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Special Article

Distal tibiofibular syndesmosis and its secrets

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Abstract

The distal tibiofibular syndesmosis is a critical fibrous joint essential for ankle stability. Injuries to this complex, if misdiagnosed or improperly treated, can lead to chronic pain, instability, and premature osteoarthritis. This review covers the essential aspects of syndesmotic injuries, including anatomy, biomechanics, diagnosis, and current treatment strategies. The syndesmosis is stabilized by the anterior and posterior inferior tibiofibular ligaments and the interosseous ligament. These structures permit controlled motion during ankle movement. The typical injury mechanism involves excessive external rotation and dorsiflexion, leading to a sequential ligamentous rupture. Clinical diagnosis relies on the mechanism of injury and physical tests such as the squeeze and external rotation tests, although their reliability is debated. Imaging is crucial for confirmation. Weight-bearing radiographs are the first-line study, but computed tomography (CT), especially weight-bearing CT, offers greater accuracy for diagnosing instability. Magnetic resonance imaging (MRI) is excellent for assessing soft-tissue damage and associated injuries. Treatment is determined by joint stability. Stable, partial injuries are managed conservatively with immobilization and structured rehabilitation. Unstable injuries require surgical intervention to ensure anatomic reduction and restore stability. While rigid screw fixation was historically the standard, it impairs physiological motion and often necessitates a second surgery for hardware removal. Flexible fixation with suture-button devices has emerged as the modern standard of care. This technique provides dynamic stabilization, allows for natural joint micro-motion, and is associated with improved clinical outcomes and a lower rate of reoperation. Arthroscopy is a valuable tool for diagnosing and treating these injuries, enabling direct visualization and debridement to ensure accurate reduction. Proper management of syndesmotic injuries is paramount for optimizing patient recovery and preserving long-term ankle function.

Level of evidence IV;

Keywords: Ankle joint; Ankle injury; Arthroscopy; Orthopedic procedures.

Introduction

Syndesmosis is a type of fibrous joint, generally formed by two adjacent bones held together by a membrane. The distal tibiofibular syndesmosis plays an essential role in ankle stability and mobility[1-3]. An injury, particularly if not appropriately treated, can lead to pain and early-onset ankle osteoarthritis.

Anatomy

The distal fibula has a convex contour, limited anteriorly by the Wagstaffe–Le Fort tubercle and posteriorly by a small tubercle. The distal tibia presents a groove for the fibula, limited anteriorly by the Tillaux–Chaput tubercle and posteriorly by the Volkmann tubercle[2]. A ligamentous complex maintains joint stability between these two bones. The anterior inferior tibiofibular ligament is trapezoidal and runs slightly obliquely. It is composed of three bands: proximal, central, and distal (also known as the Bassett ligament), which are separated from each other by a space of approximately 2 mm[2]. Posterior stability is provided by the posterior inferior tibiofibular ligament, which has a more horizontal course than the anterior ligament and a trapezoidal shape, with superficial and deep portions. Filling the space between the distal tibia and fibula, there is another short and strong ligament, the interosseous ligament[2].

Study performed at the Grupo de Cirurgia do Pé e Tornozelo; Departamento de Ortopedia e Traumatologia da Santa Casa de Misericórdia de São Paulo, São Paulo, SP, Brazil.

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Biomechanics and mechanism of injury

The syndesmosis moves during ankle motion. Because the talus is wider anteriorly, the syndesmosis widens by 1 to 2 mm during dorsiflexion. The fibula rotates internally by about 3° to 5° when the ankle is in plantarflexion and externally by a similar amount during dorsiflexion[2]. When excessive external rotation occurs during dorsiflexion, the syndesmotic ligaments may be injured. Zalavras and Thordarson[4] suggested that the first structure to fail is the anterior inferior tibiofibular ligament. As the torsional force persists, the interosseous ligament ruptures, followed by the posterior inferior tibiofibular ligament. Ultimately, as the injury mechanism progresses, the deltoid ligament is affected. It is estimated that approximately 20% of these injuries are not diagnosed at the initial evaluation[1,2].

Clinical presentation

In most cases, the injury results from a dorsiflexion and external rotation trauma[5]. Patients often cannot clearly describe the mechanism of injury but are typically unable to return to sports immediately afterwards[2,5]. There is anterolateral swelling above the ankle joint line, sometimes extending proximally along the leg, and tenderness on palpation over the anterior inferior tibiofibular ligament[4,5]. Several clinical tests have been described to aid diagnosis[1].

- External rotation (Frick) test: forced external rotation and dorsiflexion of the ankle with the knee flexed to 90°. The patient reports pain over the syndesmosis[6].
- Squeeze test: compression of the tibia and fibula at the mid-leg induces separation of the bones at the syndesmosis, eliciting pain at the syndesmosis when it is injured[2,5,6].
- Fibular translation test: the examiner grasps the distal fibula between two fingers and attempts anteroposterior translation. Excessive motion indicates syndesmotic injury[2,6].
- Cotton test: when positive for syndesmotic injury, there is excessive mediolateral translation of the talus within the ankle mortise. In a variant, the seated patient crosses the symptomatic leg over the other and pushes the medial aspect of the crossed leg's knee downward with the hands; pain at the syndesmosis suggests injury[2,4,6].
- Single-leg hop test: the patient jumps and lands only on the suspected limb; pain indicates a positive test and may improve with a tight wrap over the syndesmosis that limits abnormal motion[2].

Although history and physical examination may suggest syndesmotic injury, the applicability and accuracy of these tests have been questioned in the literature[1,6]. Therefore, once an injury is suspected, adjunctive imaging studies are recommended to confirm the diagnosis[2].

Imaging studies

Radiography

Bilateral comparative ankle radiographs should be the first requested imaging study and, whenever possible, obtained with weight-bearing in the anteroposterior (AP), mortise (AP with 20° of internal rotation), and lateral views. It is important to look for any widening of the distal tibiofibular syndesmosis. Several radiographic parameters have been described[1, 2].

- Tibiofibular clear space: measured approximately 10 mm above the tibial plafond. A distance greater than 6 mm is considered abnormal in both the AP and mortise views and is one of the most reliable signs of syndesmotic injury[2].
- Tibiofibular overlap: also measured 10 mm above the tibial plafond. Overlap less than 6 mm in the AP view and less than 1 mm in the mortise view indicates syndesmotic disruption.
- Medial clear space: widening of the space between the medial malleolus and the talus, greater than the space between the talar dome and the distal tibial articular surface, suggests deltoid ligament injury, which may be associated with syndesmotic injury.

However, these radiographic measurements have demonstrated low reproducibility in the literature[1]. Stress radiographs can also be performed and may facilitate the diagnosis of syndesmotic injury (Figure 1).

Computed tomography

Comparative bilateral ankle computed tomography (CT) is considered by some authors to be essential for diagnosing syndesmotic injuries[2]. Axial slices allow more precise assessment of the distal tibiofibular joint and measurement of the tibiofibular clear space. Rotation of the fibula relative to the distal tibia can also be compared and quantified, and the same parameters used for plain radiographs can be assessed

Figure 1. Stress radiographs for the diagnosis of syndesmotic injury.

with greater accuracy. Studies have shown that weight-bearing CT[7] or stress CT (with dorsiflexion and external rotation) is a promising method for diagnosing instability. In the presence of syndesmotic injury, these examinations demonstrate widening of the tibiofibular space relative to the contralateral side. Standardized stress maneuvers during comparative CT have proven useful for detecting subtle injuries of this joint[8] (Figure 2).

Ultrasound

Although ultrasound can detect injury of the anterior inferior tibiofibular ligament, it is less effective for evaluating the interosseous membrane and is practically useless for diagnosing posterior inferior tibiofibular ligament injury. Therefore, it is seldom used to diagnose syndesmotic lesions[2].

Magnetic resonance imaging

Magnetic resonance imaging (MRI) has high sensitivity and specificity for diagnosing syndesmotic injury[9]. However, careful slice orientation and ankle positioning are required to obtain adequate visualization. The oblique course of the ligament fibers may lead to false-positive interpretations. Images acquired with the ankle in an oblique plane can improve visualization of the anterior inferior tibiofibular ligament and reduce the likelihood of false positives[10]. Moreover, MRI has the advantage of identifying associated injuries, such as anterior talofibular ligament tears, osteochondral lesions, bone edema, and small fractures, that may not be visible on radiographs[5, 9].

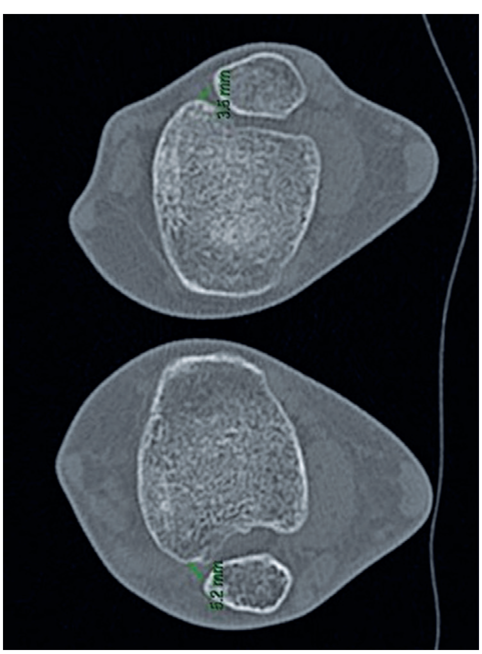

Figure 2. Stress computed tomography with dorsiflexion and external rotation showing widening of the distal tibiofibular space.

Arthroscopy

Arthroscopy can aid both diagnosis and treatment of syndesmotic injuries. During the procedure, the separation between the distal tibia and fibula can be directly observed. The syndesmosis is considered unstable when there is 2 mm of diastasis, which can be demonstrated by introducing an arthroscopic instrument into the tibiofibular space[11,12]. Arthroscopy can also be used to assist extra-articular stabilization of the syndesmosis.

Treatment

Conservative management

The primary and universally accepted indication for conservative management is a stable syndesmotic injury. This is typically defined as a Grade 1 injury according to the graded ankle sprain classification system, which involves a partial tear or sprain of the anterior inferior tibiofibular ligament (AITFL) without any objective evidence of instability or widening (diastasis) of the ankle mortise[13]. The diagnosis of a stable injury requires a thorough clinical examination and appropriate imaging. Clinical signs include tenderness localized to the AITFL and pain on the squeeze test or external rotation stress test, but without gross instability[14]. Radiographic evaluation, including standard AP, mortise, and lateral views of the ankle, should demonstrate a congruent joint with no widening of the tibiofibular clear space or reduction in tibiofibular overlap. In cases where clinical suspicion is high but static radiographs are normal, stress radiography, or more accurately, stress computed tomography or weight-bearing computed tomography (WBCT), can be employed to rule out latent or dynamic instability[1]. An injury is deemed stable and suitable for conservative care only if these investigations confirm the absence of diastasis under physiological load.

The primary goal of the conservative or non-operative treatment is to protect the healing ligaments from excessive stress while gradually restoring function and strength. The protocol is multifaceted and typically involves an initial period of immobilization and activity modification, followed by a structured, progressive rehabilitation program[1]. Initially, patients are often placed in a non-weight-bearing cast or a walking boot for a period ranging from one to three weeks to allow the acute inflammatory phase to subside and initial ligamentous healing to begin[1]. Following this, a transition to protected weight-bearing in a boot is initiated, with a gradual progression to full weight-bearing as tolerated. The rehabilitation program focuses sequentially on restoring range of motion, improving proprioception and neuromuscular control, strengthening the surrounding musculature (particularly the peroneal and posterior tibial muscles), and finally, a gradual return to sport-specific activities.

It is critical to note that for any injury demonstrating instability (Grade 2 or 3) or for cases of chronic syndesmotic instability, conservative management is widely considered to have unfavorable outcomes and is not recommended[14,15]. While some recent research has explored the potential of advanced neuromuscular training programs for functional instability, surgical intervention remains the mainstay for restoring mechanical stability in unstable injuries[15].

Arthroscopic debridement

Arthroscopic debridement of the ankle joint and syndesmosis is a minimally invasive surgical technique used to manage syndesmotic pathology. The procedure involves the use of standard anteromedial and anterolateral arthroscopy portals to gain access to the tibiotalar joint and the distal syndesmotic recess, and it is possible to directly visualize and remove hypertrophic synovitis, inflammatory scar tissue (arthrofibrosis), and any loose bodies from within the joint and the syndesmotic space[4]. This "clean-out" procedure aims to eliminate sources of mechanical impingement and pain, and it is invaluable for ensuring that no interposed soft tissue is blocking an accurate and anatomic reduction of the fibula into the tibial incisura[16], because reduction of the syndesmosis is the greatest clinical predictor for post-recovery outcomes[17].

The indications for arthroscopic debridement can be divided into two main categories. Firstly, it can be used as a selected procedure for a subgroup of patients with chronic syndesmotic instability. The ideal candidates are those who experience persistent pain and functional limitation but do not exhibit gross mechanical instability or significant talar displacement on clinical or radiographic examination[15]. Studies by Ogilvie-Harris et al.[18] have shown that, in this population, arthroscopic debridement alone can significantly reduce pain and improve activity levels (Figure 3).

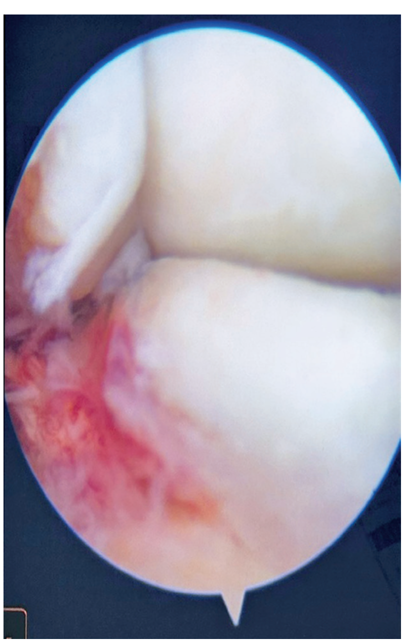

Figure 3. Arthroscopic debridement in a patients with chronic syndesmotic instability with persistent pain and functional limitation.

More commonly, however, arthroscopic debridement is performed as an adjunct to surgical stabilization for acute or chronic syndesmotic instability. In this role, its primary purpose is diagnostic and preparatory. It allows the surgeon to confirm the extent of the ligamentous injury, assess for and treat any associated intra-articular pathology, such as osteochondral lesions of the talus, and, most importantly, thoroughly clear the syndesmotic space to facilitate a precise, anatomic reduction before the placement of fixation hardware[16]. Many surgeons now consider arthroscopy an essential step in the surgical treatment of syndesmosis injuries to maximize the accuracy of reduction.

Fixation

For many years, rigid fixation with trans-syndesmotic screws was the undisputed surgical gold standard for stabilizing unstable syndesmotic injuries. The technique involves open or arthroscopically assisted reduction of the syndesmosis, followed by insertion of one or two metallic screws across the fibula and into the tibia to maintain joint reduction. There is considerable heterogeneity among the described techniques, with ongoing debate regarding the optimal screw diameter (typically 3.5 mm or 4.5 mm), the number of screws (one or two), and the number of tibial cortices to be engaged (tricortical vs. quadricortical fixation)[15,19]. The screws are typically placed approximately 2 cm to 4 cm proximal to the tibial plafond, parallel to the joint line, and angled slightly anteriorly from the fibula into the tibia. The goal is to create a rigid construct that prevents motion at the syndesmosis, allowing the injured ligaments to heal in an anatomic position.

The primary indication for rigid screw fixation is an acute, unstable injury of the distal tibiofibular syndesmosis, which includes Grade 2 and 3 injuries with demonstrable diastasis on static or stress imaging, as well as any ankle fracture pattern that results in syndesmotic disruption (e.g., Weber C, Maisonneuve, or equivalent injuries)[14]. Historically, this was the only widely accepted method for surgical stabilization.

The disadvantages of rigid fixation are now well-documented and substantial. The primary biomechanical drawback is the prevention of natural physiological micro-motion at the syndesmosis, which can lead to joint over-constraint and altered ankle mechanics[19,20]. Clinically, this translates to a high rate of complications, including hardware failure (screw breakage or loosening), and a surprisingly high rate of syndesmotic malreduction, which has been reported to be as high as 52% in some series[19]. Perhaps the most significant disadvantage from a patient perspective is the common need for a second operation for hardware removal, which carries its own risks and adds to the overall cost and morbidity of treatment[19,21].

Flexible, or dynamic, fixation using suture-button devices has rapidly emerged as the leading modern alternative to rigid screw fixation. This technique uses a construct composed of a continuous loop of high-strength, non-absorbable suture, tensioned between two small metallic buttons. The device is implanted across the syndesmosis like a screw, with one button resting on the lateral cortex of the fibula and the other on the medial cortex of the tibia. Once the syndesmosis is held in an anatomic reduction, the suture loop is tightened, compressing the buttons against the bone and providing secure fixation of the joint[19]. The key biomechanical advantage of this construct is that it provides robust resistance to abnormal tibiofibular separation (diastasis) while simultaneously permitting the physiologic micro-motion (translation and rotation) that occurs at the syndesmosis during normal gait[14]. This allows for a more anatomic and less constrained form of stabilization. The procedure can be performed with one or two suture-button devices, depending on the severity of the instability.

The indications for flexible fixation are identical to those for rigid fixation: any acute, unstable injury of the distal tibiofibular syndesmosis that requires surgical stabilization[14,16]. It has become the preferred method for the majority of surgeons treating these injuries, supported by a large and growing body of high-quality evidence. Its use is indicated in unstable high ankle sprains and in conjunction with the fixation of associated ankle fractures. Due to its advantages, particularly the elimination of the need for routine hardware removal and the facilitation of an accelerated rehabilitation protocol, it is an especially attractive option for athletes and other active individuals seeking a faster return to function[22,23] (Figure 4).

The superiority of flexible fixation over rigid fixation is now robustly supported by the literature. A landmark 2020 randomized controlled trial by Ræder et al. with a five-year follow-up demonstrated that patients treated with a suture-button device had significantly better long-term functional outcomes and, critically, a significantly lower incidence of developing post-traumatic ankle osteoarthritis (35% in the suture-button group vs. 65% in the screw group)[21].

Figure 4. Flexible fixation of a syndesmotic injury.

This suggests a long-term joint-preserving benefit. These findings were corroborated by a large-scale meta-analysis by Wang et al.[19] in 2024, which included 35 studies and over 2000 patients. The analysis concluded that, compared to rigid fixation, elastic fixation provides better postoperative ankle function, more precise anatomical reduction, a lower incidence of postoperative complications, and a shorter time to full weight-bearing.

In the setting of chronic syndesmotic instability, where the native ligaments have been attenuated, present with a poor quality, or are otherwise irreparable, simple fixation may be insufficient. In these challenging cases, an anatomic or non-anatomic ligamentous reconstruction may be required. These procedures aim to recreate the primary ligamentous restraints of the syndesmosis using a tendon graft. The graft can be an autograft (harvested from the patient, e.g., peroneus longus, gracilis, or semitendinosus tendon) or an allograft (donor tendon). The surgical technique generally involves weaving the tendon graft through bone tunnels created in the tibia and fibula to reconstruct the anterior inferior tibiofibular ligament and/or the interosseous ligament[15]. These reconstructions are often augmented with a temporary or permanent suture-button device to protect the graft during its healing and incorporation phase.

The primary indication for a ligamentous reconstruction is chronic syndesmotic instability that has failed conservative management and is not amenable to direct repair[15,24]. This diagnosis is typically made in patients who present with persistent pain, instability, and functional limitation more than six months after their initial injury[15]. The decision to proceed with reconstruction is often made intra-operatively after an arthroscopic evaluation reveals irreparable ligamentous tissue. These are complex revision-type procedures and are reserved for a small subset of patients with chronic, high-grade instability. A systematic review by Xu et al.[24] found that reconstruction of the syndesmosis with an autologous tendon graft for chronic syndesmotic instability yields favorable therapeutic outcomes, with significant improvements in subjective symptoms and objective functional scores.

The last-resort, end-stage treatment option to treat chronic syndesmotic instability is a syndesmotic arthrodesis. Its primary indication is for patients with severe, painful, and debilitating chronic instability, particularly when it is accompanied by significant degenerative arthritic changes within the syndesmosis itself[15]. It is a salvage procedure for cases where other reconstructive or stabilization options have failed or are not feasible. While the procedure can be effective in providing pain relief and creating a stable construct, it does so at the cost of eliminating all physiological motion at the syndesmosis.

The procedure involves surgically removing any remaining cartilage and soft tissue from between the distal tibia and fibula and packing the space with bone graft. The joint is then rigidly compressed and fixed with plates and/or screws to induce the two bones to fuse together into a single bone mass. This permanently obliterates the syndesmotic joint.

The long-term consequences of this on the mechanics of the ankle and the rest of the foot are not fully understood. Studies comparing arthrodesis with stabilization procedures for chronic syndesmotic instability have generally found similar functional outcomes but a significantly higher rate of reoperation (primarily for hardware removal) in the arthrodesis group, making arthrodesis less favorable when reconstruction is possible[15].

The evolution in the surgical management of unstable distal tibiofibular syndesmosis injuries has been largely defined by the paradigm shift from rigid internal fixation to more dynamic, flexible stabilization methods. The central debate in contemporary practice revolves around the long-term clinical superiority of one approach over the other. While rigid fixation with trans-syndesmotic screws was the unchallenged standard for decades, a growing body of high-quality, long-term evidence now enables a robust comparison, revealing significant outcome differences with profound implications for patient care, particularly for functional recovery and joint health preservation.

The fundamental difference between the two philosophies lies in their biomechanical principles. Rigid screw fixation is designed to eliminate motion at the syndesmosis, thereby creating a stiff construct that facilitates ligamentous healing. However, this approach inherently conflicts with the native biomechanics of the ankle, which requires physiologic micro-motion—including translation and rotation of the fibula—to accommodate the complex movements of the talus during gait[20]. By preventing this motion, screw fixation can lead to joint over-constraint, abnormal stress distribution across the tibiotalar joint, and an increased risk of hardware failure under cyclical loading[14,19]. Conversely, flexible fixation is designed to provide primary stability against pathologic diastasis while simultaneously permitting the natural, subtle movements of the syndesmosis. This more anatomic approach is hypothesized to lead to better long-term joint kinematics and a lower risk of degenerative sequelae.

Recent long-term clinical data have moved this discussion from theoretical biomechanics to evidence-based outcomes. The most compelling evidence comes from a 2020 randomized controlled trial by Raeder et al.[21], which reported five-year follow-up results comparing a single quadricortical syndesmotic screw with a suture-button device. At five years post-surgery, the suture-button group demonstrated statistically significant clinically superior outcomes.

In conclusion, the long-term evidence from the most recent and highest-quality studies indicates a clear clinical advantage for flexible fixation over rigid fixation in the treatment of unstable syndesmotic injuries. The benefits extend beyond the previously established short-term advantages of faster rehabilitation and return to sport[23,24]. At five years and beyond, dynamic stabilization is associated with superior patient-reported functional outcomes, a dramatically lower rate of post-traumatic osteoarthritis, and a significantly reduced need for subsequent surgical procedures. While a niche role for rigid fixation may persist in cases of severe instability, comminution, or in specific high-demand athletes where maximal stiffness is prioritized[16], the current body of evidence strongly supports the adoption of flexible suture-button fixation as the standard of care for the vast majority of patients to optimize long-term function and preserve the health of the ankle joint.

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