conservative therapy. Many techniques for operative repair have been proposed, most commonly performed as the Broström or modified Broström procedure. In patients with failed primary repair, hereditary collagen disorders, strenuous work activity, obesity, or ligamentous laxity, the Broström repair is less likely to be successful, and anatomic or nonanatomic reconstruction should be considered. The purpose of this study was to compare the functional outcomes and patient satisfaction between anatomic and nonanatomic reconstruction of the lateral ankle ligament complex for lateral ankle instability using a retrospective cohort study. We evaluated 64 ankles in 62 patients who underwent either a split peroneus brevis tendon (n = 36) or semitendinosus allograft tendon reconstruction (n = 28) for lateral ankle instability performed by the same surgeon. Postoperative American Orthopedic Foot and Ankle Society ($p = .943$) and patient satisfaction ($p = .279$) found no significant difference between either technique. Our results suggest that both split peroneus brevis and semitendinosus allograft may be viable alternatives for lateral ankle instability when primary ligamentous repair is not attainable.

Ankle sprains are 1 of the most common lower extremity injuries, accounting for upward of 20% of all sports related injuries (1). Although most sprains can be treated conservatively with physical therapy programs and proprioceptive training (2), there is a subset of the population that fails nonoperative treatment. The failure of conservative treatment with continued symptomatology 6 months after injury (3,4) is 1 of the main indications for surgical repair.

Several techniques of ligamentous repair have been described, categorized into anatomic repair, anatomic reconstruction, or nonanatomic reconstruction. Within the anatomic repair group, the attenuated anterior talofibular ligament (ATFL) and calcaneofibular ligament are directly repaired, most commonly performed as the Broström or modified Broström technique (5). Although there have been excellent results reported with this repair, there are many factors that have been associated with worse outcomes following the Broström technique including longstanding ankle instability with attenuated lateral ligaments, obesity, failed previous ankle stabilization surgery, generalized ligamentous laxity, or strenuous work or athletic activity (6–8). For these patients, consideration should be given to anatomic or nonanatomic reconstruction. Both methods have been shown to provide excellent functional outcomes (9–12), but there is limited research directly comparing the outcomes of both of these techniques when performed by the same surgeon. The purpose of this study was to compare the functional outcomes and patient satisfaction between anatomic and nonanatomic reconstruction of the lateral ankle ligament complex for lateral ankle instability.

Patients and Methods

Medical Record Review

With institutional review board approval after an expedited review, consecutive patients from the senior author's (R.S.R.) surgical records who had undergone a lateral ankle ligament reconstruction between December 2006 and February 2018 were identified. Inclusion criteria included consecutive patients who underwent lateral ankle ligament reconstruction performed by the primary author using either a nonanatomic split peroneus brevis tendon or anatomic semitendinosus allograft tendon. None of the patients who had undergone lateral ankle stabilization were excluded. Medical records were analyzed and data abstracted by the coauthor (K.G) including age, gender, body mass index (BMI), presence of diabetes mellitus, smoking, complications, and adjunct procedures performed. Operative repair was performed on patients who had feelings of ankle instability, recurrent ankle sprains, lateral ankle pain, and radiographic or clinical findings of increased talar tilt or anterior drawer, and who failed at least 6 months of conservative treatment including physical and proprioceptive therapy, immobilization, and nonsteroidal anti-inflammatory drugs. Our criteria for ligament reconstruction were previous failed ligament repair, obesity defined as BMI > 30, or generalized joint laxity defined as increased or excessive range of motion compared to the normal population.

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Conflict of Interest: R.R. is a consultant to Osteomed and on the National Board of Podiatric Medical Examiners.

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Magnetic resonance imaging was ordered preoperatively for patients with suspicion of intra- and juxta-articular pathologies other than lateral ankle ligament disruption as part of the surgical plan.

Patients were examined postoperatively and followed for a minimum of 4 months. Outcome measures included the American Orthopedic Foot and Ankle Society (AOFAS) ankle and hindfoot scoring system and a patient satisfaction questionnaire with a simple "yes" or "no" answer, asking if they would have the same procedure again (13,14). Complications were defined as any instance of recurrent instability, wound dehiscence, hardware loosening, development of rearfoot arthritis, nerve injury, or development of complex regional pain syndrome.

Surgical Technique

The patient was placed supine with an ipsilateral hip bump. A thigh tourniquet was applied and a local anesthetic block performed. A stress examination was performed under anesthesia and fluoroscopy to confirm instability via the anterior drawer and inversion stress test. At this time, any ancillary procedures are performed before the lateral ankle stabilization.

For the lateral ankle ligament reconstruction, a curvilinear incision was made along the peroneal tendons. The sural nerve was identified and protected for the procedure. The tendon sheath was opened and the tendons inspected and repaired as necessary. At this time, based on the extent of damage, quality of the tendons, patient body habitus, comorbidities, and history, it was decided to perform either a split tendon transfer or an allograft for reconstruction of the lateral ankle ligaments.

Surgical Technique for Semitendinosus Allograft Tendon

A guidewire was placed from lateral to medial into the talar neck under fluoroscopy to confirm positioning. A stab incision was made over the wire and a 5.5-mm drill hole was developed, leaving the medial cortex of the talus intact. At this time, a presutured semitendinosus allograft was inserted into the drill hole and a 5.5-mm absorbable tendon anchor is used to secure the graft (Fig. 1). A stab incision was then placed in the anterior fibula at the level of the ankle joint and a 4.75-mm drill hole was made from anterior to posterior with care to not violate the ankle joint (Fig. 2). The allograft was tunneled through the deep tissues from the lateral talus to the anterior fibula and passed from anterior to posterior through the fibula and held in place with a 4.75-mm absorbable tendon anchor with the ankle held in slight dorsiflexion and eversion. The allograft was then passed superficially to the peroneal tendons to prevent subluxation of the peroneal tendons (Fig. 3). A guidewire was then placed from lateral to medial under fluoroscopy in the calcaneal tubercle and a 6.25-mm drill was used to create a bone tunnel, taking care

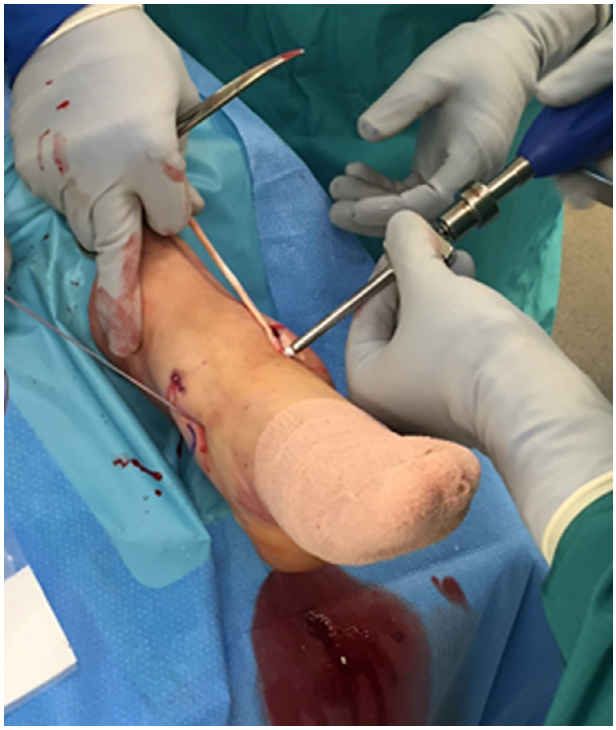

Fig. 1. Anchoring the semitendinosus allograft into the neck of the lateral talus with an absorbable tenodesis screw.

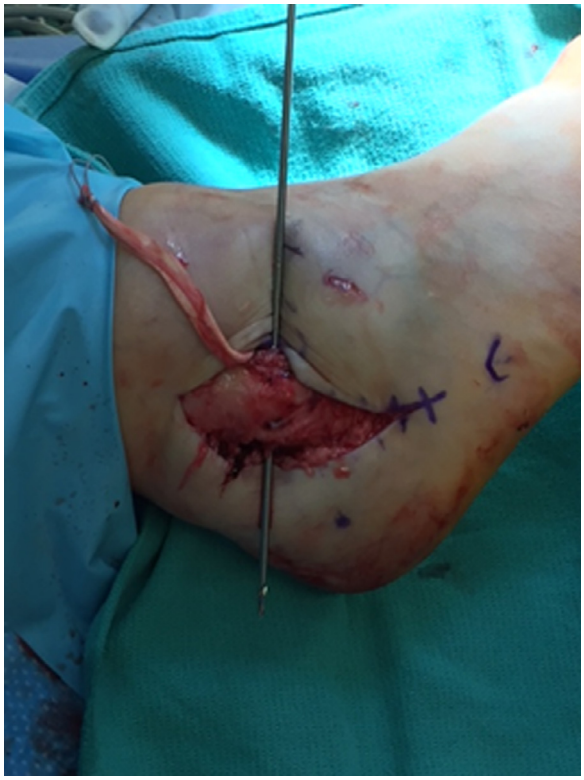

Fig. 2. Drilling of the fibula from anterior to posterior for passage of the semitendinosus allograft.

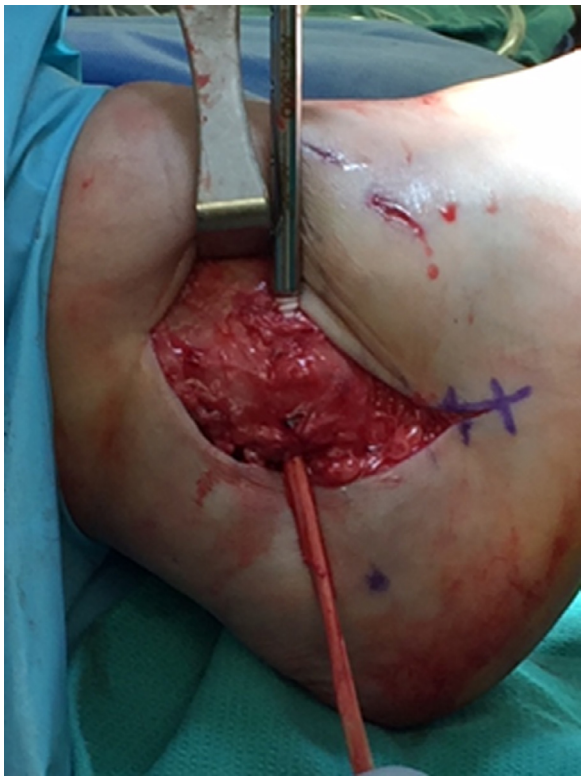

Fig. 3. Anchoring the semitendinosus allograft with an absorbable tenodesis screw with the foot held in a neutral position.

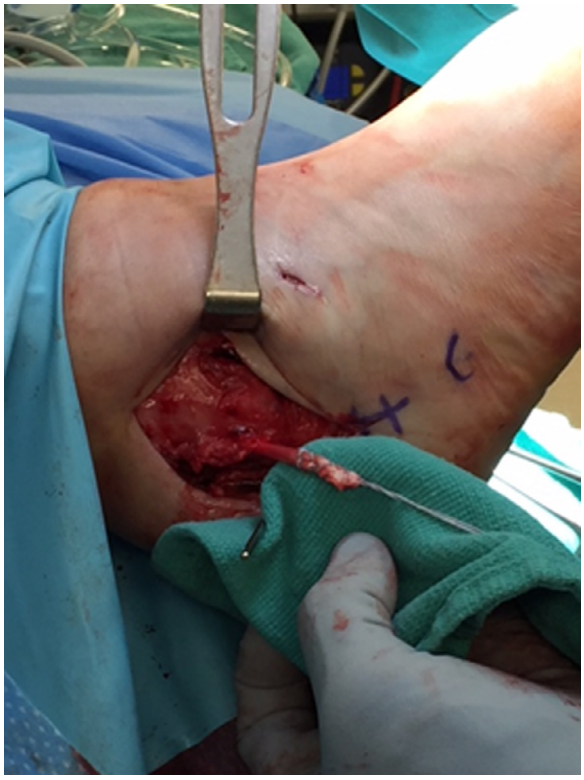

Fig. 4. Routing of the semitendinosus allograft lateral to the peroneal tendons to help prevent subluxation. The guide pin for the calcaneal drill hole is in place.

to preserve the medial cortex (Fig. 4). The allograft was then inserted from lateral to medial into the calcaneus and held under tension. A 6.25-mm absorbable tendon anchor was placed with the foot held in neutral position to hold the tendon in place. Intraoperative fluoroscopic images were taken in multiple planes to confirm alignment and correction of the deformity in all planes, confirming stability without increased talar tilt or anterior drawer. A layered tissue closure was then performed and a well-padded lower leg splint was applied with the foot and ankle held in a slight dorsiflexed and eversion.

Surgical Technique for Split Peroneus Brevis Tendon

The peroneus brevis tendon was identified proximally above the lateral malleolus. A 15 blade was used to make a stab incision in the tendon centrally, and

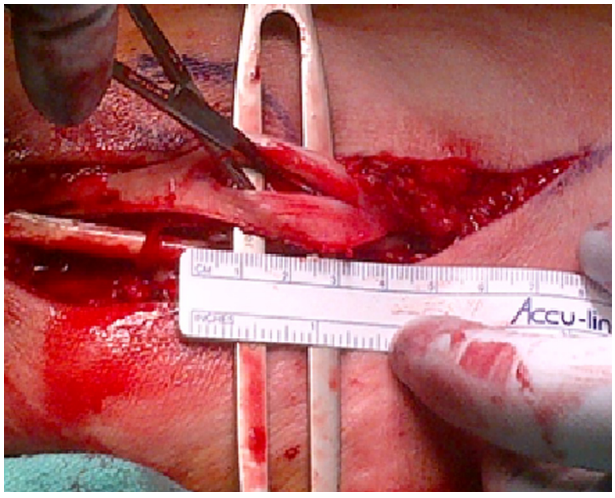

Fig. 5. Longitudinal splitting of the peroneus brevis tendon to harvest half of the tendon for the stabilization procedure.

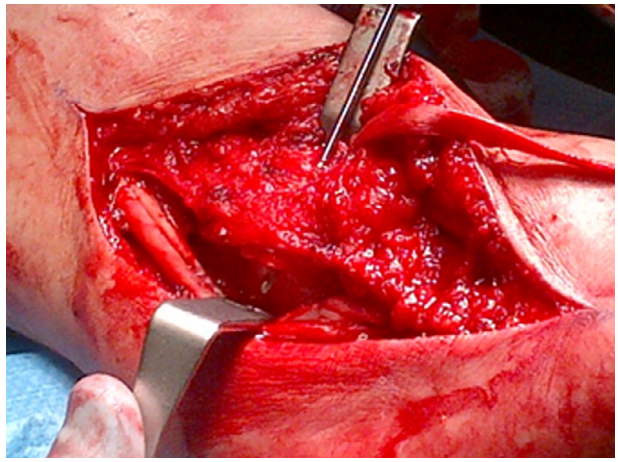

Fig. 6. Drilling of the fibula from anterior to posterior for passage of the split peroneus brevis tendon.

umbilical tape was used to split the tendon to its insertion on the fifth metatarsal (Fig. 5). Stay stitches were placed proximally and distally with 2-0 nonabsorbable suture. The dorsal half of the tendon was then whip stitched with 2-0 nonabsorbable suture loop. The tendon was then rerouted through the deep tissue and along the lateral talus to the anterior fibula. A guidewire was inserted from anterior to posterior and a 4.75-mm drill hole was made at the level of the ankle joint (Fig. 6). The tendon half was then tunneled through the fibula from anterior to posterior with the foot held in a slight dorsiflexion and eversion and was secured with a 4.75-mm absorbable tendon anchor (Fig. 7). The tendon was also passed lateral to the peroneal tendons to prevent subluxation of the peroneal tendons (Fig. 8). A guidewire was placed from lateral to medial under fluoroscopy in the calcaneal tubercle and a 6.25-mm drill was used to create a bone tunnel taking care to preserve the medial cortex. The split tendon was then inserted from lateral to medial

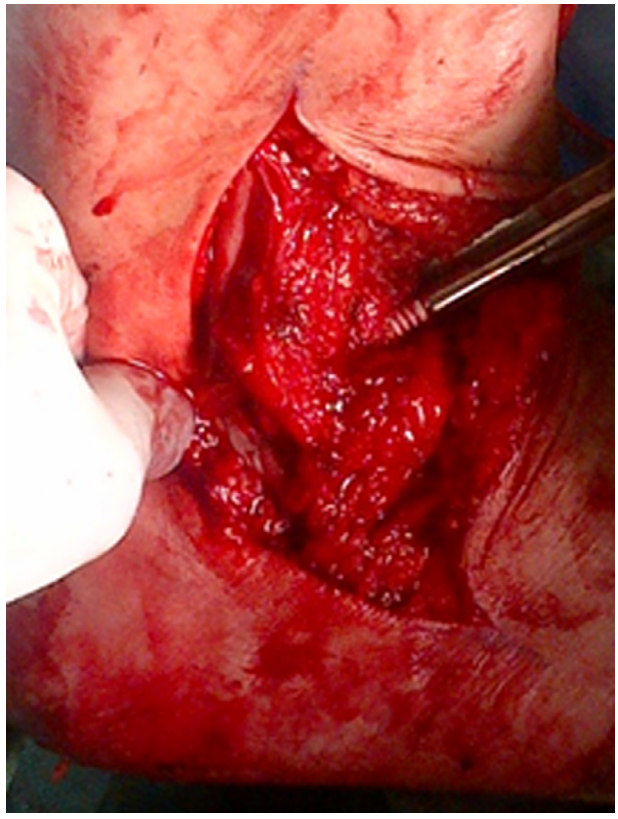

Fig. 7. Anchoring the split peroneus brevis tendon with an absorbable tenodesis screw with the foot held in a neutral position.

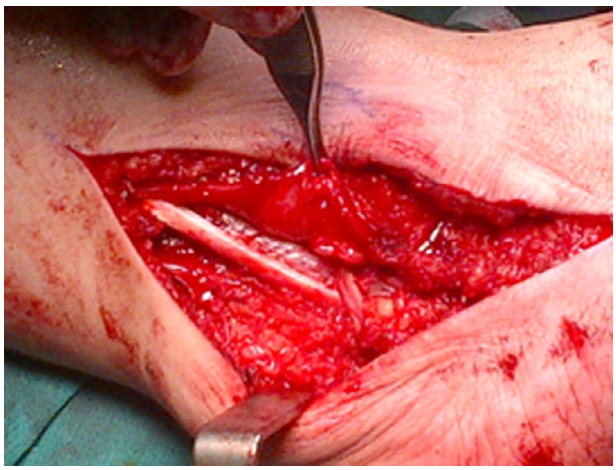

Fig. 8. After anchoring the split peroneal tendon in the calcaneus with an absorbable tenodesis anchor, with routing of the split tendon lateral to the remaining peroneal tendons to prevent subluxation.

into the calcaneus. A 6.25-mm absorbable tendon anchor was placed with the foot held in neutral position to hold the tendon in place. Intraoperative fluoroscopic views were taken to confirm alignment and correction of the deformity in all planes and confirm stability without increased talar tilt or anterior drawer. A layered tissue closure was then performed and a well-padded lower leg splint was applied with the foot and ankle held in a slight dorsiflexed and eversion.

Patients were kept immobilized and non-weightbearing for 4 weeks then transitioned to protected weightbearing for 3 to 4 weeks in a controlled ankle movement boot. Range of motion exercises were initiated at 2 weeks postoperatively once the incisions healed. Physical therapy was initiated between 8 and 12 weeks and protected physical activities were allowed at 10 to 12 weeks postoperatively. Patients were followed regularly until 1 year and then annually.

Statistical Analysis

Descriptive data of continuous variables were reported in terms of the mean ± standard deviation (range). These were considered nonparametric and compared by means of the Wilcoxon rank sum test. Descriptive data of categorical variables were reported in terms of a frequency count. These were compared by means of a 2-tailed Fisher's exact test. Statistical significance was defined at the 5% ($p = .05$) level. Data were stored in a password-protected personal computer for subsequent statistical analysis. All statistical analyses were performed using Statistical Analysis Systems software, version 25 (SAS Institute, Cary, NC). Statistical analysis was performed by an acknowledged physician (A.M.).

Results

A total of 64 lateral ankle ligament reconstructions on 62 patients were performed by the senior author (R.S.R.) between December 2006 and February 2018. The average mean follow-up period was 54.8 ± 36.3 (range 4 to 134) months. There were 36 (56.3%) ankles in 36 (58%) patients included in the split tendon group, and 28 (43.8%) ankles in 26 (42%) patients included in the semitendinosus allograft group (2 patients had both ankles done). In total, there were 19 (30.6%) males and 43 (69.4%) females included in the study. No statistically significant differences were observed between the 2 groups with respect to age ($p = .884$) and gender ($p = .403$), if ancillary procedures were performed ($p = 1.00$), complication rates ($p = 1.00$), the presence of diabetes ($p = 1.00$), smoking ($p = .774$), or BMI ($p = .262$) (Table 1).

The postoperative AOFAS score in the split tendon group was 84.05 ± 12.61 (range 43 to 100) and in the allograft group was 84.27 ± 14.47 (range 37 to 100). This difference was not found to be statistically significant ($p = .142$). In terms of patient satisfaction with the procedure, 31 (86.11%) patients in the split tendon group, and 27 (96.43%) patients in the allograft group reported that they would have the same procedure again. This difference was not found to be statistically significant ($p = .219$) (Table 2).

For the split tendon group, ancillary procedures performed included ankle arthroscopy (56%), peroneal tendon repair (2.8%), repair of talar dome lesions (8.3%), removal of prior hardware (2.8%), plantar fascia release (8.3%), retrocalcaneal exostectomy (5.6%), sural neurectomy (5.6%), rearfoot arthrodesis (5.6%), and bunion procedures (13.9%). For the semitendinosus group, ancillary procedures performed included ankle arthroscopy (79%), peroneal tendon repair (46.4%), repair of talar dome lesions (25%), removal of prior hardware (7.1%), plantar fascia release (14.3%), sural neurectomy (14.3%), rearfoot arthrodesis (7.1%), and bunion procedures (28.6%).

In terms of complications, the split tendon group had 1 incidence of a sural neuroma requiring excision (2.8%), 1 incidence of transient sural neuralgia (2.8%) that resolved with physical therapy, 1 patient who developed complex regional pain syndrome (2.8%), and 2 patients who developed subsequent ankle arthritis requiring a total ankle arthroplasty or ankle arthrodesis (5.6%). For the semitendinosus allograft group, 2 patients had an ankle injury requiring revision (7.1%), 1 patient had migration of the absorbable tendon anchor requiring removal (3.6%), and 2 patients developed arthritis requiring either a subtalar joint arthrodesis or total ankle arthroplasty (7.1%). Neither group had any documented wound complications.

Discussion

Our data show that patients in both groups did well postoperatively from both a functional and patient satisfaction standpoint. There was no significant difference between either group in AOFAS scores ($p = .943$) or if the patient would have the same procedure again ($p = .219$), which suggests that both techniques may be viable alternatives when primary ligamentous repair is not attainable. Both procedures had the same amount of total complications.

In general, our patient population was obese (mean BMI 37.28 and 34.3 for the split tendon and allograft groups, respectively) with high rates of diabetes and smoking leading our primary author to pursue a

Table 1
Patient and clinical characteristics (n = 64 feet in 62 patients)

Patient Demographics	Split Tendon Group (n = 36 Ankles in 36 Patients)	Semitendinosus Allograft Group (n = 28 Ankles in 26 Patients)	Statistical Comparison*
Age, years	41.21 ±10.25 (20-59)	41.14 ± 14.61 (16-76)	$p = .981$
Males	13 (36.11%)	6 (23.08%)	$p = .403$
BMI, kg/m^2	37.28 ± 9.17 (20.0-65.9)	34.30 ± 8.61 (15.95-48.54)	$p = .189$
Diabetes mellitus	10 (27.78%)	7 (26.92%)	$p = 1.00$
Smoking	9 (25.0%)	8 (30.77%)	$p = .774$
Ancillary procedures performed	31 (86.11%)	25 (89.29%)	$p = 1.00$

Abbreviation: BMI, body mass index.
Categorical data expressed as count (%) and continuous data as mean ± standard deviation (range). Statistical significance noted at $p = .05$.
* Comparison of continuous variables was by means of the Wilcoxon rank sum test, whereas comparison of categorical variables was by means of a 2-tailed Fisher's exact test.

Table 2
Outcome measures (n = 64 feet in 62 patients)

Outcome Measures	Split Tendon Group (n = 36 Ankles in 36 Patients)	Semitendinosus Allograft Group (n = 28 Ankles in 26 Patients)	Statistical Comparison*
Postoperative AOFAS score	84.05 ± 12.61 (43-100)	84.27 ± 14.47 (37-100)	$p = .943$
Complications	5 (13.89%)	5 (17.86%)	$p = .675$
Would have the procedure again?	31 (86.11%) yes	27 (96.43%) yes	$p = .219$

Abbreviation: AOFAS= American Orthopedic Foot and Ankle Hindfoot Score.
Categorical data expressed as count (%) and continuous data as mean ± standard deviation (range). Statistical significance noted at $p = .05$.
* Comparison of continuous variables was by means of the Wilcoxon rank sum test, whereas comparison of categorical variables was by means of a 2-tailed Fisher's exact test.

more robust construct of lateral ankle stability as these factors are associated with poor results with a primary Broström repair (6–8). Other considerations were a previous failed primary Broström or presence of ligamentous laxity such as Ehlers-Danlos.

The advantages to the semitendinosus allograft include no donor site morbidity and the ability to recreate the natural course of the ATFL and calcaneofibular ligament, which has been shown in biomechanical cadaver studies to have equivalent stiffness and load to failure as an intact ATFL (15). The disadvantages include increased cost, potential disease transmission, and alteration of the biomechanical properties of the tendon (16). As graft processing techniques have improved, however, this has become less of a factor and the allograft tendon maintains more of the normal biomechanical properties of natural tendon (16). The graft used in this study has a sterility assurance level of 10^{-6}, which equates to a 1 in 1,000,000 probability of finding a nonsterile unit (17), which makes the chance of disease transmission low.

Some of the advantages to the split tendon reconstruction include decreased cost and no risk of disease transmission. Some of the disadvantages include nonanatomic reconstruction with potential for increased stiffness, ankle or subtalar joint arthritis (18), as well as potential eversion weakness resulting from harvesting a portion of the peroneus brevis (19), and increased soft-tissue dissection, which could increase the risk of sural nerve or vascular injury.

In our cohort, the rate of complications was similar both groups. The rate of sural nerve injury was higher in the split tendon group, likely owing to the increased soft-tissue dissection. This is similar to the findings of Shibuya et al (20) where nerve related discomfort was the most common adverse effect found postoperatively with a split peroneal tendon lateral ankle ligament reconstruction. The allograft tendon group had 2 patients who had recurrent ankle injuries that required revision. Both of these patients had Ehlers-Danlos with generalized laxity, which likely contributed to recurrence of instability. Both patients have had no recurrence of ankle sprain after the revision procedure.

There were 4 instances of arthritis in our cohort (2 in the split peroneus brevis tendon group and 2 in the semitendinosus allograft group). For the 3 patients with ankle arthritis, they had evidence of large osteochondral lesions of the talus at the initial procedure requiring repair and we theorize the ankle arthritis may have been sequela of their initial injuries rather than complications of the lateral ankle procedure because articular cartilage lesions are a known complication of acute and chronic lateral ankle ligament injury (21). One patient in the semitendinosus tendon group had continued subtalar joint pain postoperatively and required a subtalar joint arthrodesis. Overall, our complications were in line with previous studies for both anatomic and nonanatomic reconstruction (11,12,22).

The present study had several limitations. First, we had a relatively small cohort of patients. Second, preoperative AOFAS scores were not obtained from the patients, which limits the evaluation of preoperative morbidity. Third, a majority of the lateral ankle reconstructions were performed with ancillary procedures and not in isolation, which may have altered the AOFAS and patient satisfaction scores.

In conclusion, the present study found no statistically significant differences between allograft or split tendon in terms of AOFAS hindfoot score or patient satisfaction. This suggests they may both be viable alternatives for complicated lateral ankle ligament reconstructions, revision stabilization repairs, or when primary ligamentous repair is not attainable.

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