Review Article

Syndesmosis Injury From Diagnosis to Repair: Physical Examination, Diagnosis, and Arthroscopic-assisted Reduction

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Abstract

Injuries to the tibio-fibular syndesmotic ligaments are different than ankle collateral ligament injuries and occur in isolation or combination with malleolar fractures. Syndesmotic ligament injury can lead to prolonged functional limitations and ultimately long-term ankle dysfunction if not identified and treated appropriately. The syndesmosis complex is a relatively simple construct of well-documented ligaments, but the dynamic kinematics and the effects of disruption have been a point of contention in diagnosis and treatment. Syndesmotic ligament injuries are sometimes referred to as "high ankle sprains" because the syndesmotic ligaments are more proximal than the collateral ligaments of the ankle joint. Rotational injuries to the ankle often result in malleolar fractures, which can be combined with ankle joint or syndesmotic ligament injuries. Most of the orthopaedic literature to this point has addressed syndesmosis ligament injuries in combination with fractures and not isolated syndesmotic ligament injuries. Thus, we propose a simplified general video guide to do the diagnostic examinations and arthroscopic-assisted reduction based on current evidence-based medicine.

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Dr. Martin or an immediate family member is a member of a speakers' bureau or has made paid presentations on behalf of Arthrex speaker and iWalk speaker; serves as a board member, owner, officer, or committee member of AOFAS. Neither Dr. Wake nor any immediate family member has received anything of value from or has stock or stock options held in a commercial company or institution related directly or indirectly to the subject of this article.

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Two types of ankle ligament injuries exist, collateral and syndesmotic. Most ankle ligament injuries occur to the collateral ligaments: anterior talofibular ligament (ATFL), calcaneofibular ligament, and deltoid ligament. In general, the collateral ligaments heal with sufficient scar to re-establish coronal stability and adequate ankle function. Not all ankle ligament injuries are to the collateral ligaments—the syndesmotic ligaments can also be injured leading to prolonged functional limitations and ultimately long-term ankle dysfunction if not identified and treated appropriately. The tibiofibular syndesmosis is a complex of well-described ligaments, but the dynamic kinematics and the effects of disruption have been a point of contention in diagnosis and treatment. Syndesmotic ligament injuries are sometimes referred to as "high ankle sprains" because the syndesmotic ligaments are more proximal than the collateral ligaments of the ankle joint. Rotational injuries to the ankle often result in malleolar fractures, which can be combined with ankle joint or syndesmotic ligament injuries. Most of the orthopaedic literature to this point has addressed syndesmosis ligament injuries in combination with fractures and not isolated syndesmotic ligament injuries. We propose a simplified

start-to-finish written and video guide to physical examination, diagnosis, arthroscopic reduction, and internal fixation of isolated syndesmosis injuries based on the past and present literature.

Anatomy and Biomechanics

The ankle joint proper, also known as the talocrural joint, is diarthrodial and includes the articulation between the talus, tibia, and fibula. The talocrural joint allows for substantial motion, approximately 70°, primarily dorsiflexion and plantarflexion from the anatomic position, which is important in bipedal ambulation. The most common ankle injury is the tear of the ATFL and is the most common ankle injury observed in the emergency department.[1] ATFL injuries allow abnormal coronal plane tilt of the talus, valgus, with ambulation which causes pain and limits patient function. The syndesmosis is made up of a combination of static and dynamic anatomic structures working synergistically to produce a stable, yet highly dynamic relationship between the tibia and the fibula. Isolated syndesmosis injury occurs when disruption of these structures exists without associated fracture. The key static stabilizer is the incisura, which is a concave groove in the distal tibia in which the fibula rotates in the horizontal plane about a vertical axis. The syndesmosis ligamentous structures are composed of the anterior-inferior tibiofibular ligament (AITFL), the interosseous ligament (IOL), posterior-inferior tibiofibular ligament (PITFL), and the inferior transverse ligament. (Figure 1) The AITFL originates on the anterolateral tibia, also known as Chaput tubercle, and inserts on Wagstaffe tubercle on the fibula. The AITFL is the weakest of the syndesmotic ligaments and is the first ligament subjected to stress on external rotation force of the fibula around a vertical axis.[2] The PITFL originates on the posterior tubercle of the tibia, also known as Volkmann tubercle, and inserts on the posterior aspect of the lateral malleolus, which is the strongest component of the syndesmosis and provides approximately 35% of syndesmosis stability.[3] Xenos et al[4] performed a cadaveric study evaluating ligamentous structures of the syndesmosis. They found a diastasis of 2.3 mm with sectioning of the AITFL alone, 5.5 mm with additional sectioning of the IOL, and 7.3 mm after additional sectioning of the PITFL. The syndesmosis functions to maintain the distal tibiofibular joint and resists axial, rotational, and translational forces. Studies have demonstrated that lateral displacement of the talus decreases the contact area of the tibiotalar articulation dramatically: lateral displacement by 1 mm could decrease the contact area by 42%, and in complete syndesmosis disruption, it could lead to a 36% increase in contact pressures.[5,6] Thus, a stable and congruent articulation is essential to restore normal ankle motion and decrease the risk of developing early degeneration of the talocrural joint.

Natural History

Ankle sprains account for approximately 10% to 30% of all presenting injuries in an athletic cohort with most being lateral ankle sprains. Although historically the incidence of syndesmosis injury has been low with reports between 1% and 18% of all ankle sprains, the growing knowledge and understanding of syndesmosis injuries has come with an increase in incidence reported in the current literature with ranges from 17% to 74%.[7] Injury to the syndesmosis is typically associated with high-speed collisions or rotational injuries that cause the foot to externally rotate while in a dorsiflexed position.[8] The talus being wider anteriorly forces separation of the fibula from the tibia and additional external rotation force leads to abnormal stress on the syndesmosis ligaments. Owing to the mechanism of injury, other ankle ligaments also have the potential to be traumatized in the setting of a high-grade syndesmosis injury. Mait et al[9] did a cadaveric study in which an external rotation force was applied to specimens in dorsiflexion, neutral, and plantar flexion. They found that syndesmotic injury occurred in 100% in dorsiflexion group, 50% in the neutral group, and 0% in the plantarflexion group. In addition, the deltoid ligaments superficial and deep were injured to varying degrees in all specimen with noted syndesmotic injury. Although the deltoid ligament also plays a role in syndesmosis stability, a cadaveric study by Clanton et al[10] demonstrated that deltoid sectioning did not destabilize the syndesmosis until the AITFL and IOL were both released. Conversely, lateral ankle sprains have a 17% rate of concurrent low- to high-grade syndesmosis injury.[11] With isolated injury, a stark contrast exists between that of lateral ankle sprains and syndesmosis injury. Injuries to the syndesmosis commonly occur in contact sports, over a 5-year span, National Football League (NFL) players had an average, per player, time loss of 2.5 weeks, 11.7 practices, and 1.4 games from syndesmotic injury compared with 1.25 weeks, 3.5 practices, and 0.3 games from lateral ankle sprains.[12] Recovery time for syndesmosis injuries can exceed 31 days, which are often highly debilitating injuries in which athletes have trouble performing moves (eg, cutting and pushing off) and can result in chronic pain.[13] Although this review covers isolated syndesmosis injuries, any ligamentous injury to the ankle

requires a detailed examination and should be thought of as a spectrum possibly involving multiple structures.

Diagnosis

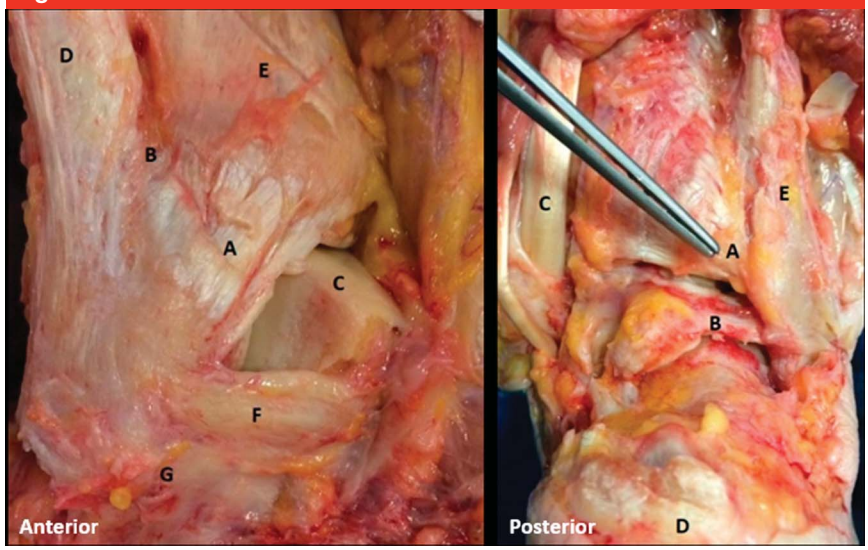
History

As with all diagnoses, a thorough history is paramount. Syndesmosis injuries are easily missed and may have been missed previously or incorrectly diagnosed. Discerning the mechanism of injury may provide greater suspicion for syndesmosis injury. Pain is usually diffuse about the ankle and can have pain anterolaterally proximal to lateral ankle ligaments. Pain is commonly reported while walking up hills, pivoting, or doing a single leg heel raise.

Physical Examination

The physical examination is conducted in a systematic sequence starting with the least painful maneuver and progressing to more painful to help with patient compliance. A comprehensive ankle examination should be done as to not miss concomitant injury to other ankle structures. The following maneuvers are specific to the syndesmosis and should be done in concert with your typical ankle evaluation. To do the crossed-leg test have the patient cross their painful leg across the contralateral side with the distal third of the fibula resting on the opposite knee, and then, the examiner applies downward pressure over the medial knee of the painful side. (Figure 2A) Pain reproduced with gentle force on the medial knee indicates a positive test. Palpation is helpful as a syndesmosis injury is typically tender at the anterolateral joint line and proximal compared with a typical sprain which is over the distal fibula. Tenderness to palpation at the level of the joint and the distance the pain extending proximally has been termed the "tenderness length" (Figure 2B).

Figure 1



Photograph showing the anterior anatomy—**A**, Anterior inferior tibiofibular ligament; **B**, Interosseous ligament; **C**, Talus; **D**, Fibula; **E**, Tibia; **F**, Anterior talofibular ligament; and **G**, Calcaneofibular ligament. Posterior anatomy—**A**, Posterior inferior tibiofibular ligament; **B**, Posterior talofibular ligament; **C**, Flexor Hallucis Longus; **D**, Calcaneus; and **E**, Peroneal Tendons.

The tenderness length has been correlated with MRI findings and time to return to sport in NFL athletes.[14] Perform the squeeze test with the patient seated on the examination table with the leg hanging off the bed in 90 degrees of flexion. The examiner squeezes the fibula and tibia together using the palms to distribute the force broadly avoiding point tenderness, pain at the syndesmosis indicates a positive examination[15] (Figure 2D). Perform the fibula translation test by having the patient in a seated or supine position; the examiner stabilizes the tibia with one hand then grasps the fibula and attempts to translate it anterior and posterior (Figure 2C). The amount of translation and pain should be carefully compared with the contralateral side; a painful soft end point with greater than 2 to 3 mm of translation is a positive examination. Once again, perform the external rotation stress examination by having the patient in the seated position; the examiner stabilizes the tibia with one hand then dorsiflexes the foot while applying an external rotational force, pain indicates a positive examination (Figure 2E). Following the aforementioned examination maneuvers, the patient may be in pain increasing the sensitivity of the subsequent dynamic examinations.

Dynamic Examination

The patient is asked to ambulate approximately 10 ft; on the return, they are asked to walk on heels then tiptoes, followed by standing-double and single leg heel raises. The standing pivot test is then done by keeping the symptomatic foot planted on the ground and externally pivoting the ipsilateral leg and trunk; pain indicates a positive test. The ankle is then tightly taped, in a circumferential fashion (4-inch silk tape), just above the ankle joint to ensure that the foot is in a nonweight-bearing neutral position to stabilize the syndesmosis. Then, the gait and pivot examination mentioned above is

Figure 2

Photograph showing the physical examination maneuvers: **A**, Crossed-leg Test; **B**, Tenderness Length; **C**, Fibular translation test; **D**, Tibiofibular squeeze test; **E**, Dorsiflexion external rotation stress test; and **F**, Stabilization Tape test—Prewrap is applied to protect skin and hair, and then, a 4-inch silk tape is circumferentially wrapped around the ankle tightly with the foot and ankle in a neutral position.

repeated; reduction of pain with increased function indicates a positive stabilization examination[16] (Figure 2F).

Although these provocative maneuvers are classically described, studies show that clinicians should not rely on a single test in isolation. The sensitivities and specificities of the physical examination maneuvers vary widely among the literature. Sman et al[17] performed a cross-sectional diagnostic accuracy study and found the squeeze test to have the highest specificity of 88%, whereas syndesmosis ligament tenderness and external rotation stress test had the highest sensitivities of 92% and 71%, respectively. They concluded that no single test is sufficiently accurate for diagnosis and recommend combination of tests. Previous systematic review performed by the same authors showed poor diagnostic accuracy of these tests with varying sensitivities and specificities.[18]

Radiographic Examination

Standard lower extremity weight-bearing radiographs should be done including the ankle and proximal tibia to rule out fracture about the ankle in addition to Maisonneuve fracture, and plain radiographs also aid to evaluate joint symmetry. Stress

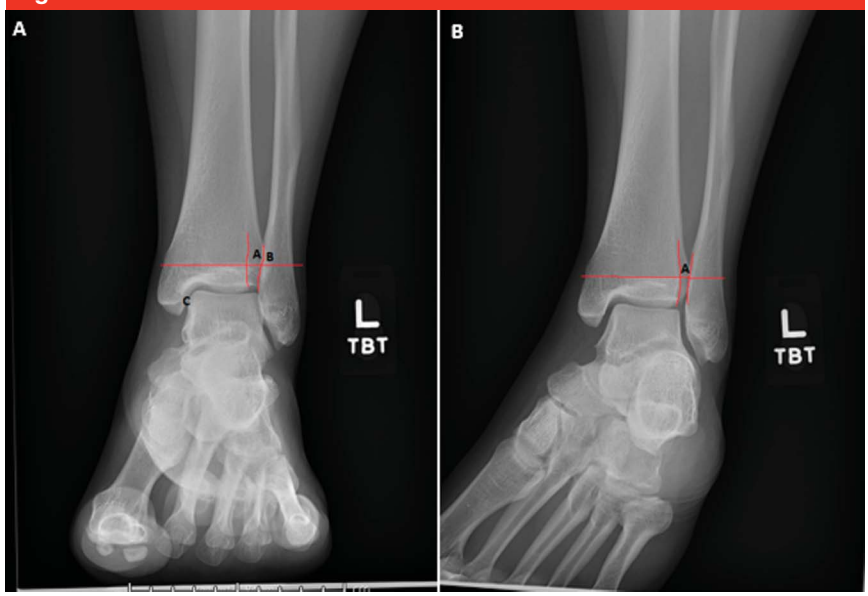
radiographs can also be beneficial; the lead author (K.D.M.) prefers a gravity stress examination which minimizes pain and can also be done reliably by the radiographic technician.[19,20] Radiographic findings that have been identified as syndesmosis injury indicators are increased tibiofibular clear space, decreased tibiofibular overlap, and increased medial clear space. (Table 1) (Figure 3A–B). The tibiofibular clear space is defined as the distance between the medial border of the fibula and the lateral border of the posterior tibia at the incisura approximately 1 cm proximal to the joint line. This distance should be less than 6 mm on AP and mortise views of the ankle. Tibiofibular overlap is defined as the overlap of the lateral malleolus and anterior tibial tubercle. This distance should be greater than 6 mm on A/P and greater than 1 mm on mortise views. Medial clear space is the distance from the lateral aspect of the medial malleolus to the medial aspect of the talus. This distance should be equal to the superior clear space, but not greater than 4 mm (Figure 4). Although plain radiograph is the most common method to evaluate the syndesmosis, the usefulness of this to diagnose syndesmosis injury is limited.[8] MRI has been shown to have sensitivity, specificity, and accuracy of 100%, 93%, and 96%, respectively.[21] Fluid making a contiguous signal from the mortise up through the syndesmosis is termed the "Lambda sign", which has been shown to yield high sensitivity (75%) and specific (85%) for syndesmosis complex injury.[22] The fluid extravasation also indicates a potential insufficient IOL which helps direct surgical management (Figure 5).

Table 1

Normal Radiographic Parameters

Factors	AP	Mortise
Tibiofibular overlap	>6 mm	>1 mm
Medial clear space		Less than or equal to 4 mm
Tibiofibular clear space	<6 mm	<6 mm

Figure 3



A, AP radiograph demonstrating **A**, Tibiofibular clear space; **B**, Tibiofibular overlap; and **C**, Medial clear space. **B**, Mortise radiograph demonstrating **A**, Tibiofibular clear space.

Examination Under Anesthesia

Examination under anesthesia (EUA) should be done in patients when a high index of suspicion exists for syndesmosis injury in the absence of plain radiograph or MRI findings. In addition, EUA should be done before operative fixation to validate the fixation. EUA is done to include dorsiflexion, dorsiflexion external rotation stress, fibular translation test, medial/lateral talar tilt, and an anterior drawer, noting the radiographic parameters described above. Next, a complete diagnostic arthroscopic examination is done to include evaluating for distal tibiofibular stability, osteochondral defects, and deep deltoid continuity. Arthroscopic stability testing includes repeating all the previous listed maneuvers while directly visualizing and noting incompetent anatomic structures.[21] Gross instability is easily noted, but a more detailed syndesmosis examination is needed. The fibular translation test is done by applying anterior to posterior force in the sagittal plane with a blunt instrument on the distal fibula, greater than 2 to 3 mm is a positive examination. The coronal plan can be evaluated with a cotton test, but we prefer placing an instrument into the syndesmosis on known size (4.0 mm shaver) to estimate instability (Figure 6). Ryan et al have demonstrated promising results in treating patients with >4 mm of diastasis, showing improvements in

Figure 4

Radiograph demonstrating the medial clear space widening.

Figure 5

Radiograph demonstrating the lambda sign as described by Ryan et al showing extravasation of fluid to the syndesmosis on coronal T2-weighted fat-suppressed image.

subjective outcome scores, and high rates of return to running sports.[23] The deltoid must also be evaluated because it may block talar reduction or have notable injury requiring repair.

Figure 6

Arthroscopic image demonstrating a 4-mm arthroscopic shaver within the distal tibiofibular joint. **A**, Tibia; **B**, Talus; and **C**, Fibula.

Treatment

Nonoperative

In the absence of gross instability or diastasis on imaging, nonsurgical management should be pursued. In lateral ankle sprains, early range of motion is ideal; by contrast, early mobilization in syndesmosis injuries may place unwanted stress at the distal tibiofibular joint. Nonoperative management should begin with immobilization and nonweight-bearing during the acute phase, first 4 days, and progressed to protected weight-bearing on days four through seven, followed by a focus on functional rehabilitation and return to sport/activity. During the immobilization period patients may participate in open-chain lower extremity exercises so long as they remain pain free and in controlled ankle motion (CAM) boot. Recovery from syndesmotic injury generally takes longer to recover than lateral ankle sprains. In an observational study of NFL players over a 5-year span, there was an average time loss of 2.5 weeks, 11.7 practices, and 1.4 games from syndesmotic injury compared with 1.25 weeks, 3.5 practices, and 0.3 games from lateral ankle sprains.[12] Recovery time for syndesmosis injuries can exceed 31 days.[13]

Operative

The first step in operative management of syndesmosis ligament injuries is reduction of the syndesmosis. This can be done open, arthroscopic, or closed. In isolated ligamentous injuries without fibula fracture, the fibula is typically externally rotated and laterally translated. Reduction is done with a bone clamp on the distal fibula to apply internal rotation and a second two-point reduction clamp from the anteromedial tibia to the posterolateral fibula 3 cm proximal to the plafond.[24,25] Reduction should be confirmed fluroscopically. Recent literature has suggested that previous methods of syndesmotic reduction have not been as effective as believed by the operating surgeon.[26] Definitive fixation can then be achieved by methods outlined below. When a Maisonneuve pattern exists, proximal fibula fracture associated with syndesmosis injury, it is important to restore length to the fibula as well as internal rotation and medial translation. When a distal fibula fracture exists with syndesmotic instability, anatomic reduction and stable fixation of the malleolar fractures should be obtained first and reduction of the syndesmosis as described above.

Syndesmotic Screw Fixation

Syndesmotic screw fixation (SSF) is a common technique to stabilize the syndesmosis; this is a proven method with decades of use, demonstrating good to excellent outcomes.[27] SSF provides immediate stability allowing healing at a low initial cost while the technique and equipment is also familiar to surgeons ensuring confidence. With the syndesmosis reduced and the ankle in a neutral position, the trans-syndesmosis screws are drilled lateral to medial at approximately 2 to 5 cm proximal and parallel to the joint line. The screw(s) should be angulated obliquely posterior to anterior at approximately

25° to 30°. An abundance of literature exists looking at multiple aspects regarding size, number of screws, cortices involved, location, and need for screw removal. Commonly, 4.5 mm or 3.5 mm screws are used; however, no evidence exists demonstrating the superiority of using larger screw size, although using 4.5 mm screws may allow for easier removal and may be less likely to break.[28] A concern with larger screws is that they may potentate a stress riser when compared with small screws on removal. Regarding the removal of screws, it is recommended to remove them once healing has taken place unless the hardware is broken.[29,30] SSF has also been associated with a significant percentage of malreduction, which has been suggested to be the strongest independent predictor of poor clinical outcomes (lower The American Orthopaedic Foot & Ankle Society [AOFAS] scores, decreased range of motion). The point must also be emphasized that the screws themselves do not cause malreduction, they simply maintain the position of fixation. The reduction before fixation is paramount in a fixed SSF. If malreduction is noted postoperatively, screw removal has been shown to allow for in situ reduction and restoration of syndesmosis motion.[31,32] Although hardware removal seems like a simple procedure, this may predispose the patient to additional unnecessary risks and costs. Lalli et al[33] concluded that the syndesmosis hardware removal places a substantial economic burden on both the patients and the healthcare system as a whole.

Suture-button Fixation

Suture-button fixation (SBF) of the distal tibiofibular joint has gained wide popularity over the use of syndesmotic screws. Although these techniques both achieve similar outcomes, mechanical and anatomic advantages exist to the SBF. After reduction of the fibula within the incisura, a guidewire is placed in the same position as a standard screw, 2 cm proximal to the joint line in approximately 25° to 30° of posterior-anterior direction. After the guidewire position is verified with fluoroscopy, a cannulated drill is passed ensuring all four cortices are breached. With multiple manufactures making SBF devices the surgeon must ensure familiarity with the chosen device. In general, a passing guidewire is used to position an oblong button device on the medial cortex of the tibia that is then flipped across the tunnel providing cortical fixation. The lateral button is sequentially tightening to lateral cortex of the fibula or fibular buttress plate. SBF is not without complications; osteolysis of the bone adjacent to the implant has been described along with subsequent subsidence of the device.[34] Early devices required multiple knots to ensure fixation that often left patients with palpable painful suture stacks and reports of abscess formation leading to osteomyelitis; however, newer devices have knotless suture fixation which has helped reduce these complications.[35,36] SBF does have a higher initial cost, but when compared with routine SSF hardware removal, the costs are much less. A study by Neary et al[37] evaluated the cost effectiveness between these two operative options demonstrating that treatment with SBF cost on average $1,482 less than patients treated with SSF. They go on to state that SSF only became more cost effective when the screw removal rate was less than 10%. Mechanically, the SBF mitigates malreduction even with poor clamp placement in a cadaveric study.[38] A randomized controlled trial also looked at this and found that there may be the same incidence of malreduction intraoperatively. However, owing to the dynamic nature of SBF fixation at the 2-year follow-up, there were markedly more cases of malreduction in the SSF group as demonstrated by CT.[39] Anatomically, SBF also allows microfibular motion because the native fibula externally rotates 3° with dorsiflexion. Owing to the more anatomic motion allotted with SBF, it does not need to be removed preventing the need for hardware removal or concerns of broken hardware.[40] Outcomes of SBF are favorable, multiple meta-analyses have been published demonstrating higher AOFAS scores and lower rates of postoperative complications, even earlier time to full weight-bearing when compared with SSF.[27,41] Anderson et al[42] published a randomized trial comparing SBF and SSF which demonstrated higher AOFAS scores, Olerud-Molander Ankle scores, lower VAS scores, and less widening at the minimum 2-year follow-up than did SSF. There have been questions regarding the use of one versus two suture buttons, studies have shown that one suture button has comparable outcomes with SSF and that using a second suture button may not significantly contribute to stability.[43,44]

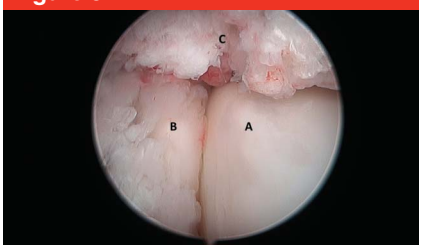
Suture-button Fixation plus anterior-inferior tibiofibular ligament Augmentation

With the noted successes of SBF, some authors have founded concerns that the micromotion allowed may lead to inadequate stability,[45-48] but functional clinical studies are needed to define stability. Through the observation of lateral ankle ligament augmentation with suture tape for lateral ankle instability, it has been proposed that suture button fixation with additional suture tape augmentation of the AITFL may restore stability while preserving motion.[49] Teramoto et al first described this surgical technique in 2017 and we outline this technique (Video 1, Supplemental Digital Content 1, http://links.lww.com/JAAOS/A468).

Figure 7

Photograph showing a revision suture button fixation with AITFL suture tape augmentation. **A**, Proximal insertion of the AITFL on the anterolateral tibia, Chaput tubercle; **B**, Distal insertion of AITFL at Wagstaffe tubercle on the fibula. AITFL = anterior-inferior tibiofibular ligament

Figure 8



Photograph showing the Mercedes sign visualized on arthroscopic reduction of the distal tibiofibular joint. **A**, Talus; **B**, Fibula; and **C**, Tibia.

Using cadaveric models, Shoji et al[50] went on to complete a biomechanical study of this technique compared with suture-button fixation alone and screw fixation. They found that suture-button fixation alone did not provide stability to the syndesmosis and screw fixation was too rigid. Using suture-button fixation and additional AITFL augmentation, they achieved dynamic stability similar to intact models (Figure 7). This technique is yet to have long-term studies evaluating outcomes. In a study conducted looking at syndesmotic instability with posterior malleolus involvement, it was demonstrated that AITFL anatomic repair and augmentation had equivalent outcomes, reduction, earlier rehabilitation, and fewer complications when compared with SSF.[51] We have found this to be a beneficial technique in patients with a shallow tibial incisura (25% to 40%)[52,53] because of the inherent instability and predisposition to malreduction.[54]

Complications

Main complications in all techniques include malreduction and overcompression. With the emergence of SBF, concerns exist regarding impinging on medial neurovascular structures. Malreduction has been shown to be the most clinically significant complication of syndesmosis treatment demonstrating significantly worse outcomes.[55] Causes of malreduction include improper positioning of the clamp tines and incisura morphology. When using reduction forceps for syndesmosis reduction, the position of the tines are important. The lateral clamp tine should be placed on the fibular ridge and the medial clamp tine should be on the anterior third of the tibial line in the lateral view.[24,26] Cherney et al looked at the morphology of incisura and found that specific malreduction patterns are associated with particular morphology. They discovered that shallow incisura correlated with anterior fibular malreduction and was less likely to be rotated, whereas deep syndesmoses predisposed to posterior sagittal plane and rotational malalignment.[54] Malreduction is mitigated by using proper clamp placement[26,56] while also avoiding over compression. Haynes et al[57] have defined overcompression as fibular medialization greater than 1.0 mm when compared with noninjured extremity. In their study, those that were overcompressed had a mean clamp force of 163 N, and they found that those with mean clamp force of 130 N had adequate compression of the syndesmosis. They describe that the appropriate amount of force would be equal to that needed to indent a 12oz beverage can. We also verify the reduction with fluoroscopy and direct arthroscopic visualization as described by Lui et al and Miller et al[58,59] (Figure 8). Regarding at-risk structures in SBF, it has been identified that the saphenous nerve and vein are in close proximity, leading to entrapment of these structures. Cadaveric studies of SBF have shown that nerve entrapment occurs 10% to 20% of the time and saphenous vein entrapment occurs 10% to 37% of the time, regardless of how proximal the SBF was placed, leading these authors to suggest medial incisions to ensure entrapment is avoided.[60-62] We have also transitioned to newer SBF techniques which help flip the button, potentially reducing the saphenous nerve complications that have been described. A newer knotless device is also available which has demonstrated good clinical results with the possibility of reducing entrapment and skin irritation seen in previous devices.[35]

Author Preferred Method of Treatment

In our practice, we use a standardized preoperative examination and radiographic workup including a gravity stress view and MRI. Based on these findings, we formulate an appropriate

surgical approach. Owing to the high prevalence of intra-articular pathology as described by Ferkel et al, we conduct an arthroscopic examination before and in conjunction with all repairs.[63] For isolated AITFL injuries, we perform an isolated anatomic repair augmented with a suture-tape construct from the anterolateral tibia (Chaput tubercle) to Wagstaffe tubercle on the fibula. If deltoid injury is noted or a medial tilt remains, a deltoid repair is performed. If the PITFL, IOL, and AITFL are all involved or sagittal and coronal plane instabilities are noted, we reduce the fibula in the incisura with a clamp under arthroscopic visualization. We then place a suture-button construct, thus providing coronal plan stability in conjunction with an AIFTL repair using suture-tape augmentation. This dual fixation construct is also used if the MRI demonstrates a flattened insufficient incisura with sagittal instability. If a posterior malleolus fracture is noted with an intact PITFL, we address this first by placing the patient prone and performing a posterior arthroscopic fixation and internal fixation with 3.5 mm cannulated screws. We then reassess stability with stress maneuvers and arthroscopic visualization, if instability is appreciated, we then proceed down our aforementioned algorithm of repairs.

Immediately after surgery, a nonweight-bearing splint is applied for 10 to 14 days. At 2 weeks, partial weight-bearing is initiated in a postoperative CAM boot, allowing for range-of-motion exercises and recumbent bike. Formal physical therapy is also initiated at this point because proprioception and strengthening are paramount. At 4 weeks, patients may transition into an ankle lace-up brace if they can maintain a nonantalgic gait, this progression is variable. The patient may begin a walk to run program and return to early sport if they can do a single leg hop and heel raise at 6 weeks.

Summary

Implementing a standardized physical examination and radiographic workup allows for specific surgical planning. All surgical planning should focus on the incompetent structures, working proximal to distal, starting with the IOL utilizing SBF, then sagittal plane AITFL repair, and finally Deltoid repair as needed. After surgery, a functional rehabilitation with early weight-bearing is recommended. Further research and control trials are needed for more definitive evidence-based recommendations.

References

Levels of evidence are described in the table of contents. In this article, references 35, 39, and 42 are level I studies. References 8, 11, 17, 24, 27, 32, 37, 51, 55, and 60 are level II studies. References 18, 22, 40, 41, 47, 54, and 57 are level III studies. References 14, 23, 25, 26, 30, 31, 34, and 36 are level IV studies. References 49 and 58 are level V studies.

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