Current Reviews in Musculoskeletal Medicine
https://doi.org/10.1007/s12178-019-09592-0

MANAGEMENT OF ANKLE INSTABILITY (M HOGAN, SECTION EDITOR)

Ultrasound-Guided Ankle Lateral Ligament Stabilization

Soichi Hattori[1,2] · Carlo Antonio D. Alvarez[1] · Stephen Canton[3] · Macalus V. Hogan[3] · Kentaro Onishi[3,4]

Abstract

Purpose of Review Ultrasound (US) is an increasingly popular imaging modality currently used both in clinics and operating rooms. The purpose of this review is to appraise literature describing traditional lateral ankle stabilization techniques and discuss potential advantages of US-guided ankle lateral ligament stabilization. In addition, albeit limited, we will describe our experiences in perfecting this technique.

Recent Findings To date, the modified open Broström-Gould technique remains as the gold standard surgical treatment for chronic ankle instability (CAI). In the past decade, modifications of this technique have been done, from a combination of arthroscopic and open procedure to an all-inside arthroscopic technique with a goal of minimizing wound complications, better outcomes, and earlier return to activity. Recently, the use of US as an adjunct to surgical procedures has gained popularity and several novel techniques have been described. The use of US in lateral ankle stabilization could allow accurate placement of the suture anchor at the anatomical attachment of the anterior talofibular ligament (ATFL) without iatrogenic damage to the neurovascular structures such as anterolateral malleolar artery, superficial peroneal nerve, and sural nerve.

Summary In summary, the use of US in ankle lateral ligament stabilization is a promising new micro-invasive technique. The theoretical advantages of US-guided ankle lateral ligament stabilization include direct visualization of desired anatomical landmarks and structures which could increase accuracy, decrease iatrogenic neurovascular damage, minimize wound complications, and improve outcomes.

Keywords Ultrasound · Ultrasound-guided surgery · Chronic ankle instability · Lateral ligament stabilization

Introduction

Ankle sprains comprise 85% of all ankle injuries and are the most common injury accounting for 14–21% of all sports injury. The lateral ligament complex (LLC) of the ankle has three main structures: the anterior talofibular ligament (ATFL), calcaneofibular ligament (CFL), and posterior talofibular ligament (PTFL) [1•, 2]. A recent anatomic study by Vega et al. proposed the presence of the lateral fibulotalocalcaneal ligament complex which connects ATFL and CFL as a stabilizing structure of the lateral ankle [3••]. Tearing, stretching, and recurring sprains of these ligaments can result in chronic ankle instability (CAI). The ATFL is involved in 90% of all lateral sprains, whereas the CFL is involved in 50 to 75% of these sprains and the PTFL less than 10%. Conservative treatment with functional rehabilitation therapy remains as the standard of care for acute ankle sprains [1•, 2]. Approximately 74% of acute ankle sprains result in persistent symptoms, 30% of which progress to CAI [4••]. CAI is defined as the perception of recurring "giving way" of the ankle accompanied with a plethora of symptoms including recurrent sprains, pain with activity, swelling, difficulty walking on uneven ground, and avoidance of activities leading to persistent disability [1•, 2, 4••].

This article is part of the Topical Collection on *Management of Ankle Instability*

✉ Soichi Hattori
solich.h@gmail.com

[1] Department of Sports Medicine, Kameda Medical Center, 929 Higashi-cho, Kamogawa City, Chiba Prefecture 2968602, Japan

[2] Department of Clinical Anatomy, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Tokyo, Japan

[3] Department of Orthopedic Surgery, University of Pittsburgh School of Medicine, Pittsburgh, PA 15213, USA

[4] Department of Physical Medicine and Rehabilitation, University of Pittsburgh School of Medicine, Pittsburgh, PA 15213, USA

Published online: 20 November 2019

Surgical intervention may be warranted when patients with CAI fail to improve with conservative treatment. Many surgical techniques to stabilize the LLC have been proposed. These procedures are categorized into non-anatomic and anatomic repair or reconstruction. Early surgical techniques were non-anatomic reconstruction of the LLC proposed by Evans, Chrisman-Snook, Watson-Jones, and Castaing [1•, 5–7•]. These techniques required peroneal tendons to be sacrificed and used as grafts to restore ankle stability. However, the results were suboptimal both from clinical and biomechanical standpoints, with recurrent instability due to altered ankle biomechanics, persistent pain, and stiffness [5–7•]. Anatomic open surgical technique was later developed by Broström, wherein the native ATFL and CFL were imbricated together with ankle joint capsule [7•]. Gould later modified this procedure by adding the inferior extensor retinaculum (IER) as part of the repair [8, 9]. The simplicity of the procedure and restoration of physiologic joint anatomy and kinematics offered better outcomes and patient satisfaction compared to non-anatomic techniques. Thus, the modified open Broström-Gould technique remains the gold standard surgical treatment for CAI to date [1•, 6, 8, 9]. In recent years, arthroscopic ankle evaluation has been routinely performed followed by open procedures. Arthroscopic evaluation is performed in order to address simultaneous intra-articular pathological entities such as impingement lesions, ankle synovitis, intra-articular loose bodies, talar osteochondral lesions, and medial ankle tenosynovitis [10–12]. Subsequently, physicians moved toward arthroscopic evaluation with mini-open repair of lateral ligaments utilizing staples, suture anchors, thermal shrinkage, and plication. Recently, completely arthroscopic or "all-inside" techniques have been developed and the use of these procedures has been rapidly increasing [11, 13, 14].

Musculoskeletal ultrasound (MSK US) represents a cost effective, readily-available imaging modality that are both diagnostic and interventional [15–18•]. Interventional US refers to the use of a real-time guidance in order to perform various procedures such as local injections, aspirations, or biopsies. In some places, US guidance is used in place of conventional operative procedures. To distinguish these from arthroscopic procedures which are frequently referred to as "minimally invasive," these US-guided surgical procedures are sometimes referred to as micro-invasive surgery [15, 17]. Once one is familiar with regional anatomy, or sono-anatomy, micro-invasive surgical procedures appear to be as safe as their conventional alternates. In theory, a real-time visualization of vital structures in the region affords added safety and accuracy compared to conventional surgery where visualization of these structures is not possible. In addition to being less invasive, existing micro-invasive surgeries are generally performed faster due to the use of local anesthetic as opposed to regional or general. Therefore, some micro-invasive surgeries result in a faster recovery and a reduction of pain medication use [19–23]. The evolution of US-guided surgical techniques has been described, from procedures where US is utilized to guide a conventional needle to perform traditional surgical procedures percutaneously, to US-guided procedures wherein special needles or devices are used to cut or release the target structures. Several authors continue to describe novel US-guided micro-invasive surgical techniques in the upper and lower extremities [24–33]. Although there are no English publications describing repair or reconstruction procedures that have been completely converted to US-guided procedure, some novel techniques have been reported such as US-guided percutaneous mini-open repair of the Achilles tendon [34, 35•] and medial patellofemoral ligament (MPFL) [36].

Recent systematic reviews have shown that US is a valuable diagnostic tool for detecting CAI, ATFL injuries in particular [4••, 37, 38•]. However, to the best of our knowledge, previous studies regarding US-guided repair or reconstruction techniques of the LLC of the ankle are limited. The purpose of this review is to appraise literature describing traditional lateral ankle stabilization techniques and discuss potential advantages of US-guided ankle lateral ligament stabilization. In addition, albeit limited, we will describe our experiences in perfecting this technique.

US-Guided Ankle Lateral Ligament Stabilization

Theoretical Advantages

A recent meta-analysis of arthroscopic and open repair of ankle lateral ligament showed that overall complication rate of arthroscopic repair of ankle lateral ligament was 10.3% and open repair complication rate was 10.0%. With open repair, the nerve complication rate was 4.5% and the wound complication rate was 3.6%. Meanwhile, they were 5.2% and 0% with arthroscopic repair respectively. The other complications in arthroscopic repair included persistent pain, wound/scar pain, and deep venous thrombosis (DVT) [7•]. Most of the nerve complications involve the superficial peroneal nerve (SPN) and its branches [7•]. A cadaveric study done by Pitts et al. suggested that sural nerve as well as SPN were the anatomical structures at greatest risk during arthroscopic Bronström procedure [39]. With US guidance, both SPN and sural nerve are made visible, and iatrogenic damage to these nerves could be avoided. The use of US to determine the course of the SPN was shown to be better than gross visualization/palpation in a cadaver study [40•]. Also, we could possibly reduce wound complication rate with "micro-invasive" nature of US-guided lateral ligament stabilization with one 5-mm incision.

Some authors pointed out that anchor insertion in arthroscopic procedures was often placed proximal to the

anatomical ATFL attachment site of the fibula [41, 42••]. Teramoto et al. showed in their cadaveric study that the distance of markings made at the distal margin of the lateral malleolus under arthroscopy was 7–10 mm away from the center of the ATFL attachment site [42••]. In our retrospective analysis of 22 procedures of lateral ligament repair of the ankle, the distance of anchor placement from the anatomical ATFL attachment site in the US-guided procedure was non-inferior to open procedures. With the fibular obscure tubercle (FOT) as a reference point, the mean distance between the anchor and FOT was 6.0 ± 2.7 mm in open procedures, and 7.4 ± 2.5 mm in the US-guided procedure respectively. The mean differences between the two techniques (open-US guided) were − 1.5 mm (95% confidence interval 1.0 to − 3.9). The confidence interval was smaller than the non-inferiority margin (4 mm) [43••]. Thus, US-guided anchor placement could be more anatomically accurate than the conventional arthroscopic Broström procedure.

US Evaluation Protocol for Lateral Ligament Complex (LLC) of the Ankle

After acute ankle lateral ligament injury, the initial treatment is usually conservative, such as functional rehabilitation [1•, 2]. An incidence of 5 to 33% of patients experience pain and instability after ankle sprain [44]. Surgical management is warranted in these situations. The investigators of CAI described two subgroups: mechanical instability and functional instability. Mechanical instability is thought to result from various anatomic changes that may exist in isolation or in combination such as laxity caused by ligament tears. These changes are proposed to lead to insufficiencies that predispose the person to further episodes of instability. Functional instability is proposed to result from functional insufficiencies such as impaired proprioceptive and neuromuscular control after ankle sprain. Both mechanical and functional instabilities are difficult to distinguish as they often occur in combination during the development of CAI [2, 45]. The former is evaluated with physical examinations and imaging modalities including US, and sometimes requires surgical stabilization. The latter is managed with functional rehabilitation, which addresses impaired proprioception and incoordination of dynamic stabilizers of ankle.

During the US evaluation of the mechanical instability of the ATFL, the patient assumes a sitting position with the heel of the injured ankle hanging on the edge of examination bed [46•] or examiner's knee. The ankle is maintained in the naturally plantarflexed (30 to 40°) position. The probe is placed at the distal edge of the lateral malleolus almost in parallel with the sole. In this position, a long-axis view of ATFL can be visualized, and the weight of the lower limb can place the ankle in the anterior drawer stress to evaluate mechanical instability (Fig. 1a–d) [46•]. The anterior branch of the peroneal artery, which is often called the anterior lateral malleolar artery and provides vascular supply to the ATFL [47•, 48], is identified with color doppler mode (Fig. 1c). The CFL is evaluated in a prone position with the ankle maximally dorsiflexed. The US probe is placed on the oblique coronal plane to visualize the long-axis view of the CFL for thickness, echogenicity, and continuity (Fig. 2) [49•]. In the CFL with normal tension, the peroneal tendons are elevated toward the probe during dorsiflexion of the ankle [50]. US-guided lateral ligament stabilization is considered if any pathologic finding is detected in ATFL and/or CFL by US (Fig. 3), and patients experience recurrent instability after intensive functional rehabilitation.

Surgical Technique

The patient is placed in a supine position with the affected leg internally rotated. A bump is placed under the buttocks to keep the leg internally rotated. A sterilized wedge surgical cushion is placed under the calf as a counter during distraction when arthroscopic procedures for intra-articular lesions are performed. Standard high frequency linear transducers (> 12 MHz) or hockey stick probes are used. It is easier to perform this procedure with the hockey stick probe because of its superior controllability and visualization of the ATFL and anterior lateral malleolar artery. In a case of severe mechanical instability (namely, both ATFL and CFL are abnormal), however, standard linear transducers are employed to visualize the sinus tarsi as well as the ATFL to place multiple sutures.

1. The tibiotalar joint is then infiltrated using 20 cc of epinephrine or lidocaine with epinephrine while visualizing the long axis of the ATFL with out-of-plane technique with 25G needle. The local infiltrates such as epinephrine and lidocaine allow us to improve the visualization of the ATFL with US by separating the ATFL from surrounding tissues.
2. While visualizing the ATFL in a long-axis view, a large spinal needle with a curved tip such as the Micro SutureLasso™ minor bend (Arthrex, Florida) is passed under the ATFL with out-of-plane technique (Fig. 4a, b), paying attention to the anterior lateral malleolar artery. Once the needle tip becomes visible below the ATFL, the probe is rotated 90° to scan the short-axis view of ATFL, and then the needle is advanced just proximal to peroneal tendons (Fig. 4c, d). By passing the needle below ATFL and perpendicular to the long axis of the ATFL under US guidance, we place sutures in the same manner as the arthroscopic all-inside ATFL repair technique [51••]. The needle position should be in close proximity to the peroneal tendons, which enables us to pass sutures into the lateral fibulotalocalcaneal ligament complex [3••] to lift up elongated ATFL.

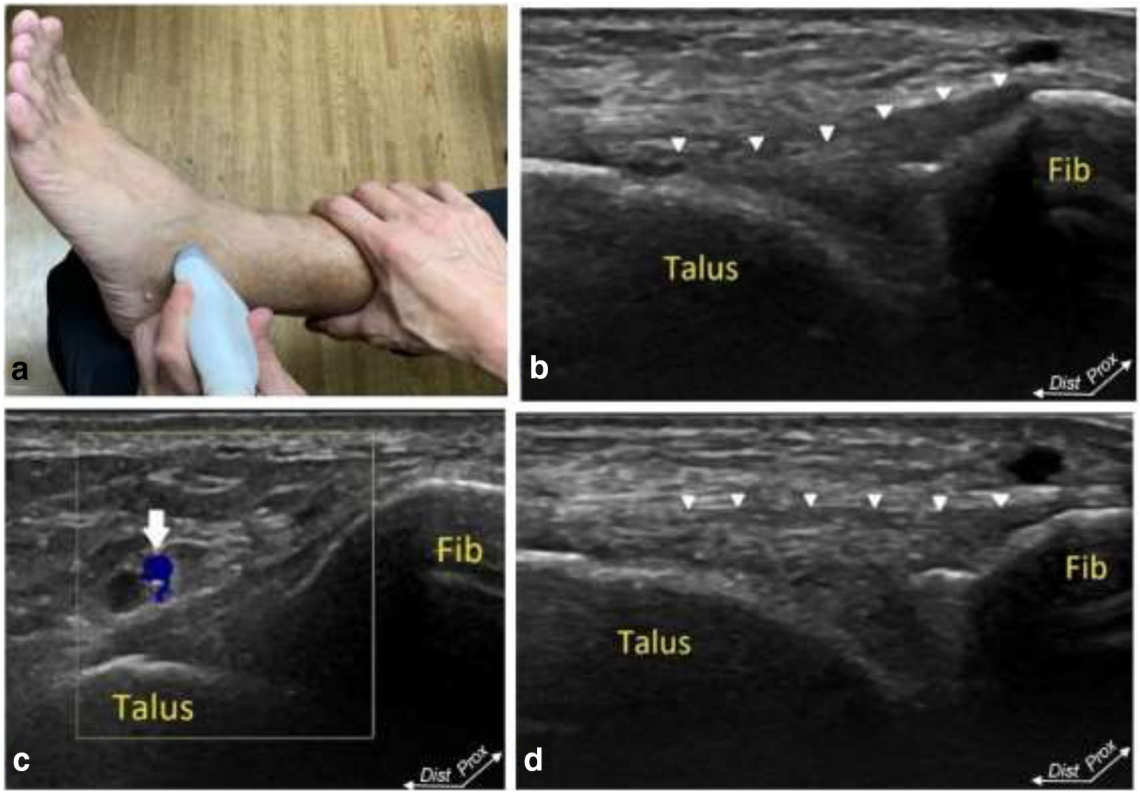

Fig. 1 Ultrasound (US) evaluation of the anterior talofibular ligament (ATFL) in left ankle. **a** The patient assumes a sitting position with the heel of the injured ankle hanging over the examiner's knee. The probe is placed at the distal edge of the lateral malleolus almost in parallel with the sole. **b** A long-axis view of the ATFL is visualized (white arrowheads). **c** The anterior lateral malleolar artery is identified next to vein with color doppler mode (white arrow). In order to obtain clear vascular images, we should avoid excessive compression of the artery or vein by the transducer. **d** Under the anterior drawer stress by the weight of the lower limb and the examiner's hand, the ATFL is stretched (white arrowheads) with a clear fibrillar pattern

3. Also, the sural nerve can be avoided since it runs distal to the peroneal tendons. The wire of the Micro SutureLasso™ is deployed after the needle tip penetrates the subcutaneous tissue and skin. The second wire can then be placed along with the long axis of ATFL under US guidance, again attempting not to damage the anterior lateral malleolar artery.
4. After confirming a bony landmark of the fibular attachment of the ATFL, a 5-mm skin incision with no. 11 blade is made 45° to the long axis of the fibula and 1 cm distal-medial to the anatomical attachment of the ATFL. Blunt dissection with a mosquito forceps is carried down to the intra-articular area between the fibula and talus (Fig. 5a, b). A suture anchor is placed at the anatomical attachment of the ATFL after bringing the outer trocar to the attachment of the ATFL under US guidance (Fig. 5c–e).

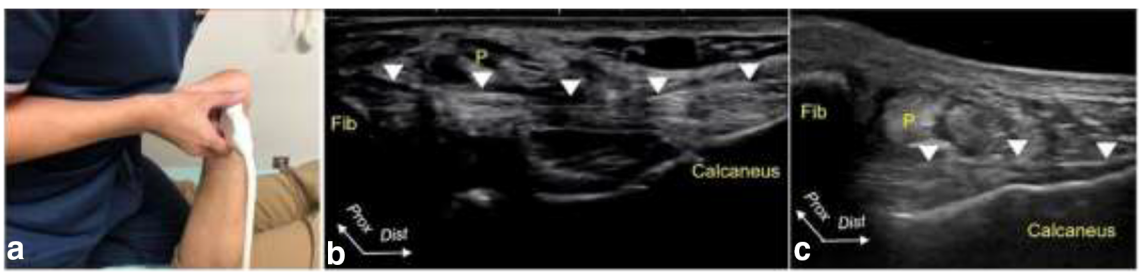

Fig. 2 Ultrasound (US) evaluation of the calcaneofibular ligament (CFL) in right ankle. **a** The CFL is evaluated with the patient in prone position with the ankle in maximum dorsiflexion. The probe is placed anterior to the tip of the fibula toward calcaneal tuberosity. Anatomic studies have suggested that the calcaneal attachment of the CFL has variations. **b** With the ankle in maximum dorsiflexion, both fibula and calcaneal fibers of the CFL can be visualized (white arrowheads). **c** With the ankle in plantarflexion, only the calcaneal fibers of the CFL are visible (white arrowheads). Peroneal tendons are also visible above the CFL

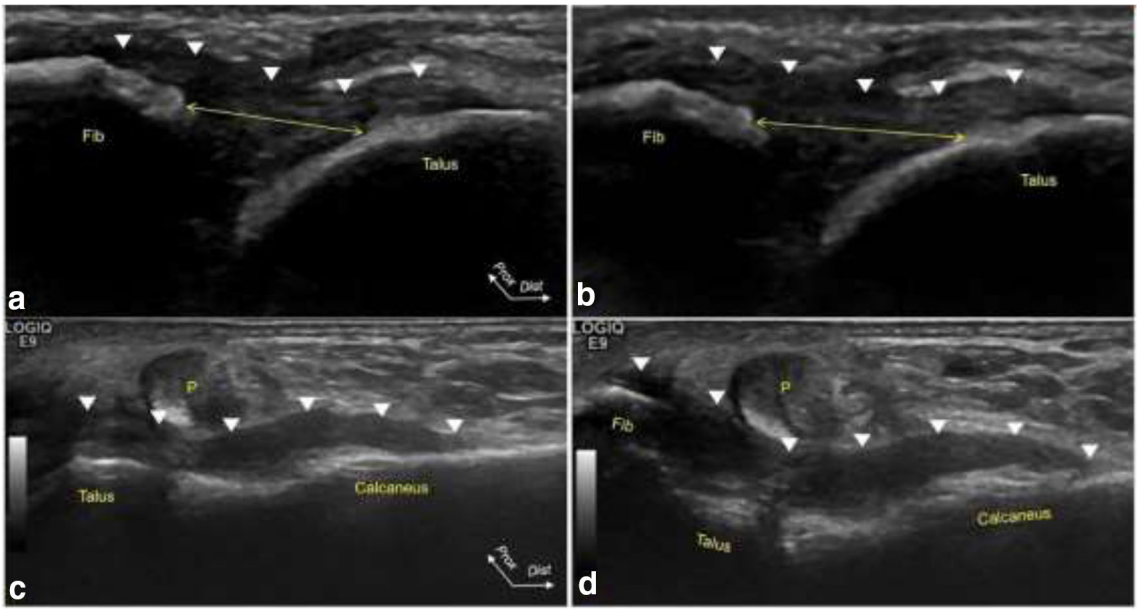

Fig. 3 Ultrasound (US) images of pathological anterior talofibular ligament (ATFL) and calcaneofibular ligament (CFL) in chronic ankle instability (CAI). **a** A long-axis view of hypoechoic ATFL (white arrowheads) without clear fibrillar pattern is visualized. **b** Under anterior drawer stress, no fibrillar pattern of elongated ATFL becomes apparent. The distance between intra-articular fibular footprint and calcaneal footprint (yellow double arrow) is increased under anterior drawer stress. **c** A long-axis view of hypoechoic and thick CFL (white arrowheads) is visualized. Only calcaneal fibers of the CFL below peroneal tendons (P) are assessed in plantarflexion. **d** Under maximum dorsiflexion, the fibular fibers of the CFL (white arrowheads) become visible, yet no fibrillar pattern is apparent

5. The proximal and distal limbs of the wire are retrieved subcutaneously with a grasper through the anchor incision. After suture relay, a simple interrupted suture with or without a knot pusher or the lasso loop stitch technique [52•] is performed for tensioning the LLC with the ankle in a neutral position.

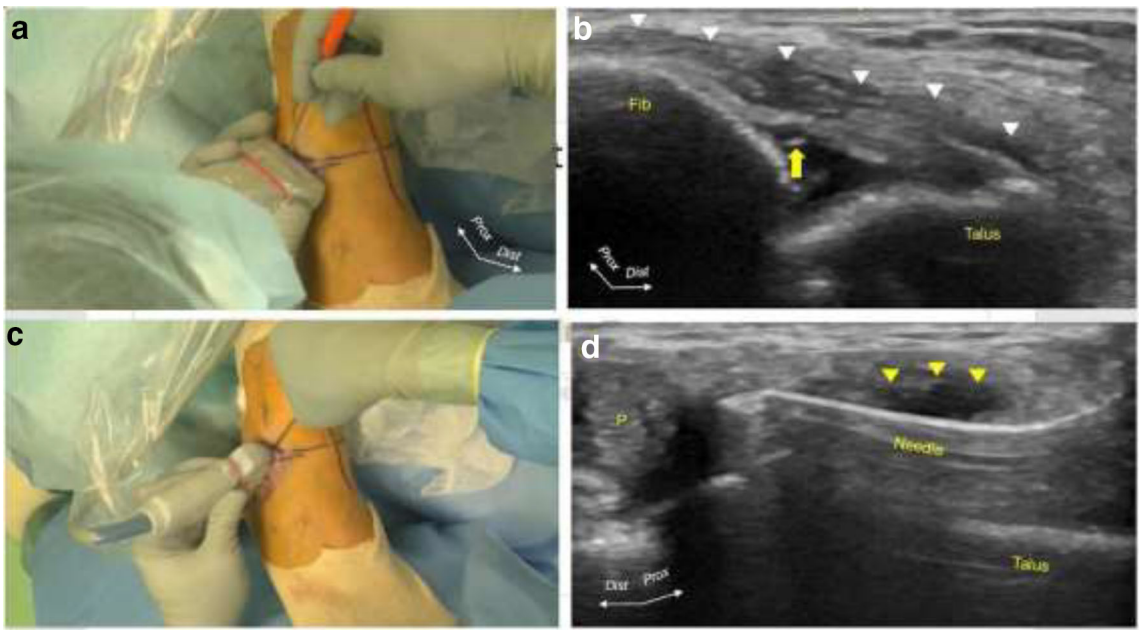

Fig. 4 Ultrasound (US)-guided passing of the needle into the lateral ligament complex of right ankle. **a**, **b** A large spinal needle with a curved tip (yellow arrow) such as the Micro SutureLasso™ minor bend (Arthrex, Florida) is introduced below the ATFL (white arrowheads) in a long-axis view with out-of-plane technique while paying attention to the location of anterior lateral malleolar artery. **c**, **d** The transduce is rotated 90° and a short axis of the ATFL (yellow arrowheads) is visualized. The needle is advanced below the ATFL just proximal to the peroneal tendons (P). Theoretically, the needle tip could reach the lateral fibulotalocalcaneal ligament complex which connect ATFL and CFL fibers

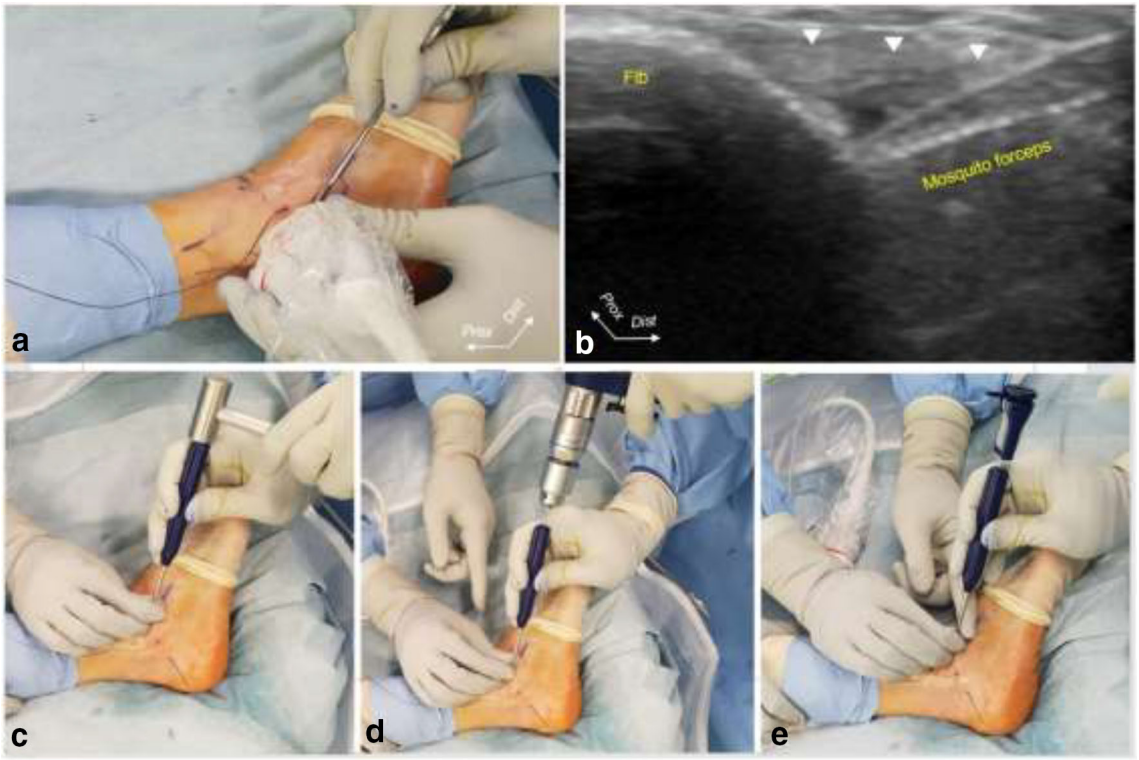

Fig. 5 Sonographically guided fibular anchor placement. **a**, **b** The anatomical attachment of the ATFL (white arrowheads) with a unique angular shape at fibula is confirmed. After a 5-mm skin incision with no. 11 blade is made 45° to the long axis of the fibula and 1 cm distal-medial to the anatomical attachment of the ATFL. Blunt dissection with a mosquito forceps is carried down to the intra-articular area between the fibula and talus. **c** After bringing the outer trochar to the anatomical attachment of ATFL under US guidance, we fix it with a hammer. **d** A small hole is made via the outer trochar by a drill. **e** A suture anchor is placed at the anatomical attachment of the ATFL

6. Additional arthroscopic procedures are necessary in cases of anterior impingement due to osteophytes and soft tissues, osteochondritis dissecans, and synovitis before applying the tension to the LLC. The suture wires can be visualized with arthroscopy 100% of the time, but the suture anchors are rarely visible since it is difficult to

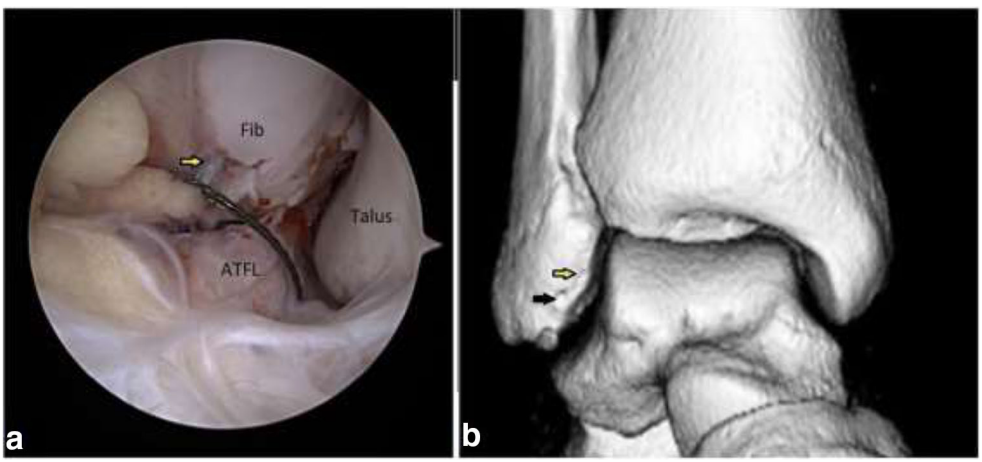

Fig. 6 Arthroscopic view of the wire and suture anchors in ultrasound (US)-guided lateral ligament stabilization. **a** The wire, which is placed under US guidance, can be visualized over the ATFL under arthroscopy without fail. In contrast, a suture anchor is rarely visible under arthroscopy. In the current case, we placed two anchors under US guidance: one at the anatomical footprint of the ATFL, the other placed proximally to the anatomical footprint. Only the proximally placed anchor (yellow arrow) was visible under arthroscopy at the distal margin of the fibula. **b**) A postoperative computed tomography (CT) showed two anchors. The proximal anchor (yellow arrow) was visible under arthroscopy. The distal anchor (black arrow), which was placed at the center of the anatomical attachment of the fibula under US guidance, was not visible under arthroscopy

visualize the center of anatomical footprint of the ATFL under arthroscopy guidance [42••] (Fig. 6).

Rehabilitation

Despite micro-invasive nature of this procedure, rehabilitation program is similar to that of conventional arthroscopic and open stabilization since the time period required for biological healing process would be the same. It consists of three phases: phase 1 (0–4 weeks) focuses on restoring full range of motion with a brace after weaning off crutches and splint in 2 weeks; phase 2 (4–8 weeks) focuses on restoring strength and proprioception in the brace; phase 3 (8–12 weeks) focuses on implementing a sport-specific functional progression program, starting with jogging and ending up with return to sport or work-related activity by the end of phase 3 [1•].

Limitations

US-guided procedures are operator-dependent; thus, the physicians should be skilled in handling and operating US machines. Also, US view is limited to superficial structures of the ankle; therefore, if additional intra-articular pathologic is present, they cannot be appreciated or treated using US only.

Conclusions

Ultrasound is a useful adjunct to traditional surgical procedures for CAI. With US guidance, direct visualization of desired ankle anatomical landmarks and structures could increase accuracy, thus reducing surgical time, decreasing the incidence of iatrogenic damage to neurovascular and other soft tissue structures, minimizing wound complications, and improving outcomes. Despite the steep learning curve, fundamental knowledge in the use of US equipment and knowledge of the anatomy of lateral ankle make ultrasound-guided ankle lateral ligament stabilization reproducible.

Compliance with Ethical Standards

Conflict of Interest Soichi Hattori, M.D., Carlo Antonio Alvarez, M.D., Stephen Canton, M.D., Kentaro Onishi, D.O., and Macalus V. Hogan, M.D. declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance

1.• Porter D, Kamman K. Chronic lateral ankle instability: open surgical management. Foot and Ankle Clin N Am. 2018;23:539–54 **Anatomic ligament repair/reconstruction with patient satisfaction rates more than 90%, the most popularized technique, the modified Brostrom is routinely considered the first-line treatment of CLAI. We prefer the open approach with the use of bone tunnels with an absorbable suture (BT) rather than suture anchors (SAs). A recent level II prospective cohort study comparing BT and SA techniques in 81 patients undergoing the modified Brostrom procedure demonstrated similar outcomes.34 The mean Karlsson scores, American Orthopedic Foot and Ankle Society scores, anterior talar translation, and talar tilt improved significantly with both procedures after intervention. There were no significant differences between the two cohorts, yet there was a clear trend in preoperative scores favoring the SA group over the BT group, suggesting the BT patients had more attenuated ligaments preoperatively. Associated pathology (defined as synovitis, OCL of talus, anterior bony impingement, loose body, and ossicles at the lateral malleolus) occurred in 53% of BT patients and 63% of SA patients. SA displacement, breakage, and pullout have all been reported in the literature35; but these complications that are unique to the SA technique were not investigated in this study. Indeed, one disadvantage of SAs is the unique complications that are inherent to its use. For these reasons, as well as the cost of SA and the ease of using BT, we advocate the use of bone tunnels for our open approach BLAR. In overview, the BLAR operative technique begins with diagnostic arthroscopy using anterolateral and anteromedial portals (and other auxiliary portals as needed) and after appropriately evaluating for and treating intra-articular pathology, finishes with an open modified Brostrom ligament reconstruction using bone tunnels. Arthroscopy time should be minimized to limit soft tissue edema and induration.**

2. Hong C, Tan KJ. Concepts of ankle instability: a review. OA Sports Medicine. 2014;2(1):3.

3.•• Vega J, Malagelada F, MCM C, Dalmau-Pastor M. The lateral fibulotalocalcaneal ligament complex: an ankle stabilizing isometric structure. Knee Surg Sports Traumatol Arthrosc. 2018. https://doi.org/10.1007/s00167-018-5188-8 **The purpose of this study was to describe in detail the components of the lateral collateral ligament complex—ATFL and CFL—and determine its anatomical relationships. Methods An anatomical study was performed in 32 fresh-frozen below-the-knee ankle specimens. A plane-per-plane anatomical dissection was performed. Overdissecting the area just distal to the inferior ATFL fascicle was avoided to not alter the original morphology of the ligaments and the connecting fibers between them. The characteristics of the ATFL and CFL, as well as any connecting fibers between them were recorded. Measures were obtained in plantar and dorsal flexion, and by two different observers. Results. the ATFL was observed as a two-fascicle ligament in all the specimens. The superior ATFL fascicle was observed intra-articular in the ankle, in contrast to the inferior fascicle. The mean distance**

measured between superior ATFL fascicle insertions increases in plantar flexion (median 19.2 mm in plantar flexion, and 12.6 mm in dorsal flexion, p<0.001), while the same measures observed in the inferior ATFL fascicle does not vary (median 10.6 mm in plantar flexion, and 10.6 mm in dorsal flexion, n.s.). The inferior ATFL fascicle was observed with a common fibular origin with the CFL. The CFL distance between insertions does not vary with ankle movement (median 20.1 mm in plantar flexion, and 19. 9 mm in dorsal flexion, n.s.). The inferior ATFL fascicle and the CFL were connected by arciform fibers, that were observed as an intrinsic reinforcement of the subtalar joint capsule. Conclusion The superior fascicle of the ATFL is a distinct anatomical structure, whereas the inferior ATFL fascicle and the CFL share some features being both isometric ligaments, having a common fibular insertion, and being connected by arciform fibers, and forming a functional and anatomical entity, that has been named the lateral fibulotalocalcaneal ligament (LFTCL) complex. The clinical relevance of this study is that the superior fascicle of the ATFL is anatomical and functionally a distinct structure from the inferior ATFL fascicle. The superior ATFL fascicle is an intra-articular ligament, that will most probably not be able to heal after a rupture, and a microinstability of the ankle is developed. However, when the LFTCLis injured, classical ankle instability resulted. In addition, because of the presence of LFTCL complex, excellent results are observed when an isolated repair of the ATFL is performed even when an injury of both the ATFL and CFL exists.

4.•• Radwan A, Bakowski J, Dew S, Greenwald B, Hyde E, Webber N. Effectiveness of ultrasonography in diagnosing chronic lateral ankle instability: a systematic review. Int J Sports Phys Ther. 2016;11:164–74 **The purpose of this systematic review was to investigate the effectiveness of ultrasonography in diagnosing CAI, in comparison with other diagnostic tools. Methods: articles published between the years 2000–2015, and articles that were peer reviewed and published in the English language. Databases searched: CINAHL, PubMed, Medline, Medline Plus, Science Direct, OVID, Cochrane, and EBSCO. Titles and abstracts of the 1,420 articles were screened for the inclusion criteria by two independent raters, with discrepancies solved by a third rater. The modified 14-point Quality Assessment of Diagnostic Accuracy Studies (QUADAS) scale was used to assess methodological quality of included articles. Results: Six high quality articles were included in this systematic review, as indicated by high scores on the QUADAS scale, ranging from 10 to 13. Sensitivity of US ranged from: 84.6–100%, specificity of US ranged from: 90.9–100% and accuracy ranged from: 87–90.9%. The results of the included studies suggest that US is able to accurately differentiate between the grades of ankle sprains and between a lax ligament, torn ligament, thick ligament, absorbed ligament and a non-union avulsion fracture. These findings indicate that US is a reliable method for diagnosing CAI, and that US is able to classify the degree of instability. Conclusion: Researchers found that US is effective, reliable, and accurate in the diagnosis of CAI. Clinical Implications: US would allow for earlier diagnosis, which could increase the quality of care as well as decrease the number of outpatient visits. This could lead to improvement in treatment plans, goals and rehabilitation outcomes. level of Evidence: 1a**.

5. Guelfi M, Zamparetti M, et al. Open and arthroscopic lateral ligament repair for treatment of chronic ankle instability: a systematic review. Foot Ankle Surg. 2016;24:11–8.

6. Cao Y, Hong Y, et al. Surgical management of chronic lateral ankle instability: a metanalysis. J Orthop Surg Res. 2018;13:159.

7.• Brown A, Shimozono Y, et al. Arthroscopic versus open repair of lateral ankle ligament for chronic lateral ankle instability: a meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2018. https://doi.org/10.1007/s00167-018-5100-6. **The purpose of this meta-analysis was to analyze the current comparative studies of arthroscopic and open techniques for lateral ankle ligament repair to treat chronic lateral ankle instability. Methods. A systematic search of MEDLINE, EMBASE and Cochrane Library databases was performed during February 2018. Included studies were evaluated with regard to level of evidence and quality of evidence using the Modified Coleman Methodology Score. Total number of patients, patient age, follow-up time, gender ratio, surgical technique, surgical complications, complication rate, recurrent instability or revision rate, clinical outcome measures and percentage of patients who returned to sport at previous level were also evaluated. Statistical analysis was performed using RevMan, and a p value of < 0.05 was considered to be statistically significant. Results. Four comparative studies for a total of 207 ankles were included. There was a significant difference in favor of arthroscopic repair with regard to AOFAS score, and there was no significant difference with regard to Karlsson score. There was a statistically significant difference in AOFAS score in favor of the arthroscopic repair (MD; 1.41, 95% CI 0.29-2.52, $I^2 = 0\%$, $p < 0.05$). There was no statistically significant difference in Karlsson score (MD; 0.00, 95% CI −3.51 to 3. 51, $I^2 = 0\%$, n.s.). There was no statistically significant difference in total, nerve, or wound complications. Conclusion. The current meta-analysis found that short-term AOFAS functional outcome scores were significantly improved with arthroscopic lateral ankle repair compared to open repair. There was no significant difference between arthroscopic and open repair with regards to Karlsson functional outcome score, total complication rate, or the nerve and wound complication subsets with the included studies with at least 12 months of follow-up. However, the current evidence is still limited, and further prospective trials with longer follow-up are needed. Level of evidence. III.**

8. Porter M, Shadbolt B, Ye X, Stuart R. Ankle lateral ligament augmentation versus the modified Bronstrom-Gould procedure, a 5-year randomized controlled trial. Am J Sports Med. 2019:1–8.

9. Maffulli N, Buono A, et al. Isolated anterior talofibular ligament Bronstrom repair for chronic lateral ankle instability. A 9-year follow-up. Am J Sports Med. 2013;41:–4.

10. Guillo S, Takao M, et al. Arthroscopic anatomical reconstruction of the lateral ankle ligaments. Knee Surg Sports Traumatol Arthrosc. 2015, 2016. https://doi.org/10.1007/s00167-015-3789-z.

11. Acevedo J, Mangone P. Ankle instability and arthroscopic lateral ligament repair. Foot and Ankle Clin N Am. 2015;20:50–69.

12. Almohrej O, Al-Kenani NS. Chronic ankle instability: current perspectives. Avicena J Med. 2016;6:103–8.

13. Cottom J, Rigby R. The "all inside" arthroscopic Broström procedure: a prospective study of 40 consecutive patients. Foot Ankle Surg. 2013;52:568–74.

14. Cottom J, Rigby R. A comparison of the "all inside" arthroscopic Broström procedure with the traditional open Modified Broström-Gould technique: a review of 62 patients. Foot Ankle Surg. 2017. https://doi.org/10.1016/j.fas.2017.07.64.

15. Baloch N, Hasan O, Jessar M, Hattori S, Yamada S. "Sports Ultrasound", advantages, indications and limitations in upper and lower limbs musculoskeletal disorders. Review article. Int J Surg. 2018;54:333–40.

16. Lento P, Primack S. Advances and utility of diagnostic ultrasound in musculoskeletal medicine. Curr Rev Musculosket Med. 2008;1:24–31.
17. Del Cura J, Corta R. Ultrasound guided interventional procedures in the musculoskeletal system. Radiologia. 2010;52(6):525–33.
18.• Beard N, Gousse R. Current ultrasound application in the foot and ankle. Orthop Clin N Am. 2018;49:109–21 **Ultrasound has been used in the foot and ankle for nearly 2 decades and is being used with increasing frequency and indication. Utilization in diagnosis demonstrates unique advantages that are complementary to other imaging modalities. High-resolution ultrasound is the modality of choice for needle placement, including joint injection. Increasing collaboration between foot and ankle surgery and skilled ultrasonographers is leading to innovation in minimally invasive treatment of common diagnoses. Ultrasonic augmentation of surgery. Ultrasound has the potential to augment many aspects of traditional foot and ankle surgery. Perhaps most helpful is the ability to use ultrasound preoperatively or intraoperatively to identify soft tissue and bony structures over and above traditional palpation or landmark-guided techniques. Assistance in endoscopy is documented not just in helping with port placement but also with offering another means of visualization. Published cases and series include arthroscopy of the hallux and several techniques at the plantar fascia. Augmentation of traditional surgery techniques and tools, although promising, is not yet well established and requires a team of highly skilled interventional ultrasonographers and orthopedic surgeons to effectively apply**.
19. Lapeque P, Andrei A, et al. US-guided percutaneous release of the trigger finger using a 21-gauge needle: a prospective study of 60 cases. Radiology. 2016;280(2):483–99.
20. Petrover D, Richette P. Treatment of carpal tunnel syndrome: from ultrasonography to ultrasound guided carpal tunnel release. Joint Bone Spine. 2018;85:545–52.
21. Ohuchi H, Hattori S, et al. Ultrasound-assisted endoscopic carpal tunnel release. Arthroscopy Techniques. 2016;5(3):e483–7.
22. Dekimpe C, Adreani O, et al. Ultrasound-guided percutaneous release of the carpal tunnel: comparison of the learning curves of a senior versus junior operator. a cadaveric study. Skelet Radiol. 2019. https://doi.org/10.1007/s00256-019-03207-y.
23. Bouillis J, Lallouet S, Ropars M. Echography-guided pinning for prevention of iatrogenic injuries to the radial nerve during fixation of extra-articular distal radius fracture: an anatomical study. J Wrist Surg. 2017;6:336–9.
24. Shroeder A. Utilization of ultrasound in the treatment of athletes for beginners. In: Goto H, editor. Medical View; 2019.
25. Quinones P, Hattori S, Ohuchi H, Kato Y. Ultrasound guided muscle hematoma evacuation. Arthroscopy Techniques. 2019. https://doi.org/10.1016/j.eats.2019.03.007.
26. Ahn K, Jhun H, Choi K, Lee YS. Ultrasound-guided interventional release of rotator interval and posterior capsule for adhesive capsulitis of the shoulder using a specially designed needle. Pain Physician. 2011;14:531–7.
27. Peck E, Jelsing E, Onishi K. Advanced ultrasound guided interventions for tendinopathy. Phys Med Rehabil Clin N Am. 2016;27:733–48.
28. Zhang J, Fukushima Y, Onishi K. The application of ultrasound imaging in tendinopathy. Med Res Clin Case Rep. 2018;2(1):141–8.
29. Balius R, Bong D, Ardèvol J, Pedret C, Codina D, Dalmau A. Ultrasound guided fasciotomy for anterior chronic exertional compartment syndrome of the leg. J Ultrasound Med. 2016;35:823–9.
30. Ohuchi H, Ichikawa K, et al. Ultrasound-assisted endoscopic partial plantar fascia release. 2013. Arthroscopy Techniques.2(3):e227–e230.
31. Seng C, Mohan C, et al. Ultrasonic percutaneous tenotomy for recalcitrant lateral elbow tendinopathy: sustainability and sonographic progression at 3 years. Am J Sports Med. 2015;44(2):504–9.
32. Lungu E, Grondin P, et al. Ultrasound-guided tendon fenestration versus open-release surgery for the treatment of chronic lateral epicondylitis of the elbow: protocol for a prospective, randomized, single blinded study. BMJ Open. 2018;8:e021373.
33. Battista C, Dorweiler M, et al. Ultrasonic percutaneous tenotomy of common extensor tendons for recalcitrant lateral epicondylitis. Tech Hand Upper Extrem Surg. 2017;22:15–8.
34. Giannetti S, Patricola A, Stancati A, Santucci A. Intraoperative ultrasound assistance for percutaneous repair of the Achilles tendon rupture. Orthopedics. 2014;37(12):820–4.
35.• Chavez J, Hattori S, et al. The use of ultrasonography during minimally invasive Achilles tendon repair to avoid sural nerve injury. J Med Ultrason. 2019. https://doi.org/10.1007/s10396-019-00951-5 **Four patients with Achilles tendon ruptures underwent minimally invasive repair in our institution by the same surgeon. With the patients positioned prone under general endotracheal anesthesia, a 3-cm transverse incision was made about 1 cm proximal to the rupture site. A Percutaneous Achilles Repair System (PARS; Arthrex®, Florida, USA) jig was slid within the paratenon. With a sterile sleeve covering the transducer (12 MHz), a mobile ultrasound machine (VenueTM50, GE Healthcare, Tokyo, Japan) was used to avoid the neurovascular bundle each time a needle passed through the lateral side of the tendon. The sutures were all retrieved as the jig was pulled out andthe tendon ends were approximated with the foot in plantarflexion. The procedure was well tolerated by all patients, with no complaints pointing to sural nerve injury such as sensory disturbance and pain throughout their respective follow up periods. The incision sites all healed well without any wound complications such as dehiscence or local infection. Minimally invasive Achilles tendon repair continues to be accompanied by a risk of iatrogenic sural nerve injury despite the employment of measures to consciously protect the sural nerve during repair. Some authors have recommended exposure and visualization of the sural nerve during repair to minimize injury by being able to avoid it with a certain degree of confidence. Others have advocated performing the procedure just under local anesthesia to facilitate a wide-awake surgery so that the patient can generate feedback if any neural disturbance was felt during puncture or infiltration. We have shown that ultrasonography can be used in order to have indirect but real-time visualization during minimally invasive Achilles tendon repair. This can be achieved with the patient comfortable under general or spinal anesthesia, without having to ask feedback regarding neural disturbances throughout the surgery. This also avoids additional incisions and soft tissue trauma just to directly visualize the sural nerve in order to avoid it. Under ultrasound guidance, it was ensured that the needle was always deep to sural nerve each time it passed through the lateral side of the Achilles tendon. With these encouraging results, we highly recommend this method to avoid iatrogenic sural nerve injury during minimally invasive repair of the Achilles tendon.**
36. Hirahara A, Andersen W. Ultrasound-guided percutaneous repair of medial patellofemoral ligament: surgical technique and outcomes. Am J Orthop. 2017;46(3):152–7.
37. Chen Y, Cai Y, Wang Y. Value of ultrasonography for detecting chronic injury of the lateral ligaments compared with ultrasonography findings. Br J Radiol. 2014;87:20130406.

38.• Cao S, Wang C, Xi M, Xu W, Huang J, Zhang C. Imaging diagnosis for chronic lateral ankle injury: a systematic review with meta-analysis. J Orthop Surg Res. 2018;13:159 **This systemic review will explore the effectiveness of different imaging techniques in diagnosing chronic lateral ankle ligament injury. Methods: Relative studies were retrieved after searching 3 databases (MEDLINE, EMBASE, and Cochrane Central Register of Controlled Trails). Eligible studies were summarized. Data were extracted to calculate pooled sensitivity and specificity of magnetic resonance imaging (MRI), ultrasonography (US), stress radiography, and arthrography. Results: Fifteen studies met our inclusion and exclusion criteria. A total of 695 participants were included. The pooled sensitivities in diagnosing chronic ATFL injury were 0.83 [0.78, 0.87] for MRI, 0.99 [0.96, 1.00] for US, and 0.81 [0.68, 0.90] for stress radiography. The pooled specificities in diagnosing chronic ATFL injury were 0.79 [0.69, 0.87] for MRI, 0.91 [0.82, 0.97] for US, and 0.92 [0.79, 0.98] for stress radiography. The pooled sensitivities in diagnosing chronic CFL injury were 0.56 [0.46, 0.66] for MRI, 0.94 [0.85, 0.98] for US, and 0.90 [0.73, 0.98] for arthrography. The pooled specificities in diagnosing chronic CFL injury were 0.88 [0.82, 0.93] for MRI, 0.91 [0.80, 0.97] for US, and 0.90 [0.77, 0.97] for arthrography. Conclusion: This systematic review with meta-analysis investigated the accuracy of imaging for the diagnosis of chronic lateral ankle ligament injury. Ultrasound manifested high diagnostic accuracy in diagnosing chronic lateral ankle ligament injury. Clinicians should be aware of the limitations of MRI in detecting chronic CFL injuries.**

39. Pitts C, Haley M, et al. Anatomic structures at risk in the arthroscopic Bronstrom - Gould procedure:a cadaver study. Foot Ankle Surg. 2019. https://doi.org/10.1016/j.fas.2019.04.008.

40.• Poggio D, Claret G, et al. Correlation between visual inspection and ultrasonography to identify the distal branches of superficial peroneal nerves: a cadaveric study. Foot Ankle Surg. 2016;55:492–5 **The anatomy of the superficial peroneal nerve (SPN) and, more precisely, of the distal branches of the SPN at the ankle has attracted interest owing to the possibility of injury when performing ankle arthroscopy. The anterolateral portal is one of the most commonly used portals in ankle arthroscopy, and the intermediate dorsal cutaneous nerve can easily be injured during portal placement. The purpose of the present study was to assess whether visual inspection and palpation of the cutaneous nerves at the ankle differed from examination with ultrasonography and whether the 2 examination techniques correlated with the anatomic location of the SPN, which was verified by cadaver dissection. First, visual examination and palpation was performed to identify the SPN, after which 12 cadaver legs from separate specimens were examined with ultrasonography to mark the course of the SPN. We then measured the distance between the nerve as identified with gross visualization/palpation and ultrasound examination, and compared these with the precise location determined by anatomic dissection. The use of ultrasonography to determine the course of the SPN was good or excellent in 11 of the 12 legs (91.7%) studied. In contrast, gross visualization/palpation was good or excellent in 4 legs (33.3%). Excellent agreement was observed between the ultrasound markings and the anatomic dissection results. However, the visual examination poorly identified the course and the anatomic variations of the nerve branches evidenced in the anatomic dissection. From these findings in cadaver specimens, ultrasound identification of the SPN and its branches is likely preferable to gross visualization/palpation before placement of the anterolateral arthroscopic portal to the ankle.**

41. Thes A, Klouche S, et al. Assessment of the feasibility of arthroscopic visualization of the lateral ligament of the ankle: a cadaveric study. Knee Surg Sports Traumatol Arthrosc. 2016;24:985–90.

42.•• Teramoto A, Shoji H, et al. The distal margin of the lateral malleolus visible under ankle arthroscopy from the anteromedial portal, is separate from the ATFL attachment site of the fibula: a cadaver study. J Orthop Surg Res. 2018;23:5655 **The purpose of this study was to evaluate the relationship between the lateral malleolus view under ankle arthroscopy and the anterior talofibular ligament (ATFL) attachment site. Methods: Seven normal ankles from Thiel-embalmed cadavers were investigated. Ankle arthroscopy was performed using a 2.7-mm-diameter, 30-degree, oblique-viewing endoscope. An antero-medial portal (AM), a medial midline portal (MML), and an antero-central portal (AC) were created in order, and the ankle arthroscope was inserted. The lateral malleolus was visualized as distally as possible, and the site that appeared to be the distal margin was marked with a 1.5-mm-diameter K-wire. Visualization with arthroscopy was carried out from all portals to mark the distal margin, and the ankle was subsequently exposed to directly measure the distance from the center of the ATFL attachment site at the fibula to each marking. Results: The distances from the ATFL attachment site to the markings made under arthroscopy from the AM, MML, and AC portals were 10.4 ± 2.6 mm, 7.4 ± 1.9 mm, and 7.3 ± 1.9 mm, respectively. Compared to markings made from the MML or AC portal, the marking made from the AM portal was significantly further away from the ATFL attachment site. Conclusions: A typical ankle arthroscopy portal may not allow complete visualization of the tip of the lateral malleolus, indicating that it may not be feasible to thoroughly observe the ATFL attachment site. It is necessary to perform arthroscopic surgeries with the understanding that the distal margin of the lateral malleolus that appears under ankle arthroscopy is 7e10 mm proximal to the ATFL attachment site.**

43.•• Hattori S, Kumai T, Ohuchi H. Ultrasound-guided repair of anterior talofibular ligament: anatomical accuracy of anchor placement. Non-inferiority. Abstract. 2019. The 31st Annual Meeting of the Japanese Society of Orthopedic Ultrasonics. **The purpose of this study was to evaluate the accuracy of anchor placement in ultrasound-guided anterior talofibular ligament repair (USG ATFLR). Method: We included those underwent open ATFLR and those with USG ATFLR. The distance between the distal anchor and the fibular obscure tubercle (FOT) in 3DCT was measured. We considered that the distance of USG ATFLR would be non-inferior to open ATFLR within 5 mm. Result: We had 11 cases of open ATFLR and 10 USG ATFLR. The mean distance between anchor and FOT was 6.0 ± 2.7 mm in open ATFLR and 7.4 ± 2.5 mm in USG ATFLR respectively. The mean differences of two techniques were − 1.5 mm (95% confidence interval 1.0 to − 3.9). The CI was smaller than the non-inferiority margin (5 mm). Conclusion: Anchor placement under USG ATFLR can be anatomically accurate.**

44. Kannus P, Renström P. Treatment for acute tears of the lateral ligaments of the ankle. Operation, cast, or early controlled mobilization. J Bone Joint Surg Am. 1991;73(2):305–12.

45. Guillo S, Bauer T, Lee JW, Takao M, Kong SW, Stone JW, et al. Consensus in chronic ankle instability: aetiology, assessment, surgical indications and place for arthroscopy. Orthop Traumatol Surg

Res. 2013;99(8 Suppl):S411–9. https://doi.org/10.1016/j.otsr.2013.10.009.

46.• Kenmochi M, Sasaki S, Fujisaki K, Yusuke O, Kotani A, Ichimura S. A new classification of anterior talofibular ligament injuries based on ultrasonography findings. J Orthop Surg Res. 2016;21:770e–78 **This study aimed to assess the treatment outcomes of lateral ankle ligament injuries using a new classification for ATFL injuries based on US findings. Methods: A total of 140 acute lateral ankle ligament injuries in 132 patients (46 men, 86 women) treated non-operatively were evaluated retrospectively. The average age of the patients was 17.8 years (range, 7–57 years). Patients with a complaint of lateral ankle injury were examined using US, and the anterior talofibular ligament damage was classified into 5 types depending on the type of the injury. The treat ment method was selected based on the ultrasonographic classification, and the clinical results were assessed by original evaluation and compared between treatment methods and classification types. Results: A Good or Excellent treatment result was obtained in 133 out of 140 injuries (95.0%). Significant differences were observed in the distribution of treatment methods by injury type ($P < 0.001$), and the distribution of outcomes was significantly different from the uniform distribution ($P < 0.001$). Our findings demonstrate that the ultrasonographic classification proposed in this study can be used to determine the appropriate treatment resulting in good outcomes for all types of anterior talofibular ligament damage. Conclusion: Visualization of injured ligaments using US may introduce a novel approach of rating and treating ligament injuries.**

47.• Gosselin M, Haynes J, et al. The arterial anatomy of the lateral ligament complex of the ankle: a cadaveric study. Am J Sports Med. 2018:1–6. https://doi.org/10.1177/0363546518808060 **The purpose of this study was to define the vascular anatomy of the lateral ligament complex of the ankle. Methods: Thirty pairs of cadaveric specimens (60 total legs) were amputated below the knee. India ink, followed by Ward blue latex, was injected into the peroneal, anterior tibial, and posterior tibial arteries to identify the vascular supply of the lateral ligaments of the ankle. Chemical debridement was performed with 8.0% sodium hypochlorite to remove the soft tissues, leaving casts of the vascular anatomy intact. The vascular supply to the lateral ligament complex was then evaluated and recorded. Results: The vascular supply to the lateral ankle ligaments was characterized in 56 specimens: 52 (92.9%) had arterial supply with an origin from the perforating anterior branch of the peroneal artery; 51 (91.1%), from the posterior branch of the peroneal artery; 29 (51.8%), from the lateral tarsal branch of the dorsalis pedis; and 12 (21.4%), from the posterior tibial artery. The anterior branch of the peroneal artery was the dominant vascular supply in 39 specimens (69.6%). Conclusion: There are 4 separate sources of extraosseous blood supply to the lateral ligaments of the ankle. In all specimens, the anterior talofibular ligament was supplied by the anterior branch of the peroneal artery and/or the lateral tarsal artery of the dorsalis pedis, while the posterior talofibular ligament was supplied by the posterior branch of the peroneal artery and/or the posterior tibial artery. The calcaneofibular ligament received variable contributions from the anterior and posterior branches of the peroneal artery, with few specimens receiving a contribution from the lateral tarsal or posterior tibial arteries. Clinical Relevance: Understanding the vascular anatomy of the lateral ligament complex is beneficial when considering surgical management and may provide insight into factors that lead to chronic instability.**

48. Kelikian A. Sarrafian's anatomy of the foot and ankle: descriptive, topographical, functional. 3rd ed: Lippincott Williams & Wilkins; 2011. p. 344.

49.• Hattori S, Nimura A, Koyoma M, Tsutsumi M, Amaha K, Ohuchi H, et al. Dorsiflexion is more feasible than plantar flexion in ultrasound evaluation of the calcaneofibular ligament: a combination study of ultrasound and cadaver. Knee Surg Sports Traumatol Arthrosc. 2019. https://doi.org/10.1007/s00167-019-05630-z **Purpose Ultrasound (US) is a valuable tool for the evaluation of chronic lateral instability of the ankle; however, the feasibility of US for calcaneofibular ligament (CFL) assessment remains unknown. This study aimed to depict and compare CFL on US in various ankle positions to determine the optimal method for evaluating CFL with US and to interpret US findings using cadaveric specimens. Methods The US study included 43 ankles of 25 healthy individuals. The CFL was scanned with US in 20° plantar flexion, neutral position, 20° dorsiflexion, and maximum dorsiflexion. The distances between fibula and CFL were compared. The cadaveric study included macroscopic qualitative observation of the dynamic change of CFL in 7 ankles and quantitative observation of the directions of CFL and footprints in 17 ankles. Results In the US study, the mean distance (mm) between fibula and CFL was 7.3 ± 1.3 in 20° plantar flexion, 6.7 ± 1.6 in neutral position, 4.3 ± 2.5 in 20° dorsiflexion and 3.1 ± 2.1 in maximum dorsiflexion. The more dorsiflexed the ankle was, the shorter the distance between fibula and CFL was (Jonckheere's trend test $p < 0.001$). In the cadaveric study, the CFL fibers were aligned parallel between the mid-substance and the fibular attachment in maximum dorsiflexion, whilst CFL was reflected and rotated in plantar flexion. Conclusions The whole length of the CFL, including its fibular attachment, is more likely to be visualized with US in dorsiflexion than in plantar flexion due to the direction of the CFL at the fibular attachment, which is parallel with the mid-substance in maximum dorsiflexion. Level of evidence IV.**

50. Peetrons P, Creuter V, Bacq C. Sonography of ankle ligaments. J Clin Ultrasound. 2004;32:491–9.

51.•• Vega J, Guelfi M, Malagelada F, Pena F, Dalmau-Pastor M. Arthroscopic all-inside anterior talofibular ligament repair through a three-portal and no-ankle-distraction technique. JBJS Essent Surg Tech. 2018;8(3):e25. https://doi.org/10.2106/JBJS.ST.18.00026 **Arthroscopic treatment of ankle instability is an emerging field attracting increased interest among surgeons. The arthroscopic all-inside ATFL repair allows the surgeon to explore the ankle joint, treat concomitant pathology when encountered, and reattach the injured ATFL to its fibular anatomical location. The aim of this article is to describe the arthroscopic all-inside ATFL repair through a 3-portal no-ankle-distraction technique. Description: after patient positioning, anteromedial and anterolateral portals are created. An accessory anterolateral portal is created just anterior to the fibula and about 1 cm proximal to the tip of the lateral malleolus. The arthroscope is introduced through the anteromedial portal, and the instruments are introduced through the anterolateral portal. Recognition of the ligament and evaluation of the ligament tear with a probe are required. The footprint for the fibular attachment of the ATFL is debrided. The ligament is penetrated with a suture passer. A nitinol loop is pushed and then is pulled out through the accessory portal. The nitinol wire is replaced by a double high-resistance suture.The limbs of the suture located in the accessory portal are passed through the anterolateral portal. Next, one or both limbs of the suture are passed through the loop suture. Pulling of the suture limbs introduces the loop into the joint and the ligament is grasped by the suture. The tunnel for the anchor is drilled. The knotless**

anchor is loaded with the suture, and the anchor and suture are introduced with the ankle in dorsiflexion and valgus. Postoperatively, the ankle is immobilized with a removable walking boot for 4 weeks. Once use of the walking boot is discontinued, physical therapy is started. Rationale: The described technique has the advantage of being done with a minimally invasive approach and providing an anatomical repair of the ligament. Concomitant intra-articular pathology can be addressed during the procedure through the same arthroscopic approaches. Early rehabilitation and the lack of intra-articular knots areadditional benefits of the technique.

52.• Takao M, Matsui K, et al. Arthroscopic anterior talofibular ligament repair for lateral instability of the ankle. Knee Surg Sports Traumatol Arthrosc. 2016;24:1003–6 **Although several arthroscopic procedures for lateral ligament instability of the ankle have been reported recently, it is difficult to augment the reconstruction by arthroscopically tightening the inferior extensor retinaculum. There is also concern that when using the inferior extensor retinaculum, this is not strictly an anatomical repair since its calcaneal attachment is different to that of the calcaneofibular ligament. If a ligament repair is completed firmly, it is unnecessary to add argumentation with inferior extensor retinaculum. The authors describe a simplified technique, repair of the lateral ligament alone using a lasso-loop stitch, which avoids additionally tighten the inferior extensor retinaculum. In this paper, it is described an arthroscopic anterior talofibular ligament repair using lasso-loop stitch alone for lateral instability of the ankle that is likely safe for patients and minimal invasive. Level of evidence Therapeutic study, Level V.**