The Journal of Foot & Ankle Surgery xxx (2016) 1–5

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Original Research

A Biomechanical Comparison of 3 Different Arthroscopic Lateral Ankle Stabilization Techniques in 36 Cadaveric Ankles

James M. Cottom, DPM, FACFAS [1], Joseph S. Baker, DPM, AACFAS [2], Phillip E. Richardson, DPM [2], Jared M. Maker, DPM [2]

[1] *Director, Florida Orthopedic Foot and Ankle Center Fellowship, Sarasota, FL*
[2] *Fellow, Florida Orthopedic Foot and Ankle Center, Sarasota, FL*

A R T I C L E I N F O

Level of Clinical Evidence: 5

Keywords:
ankle instability
arthroscopy
lateral ankle stabilization
load to failure
stiffness

A B S T R A C T

Arthroscopic lateral ankle stabilization has become an increasingly popular option among foot and ankle surgeons to address lateral ankle instability, because it combines a modified Broström-Gould procedure with the ability to address any intra-articular pathologic findings at the same session. The present study evaluated 3 different constructs in a cadaveric model. Thirty-six fresh frozen cadaver limbs were used, and the anterior talofibular ligament was identified and sectioned. The specimens were then placed into 1 of 3 groups. Group 1 received a repair with a single-row, 2-suture anchor construct; group 2 received repair with a novel, double-row, 4-anchor knotless construct; and group 3 received repair with a double-row, 3-anchor construct. Specimens were then tested for stiffness and load to ultimate failure using a customized jig. Stiffness was measured in each of the groups and was 12.10 ± 5.43 (range 5.50 to 22.24) N/mm for group 1, 13.40 ± 7.98 (range 6.71 to 36.28) N/mm for group 2, and 12.55 ± 4.00 (range 6.48 to 22.14) N/mm for group 3. No significant differences were found among the 3 groups in terms of stiffness ($p = .939$, 1-way analysis of variance, $\alpha = 0.05$). The groups were tested to failure, with observed force measurements of 156.43 ± 30.39 (range 83.69 to 192.00) N for group 1, 206.62 ± 55.62 (range 141.37 to 300.29) N for group 2, and 246.82 ± 82.37 (range 164.26 to 384.93) N for group 3. Statistically significant differences were noted between groups 1 and 3 ($p = .006$, 1-way analysis of variance, $\alpha = 0.05$). The results of the present study have shown that a previously reported arthroscopic lateral ankle stabilization procedure, when modified with an additional proximal suture anchor into the fibula, results in a statistically significant increase in strength in terms of the maximum load to failure. Additionally, we have described a previously unreported, knotless technique for arthroscopic lateral ankle stabilization.

When nonoperative therapy fails in patients with chronic lateral ankle instability, surgical stabilization becomes an option for treatment. Lateral ankle stabilization procedures fall into 2 categories: anatomic and nonanatomic repairs (1). The anatomic approach was first described by Broström (2) in 1966. Gould et al (3) in 1980 reported their modification of the procedure. More recently, several investigators have described arthroscopic and arthroscopically assisted procedures (4–7). However, few investigators have explored the biomechanical strength of these constructs in a laboratory setting. The present study explored 3 different constructs for lateral ankle stabilization performed using an arthroscopic approach. Additionally, we introduced a novel, knotless approach to arthroscopic lateral ankle stabilization.

Materials and Methods

Thirty-six fresh-frozen cadaver limbs (18 matched pairs) were obtained and randomized into 1 of 3 groups, with 12 specimens in each group. The mean age of the specimens at limb loss or donation was 54 ± 7.6 years. Of the 18 matched pairs, 6 (33.3%) were from male and 12 (66.7%) from female donors. Each of the specimens was free of any obvious foot or ankle pathologic findings. The cadavers were kept at −20°C and were thawed the day of the experiment. In each specimen, the anterior talofibular ligament (ATFL) was dissected and sectioned and then repaired with 1 of the 3 techniques of interest by the senior author (J.M.C.).

Group 1 was repaired with a single-row construct using 2 bioabsorbable suture anchors (BioComposite SutureTak™; Arthrex, Naples, FL) attached to a no. 1 braided polyethylene/polyester multifilament suture (no. 1 FiberWire™, Arthrex). The repair was performed by inserting the first anchor 1 cm dorsal to the tip of the fibula, with care taken to ensure the anchor did not violate the medial and lateral cortices of the fibula. A second anchor was inserted in the same fashion but placed 1 cm proximal to the first anchor. Next, the 2 suture strands corresponding to each anchor were passed through the ATFL and inferior extensor retinaculum. The foot was dorsiflexed and everted by the assistant. Each suture strand was then tied down to its counterpart in the

Financial Disclosure: None reported

Conflict of Interest: James M. Cottom is a paid consultant for Arthrex and Stryker Corporations.

Address correspondence to: James M. Cottom, DPM, FACFAS, Director, Florida Orthopedic Foot and Ankle Center Fellowship, 2030 Bee Ridge Road, Suite B, Sarasota, FL 34239.

E-mail address: jcottom@coastalorthopedics.com (J.M. Cottom).

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http://dx.doi.org/10.1053/j.jfas.2016.07.025

Fig. 1. Example of single-row repair with no. 1 FiberWire™ performed in group 1.

same anchor using surgical knots to the appropriate tension (Fig. 1). The tails were then cut, completing the repair.

Group 2 was repaired with a novel "knotless" construct, which, to the best of our knowledge, has not previously been described in published studies. The knotless construct consisted of a double-row, 4-anchor construct incorporating Labral Tape™ (Arthrex) into the anchors. The first anchor was placed 1 cm dorsal to the tip of the fibula, with care taken to ensure the anchor did not violate the medial and lateral cortices of the fibula. A second anchor was inserted in the same fashion but placed 1 cm proximal to the first anchor. Next, the 2 tape strands corresponding to each anchor were passed through the ATFL and inferior extensor retinaculum. A separate 1- to 2-cm incision was made approximately 3 cm proximal to the distal fibula. The fibula was visualized, and, using the 2.9-mm suture anchor system, 2 drill holes were made into the fibula, with care taken to not violate the anterior and posterior cortices. At this point, an 18-gauge spinal needle was placed into each drill hole to maintain the visualized position. The foot was dorsiflexed and everted by the assistant. A strand from each anchor in the anterior fibula was then inserted into 1 of the lateral drill holes with a suture anchor. The last 2 strands were crossed and fixated into the fibula in the exact same fashion, creating a crossed suture anchor construct (Fig. 2).

Group 3 was repaired with 2 bioabsorbable suture anchors (BioComposite SutureTak™; Arthrex) attached to a no. 1 braided polyethylene/polyester multifilament suture (no. 1 FiberWire™). The repair was performed by inserting the first anchor 1 cm dorsal to the tip of the fibula, with care taken to ensure the anchor did not violate the medial and lateral cortices of the fibula. A second anchor was inserted in the same fashion but placed 1 cm proximal to the first anchor. Next, the 2 suture strands corresponding to each anchor were passed through the ATFL and inferior extensor retinaculum. The foot was dorsiflexed and everted by the assistant. Each suture strand was then tied down to its counterpart in the same anchor with surgical knots. A separate 1- to 2-cm incision was made approximately 3 cm proximal to the distal fibula. The fibula was visualized, and, using the 2.9-mm suture anchor system, a drill hole was made into the fibula. At this point, a needle was placed into the drill hole to maintain the visualized position. The strands were then secured into the fibula using the 2.9-mm bioabsorbable anchor (Fig. 3). The techniques are summarized in Table 1.

After repair, each sample was secured to a 14-in. segment of 2-in. × 8-in. wood using drywall screws. Two screws were driven through the dorsum of the foot and 2 through the calcaneus. The foot was then inspected for stability. If needed, an extra screw was driven through the talus for stability. A minimum of 4 screws were used in each foot. All specimens were then dissected, isolating the fibula, the repair, and all the tissue proximal to the repair. A medial to lateral hole was then drilled through the distal fibula, proximal to the lateral malleolus, using an 8-mm bone drill. A secured, dissected sample marked at the approximate distal fibular drill site is presented in Fig. 4.

The fibula was then cut laterally, 5 cm proximal to the center of the drill hole using a bone saw (V600 Power System; Arthrex). The repairs were then isolated by cutting all remaining proximal tissue, taking care to not damage the repair. In the case of a repair being damaged during tissue release, the entire matched pair would be discarded and a new matched pair repaired and tested in its place.

Mechanical testing was performed using an INSTRON E10 kN ElectroPuls Dynamic Testing System with a 10-kN load cell (Instron, Norwood, MA) secured to the cross-head. A clevis and pin fixture was secured to the cross-head, and a prepared sample was attached to the fixture by sliding the pin through the fibula drill hole. The sample was further C-clamped to a custom jig secured to the test platform that placed the foot in 20° of inversion and 10° of plantarflexion. The sample placement was adjusted such that the fibula was optimally centered below the load cell (Fig. 5).

The constructs were preloaded to 5 N to remove any slack from the system and then loaded to 15 N over 10 seconds, held for 5 seconds, and then pulled to failure at a rate of 20 mm/min. The load and displacement data were recorded at 100 Hz, and the mode of failure was noted for each sample immediately after the pull to failure. The ultimate load was determined from the load versus displacement curves as the maximum load value reached during loading. The construct stiffness was also determined from the load versus displacement curve by calculating the slope of the linear portion during the pull to failure.

Statistical analysis was then performed. The maximum load and stiffness measurements of the 3 sample groups were compared using 1-way analysis of variance, with the confidence level set at $\alpha = 0.05$. If either the equal variance or the Shapiro-Wilk normality test failed, a subsequent Kruskal-Wallis 1-way analysis of variance on ranks was performed.

Results

A total of 36 specimens were used in the present investigation, and their mean average age was 54 ± 7.6 years. None of the specimens were damaged during dissection of the repair site; therefore, it was not necessary to discard any of the repaired specimens. The results of the stiffness and load to failure tests are shown in Fig. 2 and presented in Table 2.

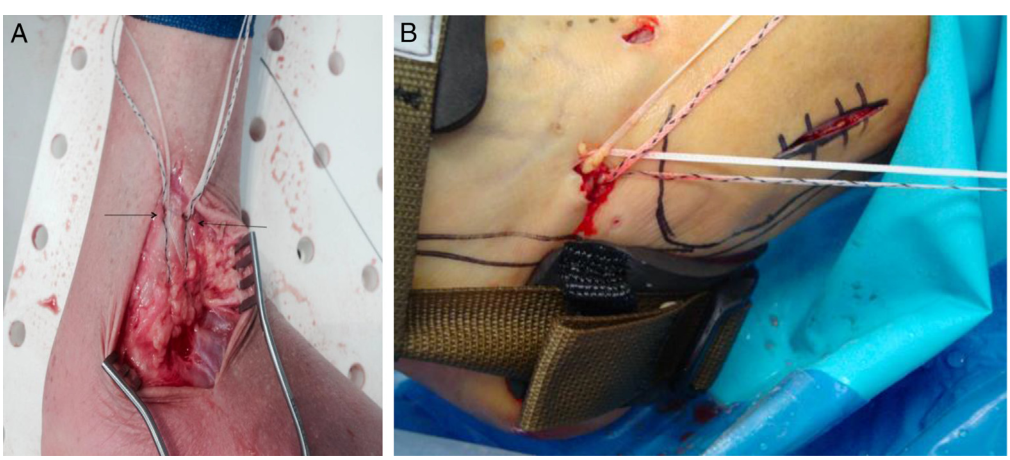

Fig. 2. (*A*) Example of double row, knotless repair performed with Labral Tape™ in group 2. (*B*) Schematic of knotless technique with Labral Tape™ in a patient who had received this type of repair.