

FIXATION TECHNIQUES IN LOWER EXTREMITY SYNDESMOTIC INJURIES

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Level of Evidence: Level V, current concept review

Keywords: trauma, sports, ankle, syndesmosis

Introduction

In recent years, there has been increasing emphasis on the diagnosis and treatment of syndesmotom injuries. Injury recognition is crucial, especially in athletes where it has been shown to be associated with long-term ankle dysfunction, missed time from sports, and the need for operative stabilization.^{26,68} However, the physical and radiographic examinations can be deceiving, and accurate diagnosis can be difficult despite improved diagnostic modalities. Additionally, there is controversy regarding criteria for operative intervention and, when indicated, which implants are optimal. Our objective is to present an evidence-based review of current techniques and implants for syndesmotom fixation.

Anatomy and Biomechanics

Stability of the ankle joint is largely due to bony articulations between the tibia, talus, and fibula. The distal tibiofibular joint is referred to as the tibiofibular syndesmosis. The lateral surface of the distal tibia forms a triangular notch into which the convex medial distal fibula articulates. Strong ligaments form a fibrous joint between these bony surfaces. Holding these articulations in a relatively constant volumetric and spatial relationship are the anterior inferior tibiofibular ligament (AITFL), the interosseous tibiofibular ligament (IOL), and the superficial and deep fibers of the posterior inferior tibiofibular ligaments (PITFL). Distal to the PITFL lies the transverse tibiofibular ligament, or inferior transverse ligament. Together, the bony articulations and the ligaments holding them together resist constant axial, rotational, and translational forces.¹⁸ Additionally, the deltoid ligament confers secondary stability by resisting lateral shift of the talus.⁷²

The AITFL consists of 3 to 5 bands that are collectively trapezoidal in shape. It traverses from the anterior tubercle of the distal tibia (Tillaux-Chaput) approximately 5 mm superior to the articular surface and narrows as it attaches to the anterior surface of the distal fibula at the lateral malleolus.³³

It runs in an oblique direction from proximal anteromedial on the tibia to distal posterolateral on the anterior fibula. In certain positions, the lower margin of the ligament comes in contact with the lateral ridge of the trochlea of the talus.^{18,69}

The PITFL has interconnections with the inferior transverse ligament. It too is trapezoidal in shape and runs from the posterior malleolus of the distal tibia (Volkman tubercle) to the posterior aspect of the lateral malleolus. At its superior edge, it is almost continuous with the IOL, making it difficult to distinguish on cadaveric specimens.¹⁸

The inferior transverse ligament is denser than the PITFL but has a smaller, oval insertion just distal to the PITFL on the fibula and has variable insertions on the distal tibia. This ligament is fibrocartilaginous and acts to deepen the posteroinferior articulation similar to a labrum.

The majority of the IOL runs laterodistal and anterior from the tibia to the fibula, resembling the orientation of the PITFL; however, anteriorly there are fibers that run in the opposite direction. The distal fibers on the tibia are at the level of the anterior tubercle (approximately 8 mm above the mortise) and attach at the fibula above the level of the talocrural joint. The fibular attachment is generally wider than the tibial attachment. The upper portion spanning from the tip of the incisura tibialis to the level of the talocrural joint is referred to as the interosseous membrane with the fibers distal to this referred to as the IOL.³³ Distally the ligament terminates at the level of the synovial recess approximately 9.3 mm above the tip of the lateral malleolus.⁶⁹

The distal aspect of the tibiofibular contact area contains a variable amount of very thin (0.5 mm) cartilaginous surface in which there is direct contact between the 2 bones. At this level, there are variable synovial plicae and synovial membrane.¹⁸

The bony and ligamentous relationships allow for controlled motion in the coronal, sagittal, and transverse planes. With ankle external rotation, the fibula externally rotates and translates posteriorly, although this displacement cannot be appreciated on radiographs.⁷ Clanton et al recently performed a biomechanical, cadaveric analysis of individual ligament contributions to ankle stability. They reported that in intact ankle specimens there was an average of 4.3 degrees of fibular rotation in the axial plane and 3.3 mm of fibular translation in the sagittal plane. Sectioning of the AITFL resulted in the greatest reduction in resistance to external rotation although there was a significant decrease in resistance with each sequential ligament sectioned. Sectioning of the superficial PITFL resulted in the greatest decrease in resistance to internal rotation.¹² Another study by Xenos et al⁷² revealed that with an external rotation force, the tibiofibular diastasis was 2.3 mm after sectioning of the AITFL, which increased to 5.5 and 7.3 mm with subsequent sectioning of the IOL and PITFL, respectively.

The peroneal artery provides a perforating branch through the interosseous membrane an average of 3 cm above the joint line that is at risk for injury with significant syndesmotic disruption. This provides the majority of the anterior ligamentous vascular supply. Anterior tibial artery contribution is less common.⁴²

Incidence and Epidemiology

Ankle sprains are the most common injury in athletes, comprising 10% to 30% of all sport-related injuries^{18,67} and up to 45% in sports such as basketball, volleyball, soccer, and football.¹⁸ The incidence of injuries to the ankle syndesmosis is reported to be 7% to 25% of all ankle injuries.^{26,32,67} Although much less common than lateral ankle sprains, and overall less common than medial ankle sprains, syndesmotic sprains require longer time for recovery.²⁰ Male athletes have more than a 3-fold greater rate of syndesmotic injury than women.⁶⁷ Syndesmotic injuries have been found to be associated with certain positions in sports as well, with offensive lineman being statistically more likely to be affected compared to other positions in college football.³⁴ This may be related to the fact that increased body mass index has been shown to increase the risk of syndesmotic injury.⁶⁷

Purely ligamentous injuries are typically referred to as high ankle sprains. While complete ligamentous disruption can occur, these more commonly occur in association with an ankle fracture,³² specifically a distal fibular Weber B or C or a proximal fibular fracture (Maisonneuve injury).⁷¹ Conversely, syndesmotic injuries that require stabilization have been shown to accompany ankle fractures 10% to 20% of the time.^{16,52} Concomitant syndesmotic injuries have also been shown to occur in 17.8% of lateral ankle sprains.⁹ However, the injury mechanism will typically favor one injury over the other as high-grade syndesmotic injuries typically have lower grade lateral ankle sprains, while the converse has also been shown to be true.⁶⁵

Mechanism of Injury

The most commonly reported mechanism of syndesmotic injury is when the foot is externally rotated while the ankle is dorsiflexed and the hindfoot everted.⁵² This puts the maximum diastasis stress on the syndesmosis with the wider portion of the talus engaged in the mortise and the rotation acting like a fulcrum on the fibula resulting in external rotation and posterior displacement. This mechanism is supported by studies that have shown that up to 55% of syndesmotic sprains in a group of athletes occurred during a collision with the foot planted and externally rotated while the ankle dorsiflexes as the player subsequently falls forward.⁴⁸ The foot position at the time of external rotation plays a key role in the nature of the injury, with studies suggesting that if the foot is in neutral position a medial injury is more likely, whereas if the foot is in an everted position the AITFL is more likely to be the first ligament injured.²⁸

Diagnosis

Diagnosing an athlete with a syndesmotic injury can be difficult. The pain is often diffuse and difficult to differentiate from a lateral ankle sprain. Additionally, as previously noted, there can be overlap in injury patterns. This can further cloud the diagnosis and potentially lead to missed syndesmotic injuries (Figure 1). However, a thorough history might uncover a mechanism that would increase the treating physician's suspicion. A thorough physical examination includes visual inspection for swelling,

palpation for tenderness, and evaluation of the proximal extent of the tenderness. The latter physical examination finding, known as “syndesmosis tenderness length” (the most proximal site of tenderness measured from the distal tip of the fibula), has been shown to correlate with the time to return to sports.⁵⁷ The typical location of tenderness in a syndesmotic injury is at the anterolateral and/or posteromedial joint line.

Figure 1. Anteroposterior radiograph of a patient who presented with persistent pain following fixation of a medial malleolar fracture revealing a missed syndesmotic injury.



There are a number of special physical examination tests for syndesmotic injuries that have been described. These include the external rotation test, heel thump test, dorsiflexion compression test, fibular translation test, crossed-leg test, and squeeze test. However, these tests have been shown to be difficult to interpret with a low predictive value in the presence of a painful or swollen ankle.³ The external rotation test has been shown to be most sensitive with the lowest false positive rate.⁵² This is performed with the ankle in neutral or slight dorsiflexion, the heel in neutral or varus position, with subsequent external rotation of the foot relative to the tibia to the point of resistance and pain. Additionally, a stress radiograph can be obtained to evaluate for medial clear space (MCS) or tibiotalar widening.²¹

In the case of a suspected syndesmotic injury, radiographs must be carefully scrutinized. Signs of syndesmotic injury include avulsion fractures of the anterior tubercle of the tibia (Tillaux-Chaput fragment), anterior fibula (Wagstaffe le Fort fragment), and posterior malleolus (Volkmann fragment). Radiographs should be evaluated for the tibiofibular clear space (TFCS) (normal = mean 4.4 ± 0.8 mm on anteroposterior view and 3.9 ± 0.9 mm on mortise view, respectively), the tibiofibular overlap (normal = mean 8.8 ± 2.4 mm on anteroposterior view and 4.6 ± 2.1 mm on mortise view, respectively),

and for any increased MCS (normal < 5 mm).¹⁵ However, it has been shown that tibiofibular overlap and TFCS do not correlate with syndesmotic injury seen on magnetic resonance imaging (MRI).³⁰ Additionally, MCS measurements have been shown to have poor accuracy and precision even among experienced providers. In a recent cadaver study, 3 specimens were evaluated with a known amount of displacement (6, 4, and 1.7 mm). Measurement errors ranged from 16% at 5 degrees of internal rotation to 36% at 15 degrees of external rotation for the specimen with 6 mm of known MCS widening but was even greater ranging from -3% at neutral to 100% at 5 degrees external rotation for the intact specimen with 1.7 mm of MCS.⁴³ Although the sensitivity and specificity of detecting a syndesmotic injury on MRI has been shown to be up to 100%, determining the severity of that injury and the need for surgery is not straightforward and often only when frank diastasis is seen on radiography is the final determination for operative intervention made (Figure 2).⁶⁹ If an injury could potentially be managed nonoperatively, then stress radiographs can be helpful in assessing the integrity of the syndesmosis and of the deltoid ligament. However, there is no standardized technique or amount of force applied and the quality of the test can be significantly limited by the patient's pain.⁴ One recent study found that gravity stress radiographs (with the foot suspended via a bump under the calf allowing gravity to pull the foot in external rotation) resulted in equivalent MCS widening to manual stress radiographs.³⁷ Conversely, if there is an operative fracture, then stress radiographs can be postponed until surgery (Figure 3).

Figure 2. Magnetic resonance image of an elite-level athlete revealing anterior syndesmotic disruption.

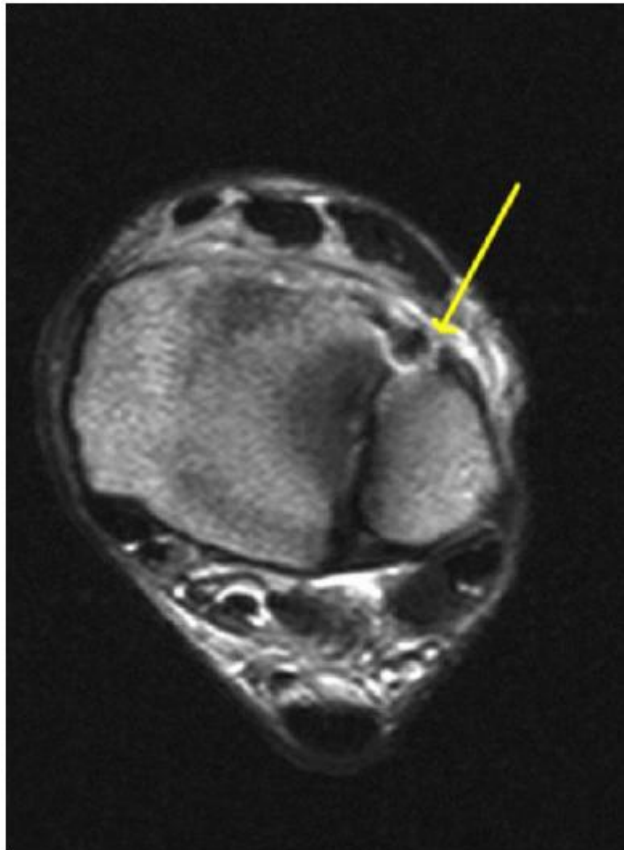


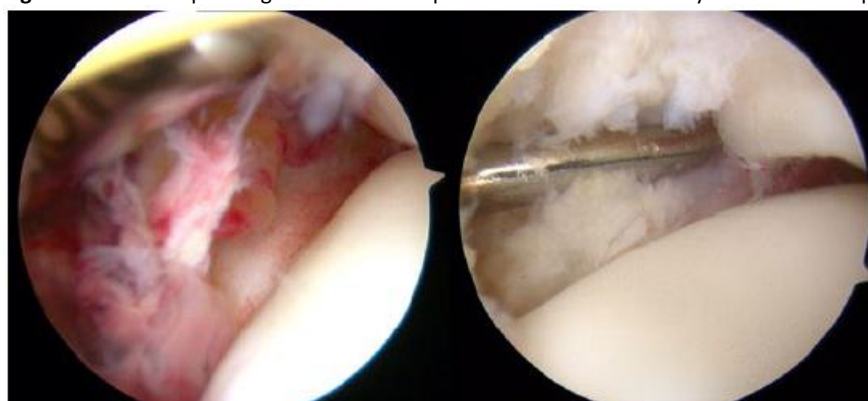
Figure 3. (A) Intraoperative fluoroscopy of ankle fixation. Left: Stress radiograph following fixation of a Weber B fibula fracture with medial clear space widening. Right: Radiograph following syndesmotic screw fixation. (B) Hook test performed in which the fibula is pulled lateral to assess for medial clear space widening.



Classification

Isolated syndesmotic injuries can be generally classified as stable or unstable. The stable variant is characterized by an intact deltoid ligament in the presence of an AITFL rupture with or without IOL rupture. Unstable injuries are syndesmotic disruption with latent or frank radiographic diastasis. Latent diastasis consists of AITFL rupture with or without IOL and deltoid ligament rupture noted on stress radiographs, MRI, or on arthroscopic evaluation (Figure 4). Frank diastasis can be seen on regular radiographs due to complete disruption of all syndesmotic ligaments.¹⁴ Unstable injuries require operative intervention, whereas there is controversy regarding the management of various grades of stable injuries.

Figure 4. Arthroscopic images of 2 different patients with evidence of syndesmotic disruption.



Another classification system attempts to grade the severity of the injury.⁷⁰ Grade I injuries are considered mild with normal radiographs and a clinically stable syndesmosis with mild lateral ankle injury. Grade II injuries are moderate in severity. These typically also have normal radiographs but with either a clinically diagnosed injury to the syndesmosis (ie, positive external rotation and squeeze test) or MRI findings of a syndesmotic injury. However, in grade II injuries there is no consensus on joint stability, with some authors suggesting grade II injuries are, by definition, stable,⁵⁶ whereas others suggest such injuries can potentially be unstable.⁷⁰ Grade III injuries are characterized as complete syndesmotic disruption with diastasis or medial widening.³³ In the case of a grade II injury, MRI,³⁰ stress

radiographs, or arthroscopy^{10,38} have all been advocated as diagnostic modalities to assist in determining severity of syndesmotic injury and appropriate treatment.

Management of Syndesmotic Injuries

PURELY LIGAMENTOUS INJURIES

In the case of sprains without diastasis, nonoperative management has been shown to result in good functional outcomes.⁴⁵ However, there is currently no consensus on the nonoperative regimen, with treatments ranging from taping to fracture boots to non-weight bearing cast immobilization. Other interventions such as injections, physical therapy, ultrasonography, nonsteroidal anti-inflammatory drugs, etc. are discussed throughout the literature without consensus. Reported lengths of immobilization vary from 1 to 6 weeks.^{14,52} Athletes should be informed that return to full sport takes longer compared to lateral ankle sprains. The syndesmosis tenderness length can be used to estimate the time loss from sports using the equation⁴⁸:

Days lost from competition = $5 \pm (0.93 \times [\text{tenderness length in centimeters}]) \pm 3.72$ days.

Rehabilitation is implemented in 3 phases. Phase I is the acute phase. Goals include joint protection, minimization of inflammation and pain control. Phase II is the subacute phase in which restoration of mobility, strength, and gait are emphasized. Finally, in phase III, emphasis is placed on strengthening, neuromuscular control and sports-specific tasks.³³

A recent cohort-controlled study by Samra et al suggested that 10 rugby players with MRI-confirmed syndesmosis injury (involvement of the AITFL, IOL, and PITFL) treated without surgery who received a single autologous PRP injection into the AITFL had significantly shorter time to return to play than a historical cohort (20.7 days less for the intervention group vs historical control). Following return, these patients had higher agility, increased vertical jump, and lower level of fear avoidance.⁵⁰ However, although they reported similar baseline characteristics between groups, the intervention was not blinded and there was no placebo control, both of which could have resulted in bias.

In contrast, all injuries with frank diastasis require syndesmotic fixation.¹ Taylor et al reported on 6 intercollegiate athlete patients with grade III syndesmosis injuries treated with a 4.5-mm stainless steel cortical screw and reported good to excellent clinical outcomes in all patients with a mean return to sports at 40.7 days.⁶⁰ In their series, all hardware was removed at an average of 74 days (range 52-97).

FRACTURES WITH SYNDESMOTIC INSTABILITY

Carr et al recently performed a large database analysis of ankle fracture and syndesmotic fixation between 2007 and 2011 and found no significant increase in procedures for all ankle fracture types (lateral malleolus, bimalleolar, and trimalleolar) during that time.⁸ However, the number of procedures to treat isolated syndesmotic injuries increased by 18% during that time period. In addition, the rate of syndesmotic fixation that accompanied fixation of ankle fractures significantly increased with a nearly 2-fold increase among bimalleolar fractures. The authors also reported that the rate of implant

removal after syndesmotic fixation significantly decreased. This suggests an overall increase in recognition and operative treatment of isolated syndesmotic injuries and those associated with ankle fractures. Although factors associated with higher energy ankle fractures (eg, bimalleolar involvement or the need for initial external fixation) are associated with delayed union, the need for syndesmotic screw fixation has not been shown to be associated with delayed union of ankle fractures that undergo fixation. Nevertheless, although bony union can be followed via routine radiographs, the healing of the syndesmosis is significantly slower, requiring prolonged periods of non-weight bearing up to 12 weeks.⁴⁰ Following fixation of medial and/or lateral malleolus fractures, an intraoperative stress radiograph can assess the integrity of the syndesmosis and guide the decision of whether or not syndesmotic fixation is of benefit.

Special consideration should be given to cases of bimalleolar ankle fractures in which there is an anterior colliculus avulsion of the medial malleolus. Tornetta reported on 27 patients with bimalleolar fractures who underwent external rotation stress radiographs intraoperatively after medial malleolar fixation and found that 7 (26%) had MCS widening even after medial fixation. He explained that this represents an injury to the deltoid ligament in which the stronger deep component has been ruptured and the weaker superficial component, which attaches to the anterior colliculus remains intact. If this occurs in conjunction with a syndesmotic injury it has the potential to present as late syndesmotic widening and significant instability.⁶³

SYNDESMOTIC FIXATION

Syndesmotic screws. Syndesmotic screws have long been considered the gold standard for fixation of syndesmotic injuries. Most authors prefer 3.5 or 4.5 cortical screws which have equivalent biomechanical characteristics.⁶² While some cadaveric studies have shown increased resistance to an applied load, specifically in shear stress, with a larger diameter screw,²⁷ this has not been reproduced in clinical studies.^{14,62} In Europe, most surgeons utilize a single 3.5 mm tricortical screw, 2.1 to 4 cm above the joint line for stabilization of Weber B or C fractures.⁵² However, a cadaveric study suggested that 2 screws provides a superior biomechanical construct compared to 1.⁶

Location of screw placement is often debated. McBryde et al reported less syndesmotic widening when the screw was placed at 2 cm above the joint compared to 3 cm.⁴¹ However, other studies have reported that screw placement at 2, 3, or 5 cm above the joint line show no difference in functional outcome.⁴¹

Tricortical screws (3.5 mm) were compared to quadricortical lag screws (both 3.5 and 4.5 mm) in terms of compression force in a 2012 cadaveric study. The lag screws maintained a significantly greater compression force after forceps removal compared to the tricortical screw. Additionally, after each 100-cycles of loading, the lag screws significantly exceeded the amount of compression force maintained by the tricortical screw. No differences were seen between the 3.5- and 4.5-mm lag screws.¹³ Ultimately, although cadaveric studies have suggested that 4 cortices provide more rigid fixation; screws with purchase in 3 cortices have been shown to more closely replicate tibiotalar biomechanics.¹⁴ Additionally, tricortical screws have decreased risk of screw breakage albeit at the cost of an increased rate of screw loosening.^{2,29,62} There is no current evidence to suggest a clinically appreciable difference between these 2 methods of screw fixation⁶ (Figure 5).

Figure 5. Left: Postoperative follow-up of a patient with a Maisonneuve injury treated with 2 tricortical syndesmotic screws. Right: Radiograph at 2 years postoperation with broken screws. The patient ultimately required screw removal of the lateral screw fragments because of prominence of the distal screw.



In terms of screw removal, there has been a long-standing debate in the literature. Although some recommend removal of quadricortical screws to prevent screw breakage,^{2,31} there is no consensus on when this should be performed, and there have been reports of diastasis at screw removal.⁵² Additionally, studies have suggested similar or better outcomes when the screw is retained,⁵¹ and, therefore, there is growing consensus that screw removal should be reserved for screws that are symptomatic (ie, painful prominence).^{5,14,46,68} A recent systematic review by Dingemans et al concluded that although there is insufficient evidence overall to draw definitive conclusions regarding routine removal, the lack of evidence to justify removal along with the additional cost and increased risk to the patient would suggest that routine removal should be avoided.¹⁶

Suture button constructs. While screw fixation is still considered the gold standard, there are a number of theoretical advantages of suture button fixation (Figure 6). These have been theorized to allow physiologic motion at the syndesmosis while maintaining reduction. Further, there is less risk of symptomatic hardware and need for implant removal. Finally, these constructs have been suggested to safely allow earlier ankle range of motion as the reduction can be held with progression of motion without the concern for implant failure (ie, screw breakage) and recurrent diastasis.⁵² The argument that these constructs might be superior because they do not require routine removal is weakened by the growing evidence against routine screw removal. However, it has been suggested that these constructs might allow earlier weight bearing. This is due to concern that early stress on a syndesmotic screw might lead to breakage prior to ligamentous healing. Conversely, less rigid constructs such as the TightRope (Arthrex, Naples, FL) are purported to be sturdy enough to withstand physiologic loading that occurs with weight bearing and normal ankle motion.⁴⁷

Teramoto et al performed a cadaveric study on 6 ankles comparing single-suture button fixation, double-suture button fixation, anatomic suture button (from posterior fibula to anterolateral distal tibia), and screw fixation. The authors evaluated the amount of diastasis with various stresses on the ankle, including anterior traction, medial traction, and external rotation. With single-suture button fixation the diastasis increased significantly with all forces, whereas with double fixation the diastasis

increased significantly with medially directed force and with external rotation but not with anterior traction. They found that with anatomic suture button placement, there were no significant differences compared to ankles tested prior to syndesmotic disruption. The screw fixation proved to be the most rigid fixation, with significantly decreased diastasis compared to suture button results.⁶¹ However, the clinical implications of that amount of motion are not currently known.

Figure 6. Top: Injury radiographs of a patient with a Maisonneuve injury. Bottom: Intraoperative fluoroscopic images of suture-button fixation of the syndesmosis.



Naqvi et al reported retrospectively on 49 patients with suture-button syndesmotic fixation. Patients with syndesmotic injuries associated with ankle fractures underwent single suture-button fixation and those with Maisonneuve injury underwent double suture-button fixation. The authors reported a mean time to weight bearing of 7.7 ± 1.1 weeks (range 5-10) and a mean return to normal activities at 11.2 ± 1.8 weeks. They reported that the original technique of tying the knot over the lateral aspect of the fibular button resulted in a significantly higher rate of wound complications compared to their reported modified technique of creating a subperiosteal recess in the posterior fibula in which they buried the knot. They reported satisfactory results at 2 years postoperatively.⁴⁷

A recent prospective randomized trial comparing screw fixation with a single 3.5-mm screw ($n = 22$) vs suture-button fixation ($n = 22$) of the syndesmosis revealed no difference in quality or maintenance of reduction between the two as seen on postoperative imaging. Additionally, there was no difference at 2-year follow-up in the incidence of ankle joint osteoarthritis.³⁶

In 2013, Ebramzadeh et al compared 2 suture-button devices (ZipTight [Biomet] and TightRope [Arthrex]) along with a 3.5-mm quadricortical screw fixation in a cadaveric, failure-to-load model. In

12 of 20 specimens, failure occurred via a fibula fracture. The screw construct was found to provide a significantly higher torsional strength than the ZipTight (30.1 vs 22.2 Nm) but the difference seen between the screw and the TightRope was not significant. The authors reported that there were no significant differences between the 2 suture button constructs. Ultimately, they suggested that the torsional fixation strengths of all 3 constructs were above the physiologic loads that would “likely” be experienced during the healing process, citing that level ground walking generally creates syndesmotic torsional stresses below 2 Nm and “various other activities” generally create stresses less than 20 Nm.¹⁹

One issue that arises with regard to the use of a suture button is how to determine the amount of force to put on the construct while securing the syndesmosis. Additionally, there has been debate regarding which position the foot should be in at the time of final tightening. A recent cadaveric study revealed that with the use of suture button syndesmotic fixation, there was consistent overcompression compared to the intact state, with significant volume reduction and medial displacement of the fibula.⁵³ Overcompression, however, is not unique to suture button constructs as it has been reported to occur with forceps reduction and screw fixation as well.⁴⁹ However, the clinical impact of overcompression of the syndesmosis is not known and it has been shown that this compression does not appear to affect ankle dorsiflexion/plantarflexion. Further, it has been shown that the position of the foot (ie, plantarflexion, neutral, or dorsiflexion) during the time of compression and fixation has no significant effect on postoperative ankle motion.^{49,53,64}

Another recent cadaveric study compared a single screw to either a single suture-button construct or a divergent double-suture button construct.⁹ The authors found that while all fixation techniques provided significant torsional stability, no technique provided the rotational stability and native anatomic relationships provided by the intact ligaments. Further, the screw provided the most rigid restraint to anterior-posterior translation of the fibula with the highest amount of translation seen in the single-suture button group.¹¹

Although multiple studies have addressed biomechanical stability, Laflamme et al reported on functional scores in addition to radiographic outcomes of patients randomized to either static fixation with a single 3.5-mm quadricortical screw (n = 36) or dynamic fixation with a single TightRope (n = 34). Dynamic fixation resulted in improved Olerud-Molander functional scores at 3, 6, and 12 months (significant at 12 months). AOFAS scores were significantly better in the TightRope group at 3 months only. There were 4 cases of lost reduction in the screw group compared to zero in the TightRope group.

Anatomic repair of syndesmotic ligaments. There has been recent support for anatomic repair of the syndesmosis. Schottel et al in 2016 reported from a cadaveric model that anatomic repair using suture anchors for the deltoid ligament and PITFL was not significantly inferior to screw fixation in terms of external rotational stability.⁵⁴ Zhan et al reported that patients who had augmented anatomic repair of the AITFL with a 5.0-mm anchor placed into tibia and tied to the fibular plate had better functional outcomes and earlier return to work than patients with screw fixation. Additionally, there were significantly fewer cases of malreduction in the repair group (19.2% vs 7.4%). The repair group had significantly higher overall range of motion, although they had significantly decreased plantarflexion compared to the screw group.⁷³

A recent topic of debate is in relation to fixation of the posterior malleolus and the role that it plays in syndesmotic reconstruction and stabilization. Even small posterior fragments in trimalleolar fractures can represent complete avulsion of the PITFL. Therefore, the previous teaching that posterior malleolar fractures that constitute less than 20% of the joint surface do not require fixation has been called into question. Posterior malleolar fixation has been found to further stabilize the syndesmosis and decrease the risk of post-traumatic arthritis.¹⁷ A cadaveric study by Gardner et al found that in specimens with unstable syndesmoses, fixation of a posterior malleolus fracture restored 70% of preinjury stiffness compared to only 40% with screw fixation.²³ A prospective clinical study of 31 patients (9 who underwent posterior malleolus fixation and 14 who underwent screw fixation of their syndesmotic injury) revealed that fixation of a posterior malleolus fracture with the PITFL attached resulted in at least equivalent stability and clinical outcomes as trans-syndesmotic screw fixation.⁴⁴ This is typically performed through a posterolateral approach with the patient in a prone position.⁶⁶

Complications and Technical Considerations

The overall rate of complications for nonoperative management of purely ligamentous injuries has been reported to be 68%.¹⁴ These complications include stiffness, pain and/or limp with activity, mild swelling, reinjury, heterotopic ossification (HO), and residual painful instability (Figure 7). HO is a late marker of a more severe injury and has been reported in up to 50% of cases of isolated ligamentous injuries and is associated with a higher rate of reinjury and recurrent ankle sprains. However, Taylor et al suggested that early functional and proprioceptive exercises after a 4-day period of immobilization decreased the zone of secondary injury due to inflammation with a decreased rate of HO formation.⁵⁹

Figure 7. Anteroposterior radiographs of 2 patients with chronic ligamentous syndesmotic injuries. Left: Autofusion of the syndesmosis is seen. Right: Mild heterotopic ossification and early degenerative changes are seen.



In terms of operative complications, syndesmotic malreduction has been shown to occur in up to 50% of cases.^{24,39} Intraoperative measurements such as MCS, tibiofibular overlap, and TFCS can be challenging. An intraoperative lateral radiograph of the contralateral ankle with the medial and lateral talar domes overlapping can assess the distance between the posterior tibial and fibular cortices. This

can be compared to the injured ankle after reduction prior to placing the final fixation.⁵⁵ This technique has been suggested to result in better assessment of reduction compared to anteroposterior or mortise radiographs and can help guide reduction to within 2.5 mm. Without the direct comparison, it has been shown that experienced surgeons have difficulty identifying posteriorly displaced malreduction compared to an anteriorly malreduced fibula.³⁵

A 2012 study found that forceps can aid in maintaining reduction during screw placement but that the best position for clamp placement was on the lateral malleolar ridge of the fibula and at the midpoint of the anterior-posterior width of the tibia. However, they found that forceps reduction in their cadaveric study resulted in overcompression of the syndesmosis in all tong positions.⁴⁹ Some authors suggest the use of postoperative CT scan to evaluate the quality of the reduction as this has been shown to correlate with the development of posttraumatic arthritis and overall clinical outcome.⁶⁸ Franke et al reported that in 251 patients, intraoperative CT scans were obtained after the surgeon felt that the joint was anatomically reduced based on 3-view fluoroscopy. They found that even with fluoroscopic imaging, 32.7% of patients had malreduced syndesmoses that required correction.²² A 2014 study including 25 patients requiring syndesmotic fixation using postoperative CT scans reported 36% (9 patients) were malreduced. Interestingly, however, with syndesmotic screws removed at an average of 107 days, 8/9 malreduced syndesmoses spontaneously reduced after screw removal as seen on repeat CT scan.⁵⁸ Another study by Gennis et al reported that even with slight change in MCS, TFCS, and overlap after weight bearing, there was no significant difference seen between patients who underwent elective screw removal at 3 months, versus patients who had broken or intact screws at final follow-up.²⁵

Summary

Syndesmotic injuries are increasingly common in both competitive and recreational athletes. Although screw fixation has been shown to provide greater stability than newer suture-button constructs, the benefit of the earlier motion allowed by these constructs is not completely understood. Although both of these techniques have the ability to overcompress the syndesmosis, it is unclear what effect this has on healing and ankle motion. Additionally, direct anatomic repair of syndesmotic ligaments with or without augmentation has shown promising results in terms of anatomic restoration of the joint with acceptable strength. At present, more work is needed to understand the long-term impact of newer treatments and the utility of more aggressive rehabilitation techniques.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. ICMJE forms for all authors are available online.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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