

Sonographically Guided Anchor Placement in Anterior Talofibular Ligament Repair Is Anatomic and Accurate



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Background: Arthroscopic repair is a widely accepted surgical treatment for chronic ankle instability; however, recent studies have shown that arthroscopic repair is nonanatomic in its anchor placement and resultant biomechanics. Ultrasound may improve the accuracy of the anchor placement.

Hypothesis: Our hypothesis was that the accuracy of anchor placement in sonographically guided anterior talofibular ligament (ATFL) repair will be comparable with that in open ATFL repair.

Study Design: Cohort study; Level of evidence, 3.

Methods: The study included 26 patients who received surgical treatment between April 2012 and October 2019 for chronic ankle instability. Fifteen patients underwent open modified Broström repair and 11 underwent sonographically guided ATFL repair. The distance between the anchor hole and the fibular obscure tubercle was measured using 3-dimensional computed tomography and was compared between the operative procedures. For comparison, a noninferiority trial was employed, with open modified Broström repair as the reference surgery. The noninferiority margin was defined as 5 mm.

Results: The mean \pm SD distance between the anchor and fibular obscure tubercle was 6.0 ± 2.7 mm in open repair and 5.6 ± 3.3 mm in sonographically guided repair. The mean difference in distance between the techniques (*open repair* – *sonographically guided repair*) was 0.37 mm (95% CI, -2.1 to 2.9 mm). The lower margin of the confidence interval was within the noninferiority margin (-5 to 5 mm).

Conclusion: Anchor placement under sonographically guided ATFL repair was equivalent to that of open ATFL repair and can be considered anatomic and accurate.

Keywords: ankle sprain; chronic ankle instability; sonographically guided ATFL repair; anchor placement

Ankle sprains are among the most common sports-related injuries, comprising up to 30% of these injuries.^{12,22} Most injuries involve the lateral ligament complex (LLC) during forced inversion and adduction while the ankle joint is in plantarflexion.^{3,14} Tearing, stretching, and recurring sprains of these ligaments can result in chronic ankle instability (CAI). It has been reported that 32% to 74% of individuals with a history of ankle sprain experience some type of residual and chronic symptoms, recurrent ankle sprains, and/or perceived instability.^{2,23} Surgical intervention may be warranted when patients with CAI fail to improve with nonoperative treatment.⁶

Many surgical techniques to stabilize the LLC have been proposed. The earliest documented surgical reconstruction

technique, proposed by Evans,¹⁰ was nonanatomic because it used the peroneus brevis tendon to reconstruct the LLC with nonanatomic bone tunnels. A later anatomic open repair technique was developed by Broström,⁴ in which the native LLC was imbricated with ankle joint capsule without a need to sacrifice the peroneal tendon. Gould et al¹⁵ later modified this by reinforcing the LLC repair with the inferior extensor retinaculum, but some surgeons argued that it could restrict full plantarflexion of the ankle, possibly because of the nonanatomic nature of this procedure.³²

Suture anchors have been used to add strength to the repair, and this open modified Broström technique is anatomic and remains the gold standard surgical treatment to date.^{5,28} Yet, nerve and wound complications (4.5% and 3.6%, respectively) inevitably result from the open repair technique.⁵ Recently, an arthroscopic Broström technique has been developed.^{1,7} The arthroscopic repair technique is comparable with the open Broström-Gould technique in

The Orthopaedic Journal of Sports Medicine, 8(12), 2325967120967322

DOI: 10.1177/2325967120967322

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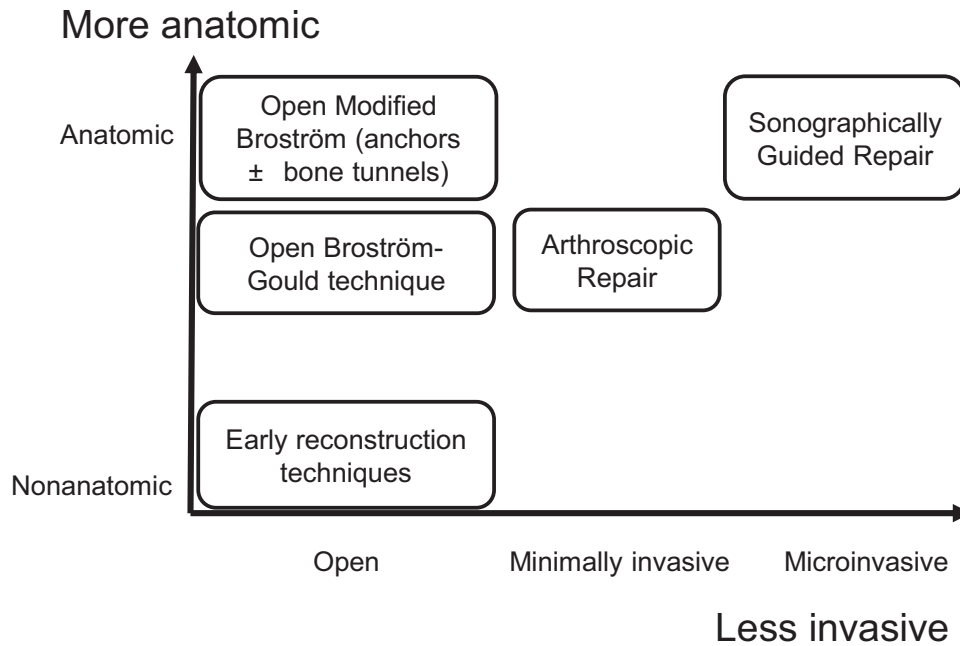


Figure 1. Advantages of sonographically guided repair as compared with other procedures. Procedures differ in terms of their invasiveness and anatomic accuracy. Early reconstruction techniques were invasive and nonanatomic. Open Broström and modified Broström techniques using anchors and/or bone tunnels are anatomic yet more invasive than arthroscopic and sonographically guided techniques. The Broström-Gould technique is less anatomic than its original Broström technique, as it uses inferior extensor retinaculum for augmentation of the repair. The arthroscopic repair technique is less invasive than other open procedures, but it could result in proximal anchor placement relative to the anatomic attachment of the anterior talofibular ligament. Sonographically guided repair of the anterior talofibular ligament can be microinvasive and anatomic in terms of anchor placement.

functional and patient satisfaction outcome scores.^{5,29} With its less invasive nature and its capability of addressing intra-articular lesions, this technique has gained in popularity but is not without its shortcomings. A recent cadaveric study showed that the center of the attachment of the anterior talofibular ligament (ATFL) was not fully appreciated with arthroscopic repair³³; therefore, the anchor insertion under arthroscopy was more proximal to the fibular origin of the ATFL. When anchor placement is proximal relative to the anatomic attachment, the ankle kinematics alter and the result is excess laxity relative to the intact ankle.³¹

Musculoskeletal ultrasound (US) represents a readily available and cost-effective imaging modality that has gained popularity in sports medicine as a diagnostic tool

as well as an interventional tool. US-guided interventions are known to be more accurate than unguided interventions¹¹ and safer because of their ability to visualize sensitive structures around the target tissue.⁸ Our recent publication proposed the utility of sonographic guidance to improve current ATFL repair. The potential advantages suggested were the microinvasive nature of the procedure, the safety to nearby neurovascular structures, and the procedural accuracy (Figure 1).¹⁷ However, to our knowledge, no previous reports have examined the anatomic accuracy of the anchor position in sonographically guided ATFL repair.

The objective of the current study was to evaluate the accuracy of anchor placement in the sonographically guided ATFL repair. Our hypothesis was that anchor placement under the

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Final revision submitted May 21, 2020; accepted June 17, 2020.

One or more of the authors has declared the following potential conflict of interest or source of funding: S.H. has received consulting fees from Konica-Minolta. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Ethical approval for this study was obtained from Kameda Medical Center (No. 19-001).

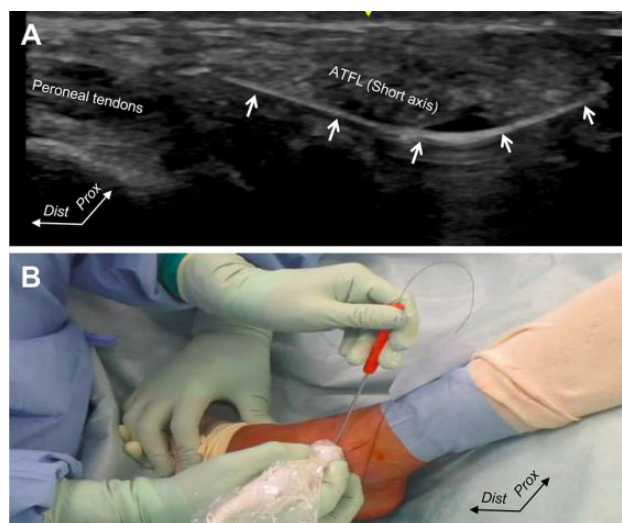


Figure 2. Suturing of the anterior talofibular ligament (ATFL) under sonographic guidance. (A) While the ATFL is visualized in a short-axis view, a large spinal needle with a curved tip (white arrows; Micro SutureLasso Minor Bend; Arthrex) is passed under the ATFL and advanced just proximal to peroneal tendons. (B) Operative camera view of the suturing in the left ankle shows that the spinal needle is introduced under sonographic guidance. Dist, distal; Prox, proximal.

sonographically guided technique would be equivalent to open modified Broström repair.

METHODS

Selection of Patients

This was a retrospective cohort study. It included patients who had received either an open modified Broström repair or a sonographically guided ATFL repair for CAI deemed secondary to ATFL injuries; all procedures were conducted between April 2012 and October 2019 at our sports medicine department. This study was approved by the institutional review board of our institution, and informed consent on using imaging data and clinical scores for research purposes was obtained from all patients before surgery. Exclusion criteria were arthroscopic repair and the lack of postoperative 3-dimensional (3D) computed tomography (CT) within 12 months after surgery. A total of 26 patients met the criteria.

Surgical Technique

All surgical procedures were performed or assisted by the primary author (S.H.), who has 10 years of sport-related foot and ankle surgical experience. In the open repair group, the ATFL was repaired with 1 or 2 standard anchors using an open modified Broström repair technique.²⁵ A Gould procedure was added in case of severe ankle instability attributed to ATFL and CFL injuries, without a modification from the original description.¹⁵

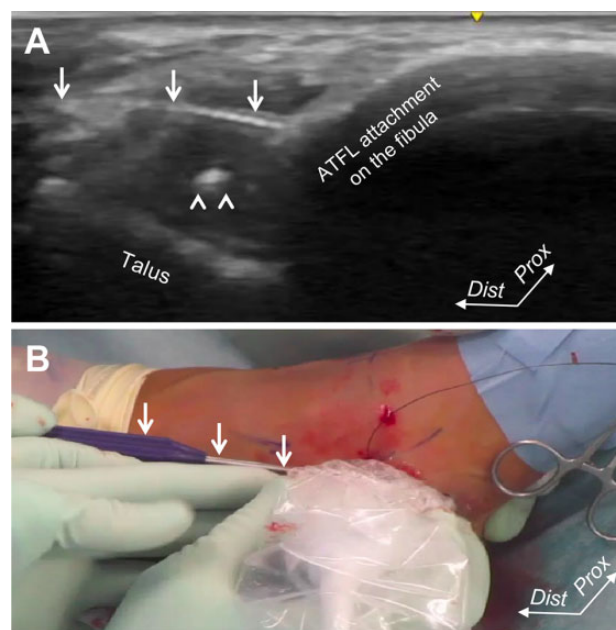


Figure 3. Insertion of the anchor at the fibula under sonographic guidance. (A) A suture anchor is placed at the anatomic attachment of the anterior talofibular ligament (ATFL) after bringing a drill guide (white arrows) to the attachment of the ATFL under sonographic guidance. A suture wire (arrowheads) is visible in the talocrural joint under the ATFL. (B) Operative camera view of the anchor insertion in the left ankle shows that the accurate position of the drill guide (white arrows) is confirmed under sonographic guidance. Dist, distal; Prox, proximal.

It took the primary author 5 cases to feel comfortable performing the sonographically guided ATFL repair. Patients assumed a supine position under general or regional anesthesia with the affected leg internally rotated. Standard high-frequency linear transducers (>12 MHz) or hockey stick probes were used. After preparing and draping below the knee were performed, the tibiotalar joint was infiltrated with 20 mL of epinephrine or lidocaine with epinephrine using an out-of-plane technique while visualizing a long axis view of the ATFL. No air tourniquet was used. A large spinal needle with a curved tip (Micro SutureLasso Minor Bend; Arthrex) was passed into the ATFL and advanced just proximal to the peroneal tendons under US guidance (Figure 2). A loop wire of the Micro SutureLasso was deployed after the needle tip penetrated the skin. After the unique angular bony shape of the fibular attachment of the ATFL was visualized with US, a 5-mm skin incision was made 10 mm distal-medial to the fibular attachment of the ATFL. After blunt dissection, a suture anchor was placed at the anatomic footprint of the ATFL (Figure 3; also see the Video Supplement for a demonstration of the anatomic anchor placement under sonographic guidance). If an additional anchor was necessary, it was placed 5 mm proximal to the first anchor. After the distal and proximal limbs of the loop wire were retrieved subcutaneously through the

anchor incision, the loop wire was replaced by anchor sutures. Finally, knot tying was performed for tensioning the ATFL with the ankle at a neutral plantarflexion-dorsiflexion position.¹⁷ Additional arthroscopic procedures and/or open procedures were performed in cases where intra-articular lesions, such as symptomatic os trigonum, osteochondral lesions, loose bodies, or impinging osteophytes, and peroneal tendon lesions were clinically suspected in addition to CAI (Table 1).

In the open repair group, we had no neurologic complications; 1 case of delayed wound healing, which took 1 month to heal with careful observation; and 3 cases of prolonged wound pain, which resolved by 8 weeks after surgery. In the sonographically guided group, 1 case of delayed wound healing compared to anticipated norm at an arthroscopic

TABLE 1
Demographic and Clinical Data Between
Open and Sonographically Guided
Anterior Talofibular Ligament Repair Groups^a

	Open (n = 11)	US Guided (n = 15)	P Value
Age, y	29 ± 14 (21-37)	30 ± 17 (22-39)	.81
Male:female sex	4:7	8:7	.41
Right:left side	7:4	8:7	.66
No. of anchors, 1:2	10:1	13:2	.86
Additional procedures	Os trigonum resection (2), LB removal (2), OATS for OCL (1)	Osteophyte resection (3), peroneal tendon repair (1), peroneal tenolysis (1), BMS for OCL (1)	.82

^aValues are presented as mean ± SD (95% CI) or No. BMS, bone marrow stimulation; LB, loose bodies; OATS, osteochondral autograft transfer system; OCL, osteochondral lesion; US, ultrasound.

portal where osteophyte resection was performed, but there was no prolonged wound pain or neurologic complications.

Measurement Method

The primary outcome of this study was the distance between the anchor hole and the fibular obscure tubercle (FOT), as measured using 3D CT with 0.3- to 0.5-mm slice thickness. The FOT serves as an anatomic landmark for the ATFL and it is located 3.7 mm distal to the center of the ATFL origin.²⁶ Three-dimensional CT has been employed to evaluate the size of the bone tunnel in anterior cruciate ligament (ACL) reconstruction.^{9,27} CT was chosen over magnetic resonance imaging because of the higher bony spatial resolution and the ease of choosing the image plane to accurately evaluate the distance between the anchor and the FOT. This distance was compared between the cohorts. In cases where 2 anchors were inserted, the distal first anchor hole was used for measurement. The 3D CT images in the oblique sagittal plane were employed in most cases (Figure 4A). However, if simultaneous identification of the anchor and FOT was difficult, the oblique coronal plane (Figure 4B) or oblique axial plane was used for evaluation.

A noninferiority trial was employed, with open Broström repair as the reference surgery. The intent of this study was to demonstrate that the sonographically guided surgery was not substantially worse than the reference surgery.¹⁶ As sonographically guided surgery can offer important advantages over open surgery, such as a small incision and neurovascular protection, we did not intend to show that sonographic guidance was superior to open repair.

The noninferiority margin, which indicates the maximum acceptable extent of the difference between the sonographically guided repair and the open repair, was defined as 5 mm based on the anatomy of the ATFL attachment. A cadaveric study¹⁸ showed that the mean ± SD width and length of the ATFL footprint were 5 ± 1 mm and 10 ± 2 mm, respectively (Figure 5A). Because the anchor was placed under the

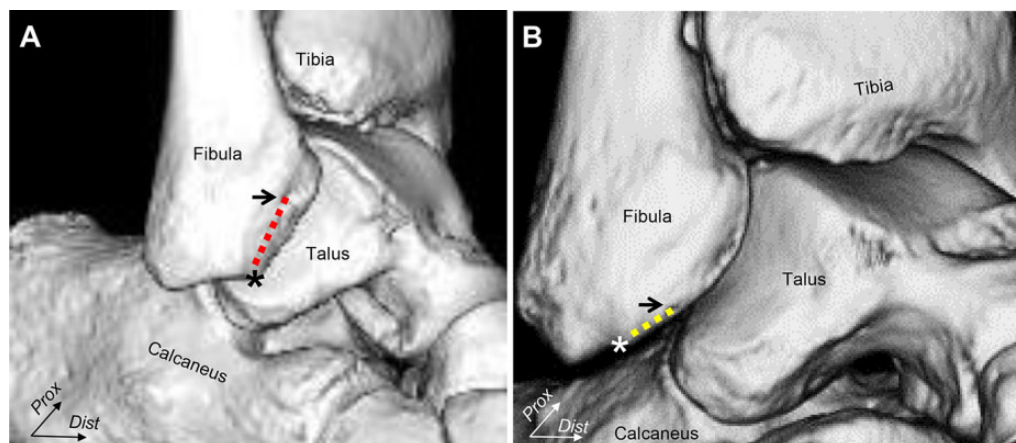


Figure 4. Measurement of the distance between the anchor and fibular obscure tubercle (FOT). (A) Using 3-dimensional computed topography, the distance (red dotted line) is measured between the anchor (arrow) and FOT (asterisk) in the oblique sagittal plane, wherein both anchor and FOT are visualized most clearly. (B) In this case, the oblique coronal plane was used to visualize both anchor hole (arrow) and FOT (asterisk) and to measure the distance (yellow dotted line) between them. Dist, distal; Prox, proximal.

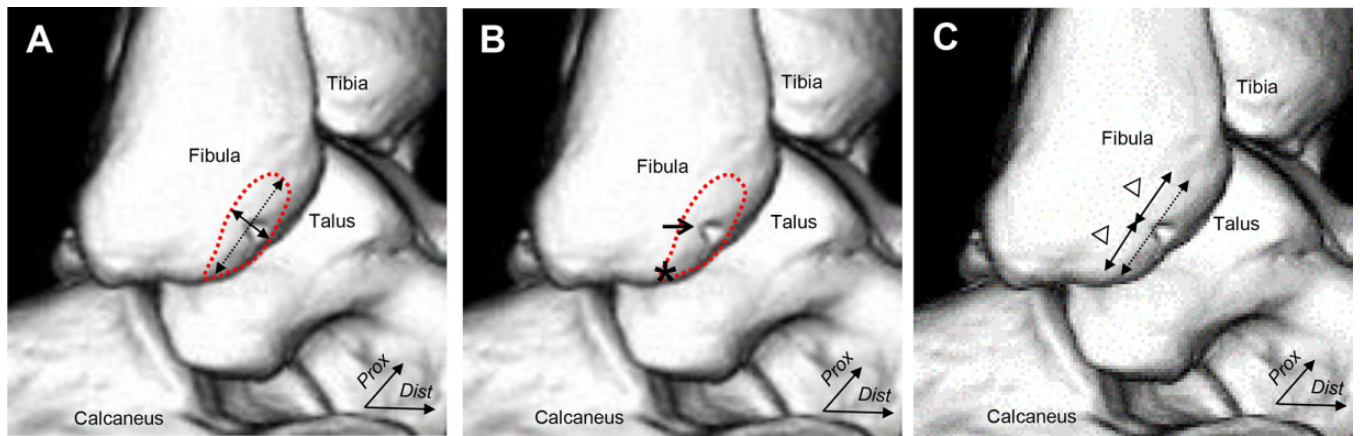


Figure 5. Definition of noninferiority margin on the basis of the anatomy of the anterior talofibular ligament (ATFL) attachment. (A) The width and length of the ATFL footprint (red dotted area) are 5 ± 1 mm (double arrow) and 10 ± 2 mm (double dotted arrow), respectively. (B) In the open modified Broström repair, the anchor (black arrow) is assumed to be at the center of the ATFL footprint, proximal to the fibular obscure tubercle (asterisk) under direct vision. (C) Half of the long axis of the ATFL attachment is 5 mm (double arrow), which was then defined as the noninferiority margin (triangles). Dist, distal; Prox, proximal.

surgeons' direct vision during open repair, we could assume that the anchor was placed at the center of the ATFL footprint (Figure 5, A and B). We set 5 mm as the noninferiority margin (Figure 5C) because it is half of the long axis of the ATFL attachment on the fibula. If the difference between the open repair and the sonographically guided repair fell within 5 mm, we could assume that the anchor of the sonographically guided repair was on the anatomic footprint of the ATFL. Noninferiority testing was performed by comparing the 95% CI of the difference of the distances between 2 groups with the predetermined noninferiority margin (5 mm).

To assess reliability, 2 experienced orthopedic surgeons (S.H., Y.K.) measured the distance between the anchor and FOT in 10 ankles each. The mean of the 10 measurements was compared between the examiners.

Statistical Analysis

All statistical analyses were performed using statistical software (EZR Version 2.13.0; Saitama Medical Center, Jichi Medical University), which was based on R and R commander and was freely available online.²¹ The threshold for significance was a P value $< .05$. Intraclass correlation coefficients were calculated and analyzed using the Landis and Koch²⁴ criteria to compare the interrater reliability of the distance measurements between the 2 examiners. Agreement was interpreted as follows: 0.01 to 0.20, slight agreement; 0.21 to 0.40, fair; 0.41 to 0.60, moderate; 0.61 to 0.80, substantial; and 0.81 to 1.00, almost perfect or perfect.

RESULTS

The 26 study patients comprised 11 cases of open modified Broström repair and 15 cases of sonographically guided ATFL repair. Demographic and clinical data between the

groups are shown in Table 1. The mean distances between the anchor and FOT were 6.0 ± 2.7 mm in open Broström repair and 5.6 ± 3.3 mm in sonographically guided ATFL repair. The mean difference between the techniques (*open repair* – *sonographically guided repair*) was 0.37 mm (95% CI, -2.1 to 2.9 mm). The lower margin of the confidence interval was within the noninferiority margin (-5 to 5 mm).

The interrater reliability for the distance measurements between the 2 experienced examiners was 0.96 (95% CI, 0.84-0.99), indicating almost perfect agreement.

DISCUSSION

This study investigated anchor placement in sonographically guided ATFL repair in comparison with open modified Broström repair. The most important finding was that the distance between the anchor hole and FOT in sonographically guided ATFL repair was noninferior to that of the open repair; therefore, anchor placement under sonographically guided repair can be considered anatomic and accurate.

In surgical repair/reconstruction of an injured ligament, it is crucial to identify the anatomic attachment of the ligament. In ACL reconstruction, for example, surgeons have sought to re-create the anatomic bone tunnels during surgery to reproduce native ACL kinematics.¹³ Regarding arthroscopic repair of the ATFL, previous studies have indicated that it may not be feasible to fully observe the center of the ATFL attachment arthroscopically.³³ As a result, the anchor position tends to be proximal to the ATFL attachment site, thus predisposing to a nonanatomic repair. In a biomechanical cadaveric study, Shoji et al³¹ revealed that nonanatomic ATFL repair results in significant inversion and internal rotation kinematics and internal rotation laxity when compared with the intact condition. In contrast, anchor placement in sonographically guided repair was

comparable with that of the open modified Broström repair and was therefore anatomic in the present study.

Several authors have converted conventional surgical procedures into sonographically guided procedures.^{19,30} Carpal tunnel release, for example, has been performed under US guidance with favorable clinical outcomes as compared with open and endoscopic releases.²⁰ One of the advantages of a sonographically guided procedure is accuracy.¹¹ In the current study, sonographic guidance in anchor placement allowed for visualizing the anatomic attachment of the ATFL and thus inserting an anchor at the center of the footprint of the ATFL, replicating the same accuracy as seen with open anchor placement. In addition, sonographic guidance allows for a broader field of view as compared with arthroscopy. During sonographically guided ATFL repair, the peroneal tendons are easily visible. This can allow for a larger suture bite relative to what is safe in a typical arthroscopic repair without risking an iatrogenic injury to the peroneal tendons.

There were several limitations inherent in the present study. First, this is a retrospective study, and a prospective study is warranted. Second, the study lacked longer term outcome assessment, as the average follow-up was 16 months. It is also unclear if the current measurement of the distance between FOT and the anchor allows for inferences with regard to the ultimate biomechanics of the repaired ankles. Additionally, a sample size calculation was not performed in advance because there had been no previous study on the measurement of the distance to estimate an effective sample size.

In conclusion, anchor placement under sonographically guided ATFL repair can be anatomic and accurate when compared with open modified Broström repair.

A Video Supplement for this article is available at <http://journals.sagepub.com/doi/suppl/10.1177/2325967120967322>.

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