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Review Article

RECENT TREATMENT ON SYNDESMOSIS INJURY: A REVIEW

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ABSTRACT

Traumatic injuries to the distal tibio fibular syndesmosis commonly result from high-energy ankle injuries. They can occur as isolated ligamentous injuries and can be associated with ankle fractures. Syndesmotic injuries can create a diagnostic and therapeutic challenge for musculoskeletal physicians. Recent literature has added considerably to the body of knowledge pertaining to injury mechanics and treatment outcomes, but there remain a number of controversies regarding diagnostic tests, implants, techniques, and postoperative protocols. Use of the novel suture button device has increased in recent years and shows some promise in clinical and cadaveric studies. This article contains a review of syndesmosis injuries, including anatomy and biomechanics, diagnosis, classification, and treatment options.

Keywords: Syndesmosis injury, Syndesmotic screw, High ankle sprain, external rotation, Sport injury, Pronation, Tight rope.

INTRODUCTION

Injuries to the distal tibio-fibular syndesmosis commonly result from high-energy ankle injuries and contact sports. They can occur as isolated ligamentous injuries, as seen in contact sports, or associated with ankle fractures. Syndesmotic injuries can create a diagnostic and therapeutic challenge for musculoskeletal physicians. While recent literature has added considerably to the body of knowledge pertaining to injury mechanics and treatment outcomes, there remain a number of controversies regarding diagnostic tests, implants, techniques, and postoperative protocols. Herein is a review of the current data on injuries to the tibiofibular syndesmosis.

Anatomy of the syndesmosis:

The tibio-fibular syndesmosis is a fibrous joint joining the fibula to the tibia and stabilized by four lateral ligaments: the anterior inferior tibiofibular ligament (AITFL), the interosseous ligament (IOL), the transverse ligament (TL), and the posterior inferior tibiofibular ligament (PITFL). At the base of the syndesmosis, there is a small contact zone where the tibia and fibula directly articulate with a small band of hyaline cartilage about 0.5–1.0 mm thick that is contiguous with the articular surfaces of the respective bones[1]. The convex fibular part of the syndesmosis is congruent with the concave incisura on the tibial side [Anatomy of syndesmosis shown in Figure 1].

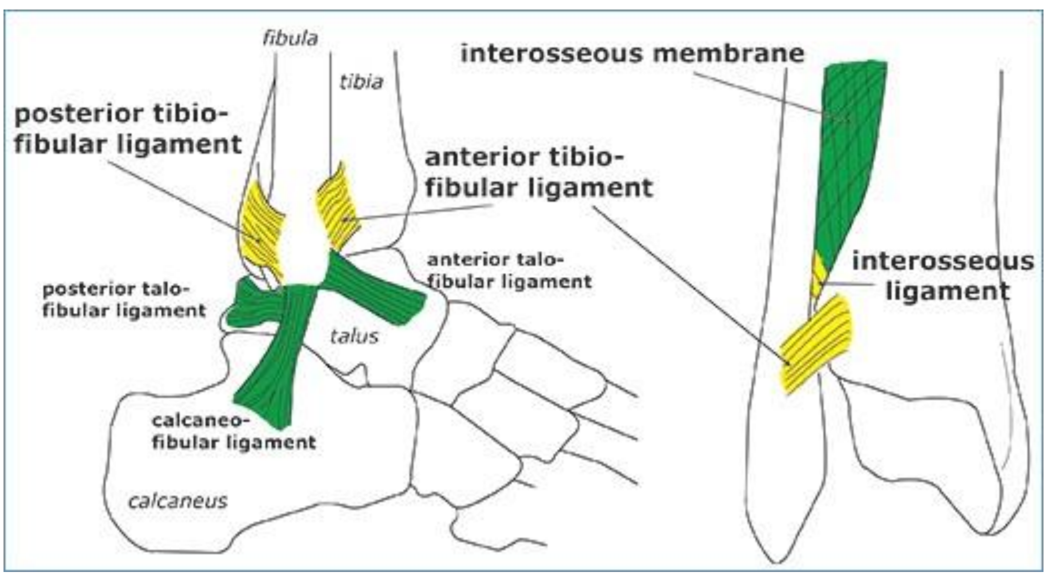

Figure 1: Anatomoy of ankle.

The anterior tubercle of the tibial incisura is larger than the posterior tubercle, preventing forward slipping of the distal fibula. In syndesmotic injuries that result from external rotation,the posterior tubercle function sasafulcrum about which the distal fibula spins around its longitudinal axis in a lateral direction .A synovial-lined syndesmotic recess is usually present, bordered cranially by the distal interosseous ligament and anteriorly by the AITFL, resulting in a synovial recess within the tibiotalar joint. The width of the syndesmotic recess is 2 mm[2, 3], and syndesmotic disruption results in injury to this membrane with increased widening, which can be easily seen arthroscopically[4]. The strong, flat, and triangularly shaped deltoid ligament on the medial side of the ankle is a key contributor to syndesmotic stability. The blood supply to the syndesmosis has been well documented[5].

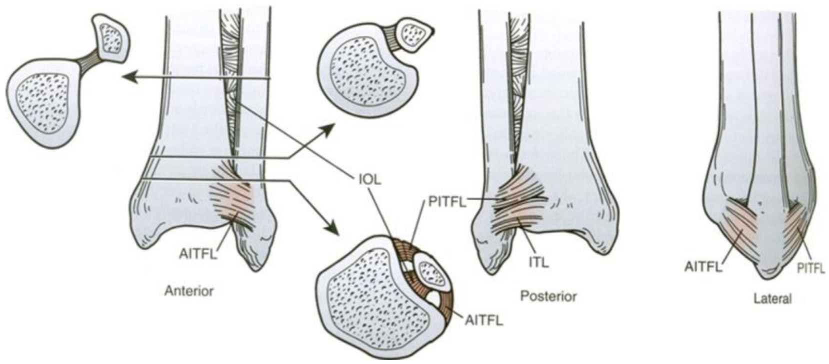

Figure 2: Line drawings depicting anterior, posterior, and lateral views of the ligaments stabilizing the distal tibiofibular syndesmosis: the anterior-inferior tibiofibular ligament (AITFL), the posterior-inferior tibiofibular ligament (PITFL), the transverse ligament (TL), and the interosseous ligament (IOL). The arrows indicate the respective location and point to the cross-sectional view.

There are three distinct anterior vascular patterns from the anterior tibial and peroneal arteries and two distinct posterior vascular patterns from the peroneal and posterior tibial arteries. These patterns vary by individual and can even differ side to side within one individual. The perforating branch of the peroneal artery, an important blood supply to the anterior syndesmosis, is located about 3 cm above the joint line and is closely associated with the IOL, making it vulnerable to injury during syndesomotic disruption and surgical treatment[5].

Biomechanics of the syndesmosis:

The ligaments stabilizing the syndesmosis prevent excess fibular motion in multiple directions: anterior–posterior translation, lateral translation, and internal and external rotation. Appropriate fibular position and limited rotation are necessary for normal syndesmotic function and talar position within the ankle mortise[6]. On the medial ankle, the deltoid ligament plays an important role in syndesmotic stability. Sequential disruption of the syndesmotic ligaments, as in a high-energy external rotation ankle injury (i.e., “high ankle sprain” or pronation external rotation ankle fracture) can result in excess lateral translation and rotation of the talus and fibula relative to the tibia[7].

Injury mechanics:

Pathologic forces to the ankle syndesmosis typically result from excessive external rotation of the ankle at the end-range of dorsiflexion or some combination of ankle dorsiflexion associated with adduction or abduction of the foot. These forces can produce widening of the fibula relative to the tibia at the ankle mortise ,disrupting the syndesmotic ligament sand resulting in secondary talar instability[8]. With high pathologic forces rotating a fixed foot (i.e., from body weight or impact with another player or object), the talus rotates laterally, resulting in injury to the AITFL. With continued force, the fibula moves further away from the tibia, producing a shearing force that can be transferred axially between the bones,causing injury to the interosseous membrane[9]. With continued high forces, the PITFL and deltoid can fail, and/or the fibula, posterior malleolus, or medial malleolus can fracture. Cadaveric studies have demonstrated that foot position impacts the nature of an injury. Haraguchi and Armiger [10]showed that external rotation of the foot while in pronation first produced damage to the AITFL, followed by medial injury to the deltoid ligament. Weietal.[11]showed that ankle external rotation with an everted foot is also more likely to disrupt the AITFL, first producing lateral translation and external rotation of the talus. Conversely, external rotation of a neutral foot is more likely to initially result in deltoid ligament injury[11], with subsequent injury to the AITFL and syndesmotic ligaments[12]. Disruption of at least two lateral ligaments and injury to the deltoid ligament are necessary for complete syndesmosis instability. However, isolated disruption of the deltoid ligament can produce medial clear space widening even with a stable syndesmosis[13]. With progressive injury to the syndesmotic ligaments, increasing diastasis will occur between the tibia and the fibula. The normal radiographic tibiofibular clear space is approximately5mm[14].Increased widening of the ankle mortise by as little as 1 mm decreases the contact area of the tibiotalar joint by 42 %, causing significant ankle instability[1]. The dramatic change in ankle joint mechanics that can occur with even mild syndesmotic injuries is a likely contributor to both the prolonged recovery and long-term dysfunction associated with syndesmotic injuries [15, 16].

Diagnosis and classification of syndesmotic injuries:

Clinical diagnosis:

The diagnosis of syndesmosis injury is based on injury pattern, thorough physical examination, and radiographic findings. When no fracture is present, clinical findings will include ankle pain, tenderness directly over the anterior syndesmosis, and positive squeeze and external rotation tests. The squeeze testis performed with squeezing of the leg above the midpoint in the calf, producing proximal compression of the fibula and tibia above the midpoint of the calf and creating separation of the two bones distally and pain at syndesmosis[17].It is important to note that this test can be painful proximally in the presence of a Maissoneuve injury. The external rotation test is performed by stabilizing the tibia with the knee flexed at 90° and externally rotating the foot. A positive examination is noted if pain is prompted at the syndesmosis during this maneuver. Both of these tests have a high specificity but low sensitivity, with MRI scans as the gold standard[18].

Radiographic diagnosis:

Radiographic evaluation should include weight bearing (where tolerated by the patient) and three views of the ankle joint (antero-posterior, mortise, lateral). Tibia/fibula x-rays should be obtained if there is clinical suspicion of fracture, particularly high in the fibula. In addition to diagnosing fracture and proximal fibula injury, radiographs can be useful in demonstrating disruption of the normal relationship between the distal tibia and distal fibula, which may be indicative of syndesmotic injury. Classically, syndesmotic injuries may be present if radiographs show increased tibiofibular clear space, decreased tibiofibular overlap, and/or increased medial clear space[19, 20]. Evidence of syndesmotic injury is not always apparent on static injury radiographs[19] showedthatthere is no optimal radiographic parameter to assess syndesmotic injury. The most useful parameters are the presence of both loss of tibiofibular overlap and widening of the medial clear space, since absence of tibiofibular overlap may indicate syndesmosis widening and a medial clear space larger than a superior clear space indicates deltoid disruption[19]. Stress radiographs may be useful for diagnosing syndesmotic injury and defining indications for surgery. However, Parikeninetal. showed that intra-operative stress radiography (lateral translation and external rotation) has very high specificity but quite poor sensitivity[21]. This means that more severe injuries are fairly easily recognized, but moderate injuries with instability may be quite easily missed with stress radiography, even under anesthesia. Contra-lateral radiograph scan also be useful. Standing x-ray scan give an indication of anatomic normal for an individual patient, which can vary considerably[22], and intra-operative use of a true lateral x-ray can help confirm reduction in the coronal plane. Intra-operative computerized tomography(CT)scanning has been shown to be a useful tool for diagnosing syndesmotic injury and confirming syndesmosis reduction[23], but this technology is not yet widely prevalent in practice. In the absence of an optimal plain radio-graphic study, MRI and CT scans can be useful static tools for assessing syndesmotic disruption, extent of ligament injury, and the position of the fibula in the syndesmosis. MRI has been shown to have high accuracy in detecting injury(96%),ascompared with AP x-ray (63 %) and mortise x-ray (71 %)[4, 24]. CT scanning is more accurate than radiographs in showing the relationship of the distal tibia and fibula[25]. CT also readily allows measurement of the contra-lateral ankle for comparison. A displacement difference of 2 mm or more side to side is considered pathologic. Arthroscopy is likely the best definitive tool for assessing syndesmosis injury and widening with 100% accuracy [4]but is not always feasible for diagnosis. In surgical cases, we will routinely use arthroscopy to confirm the diagnosis and reduction after stabilization[26].

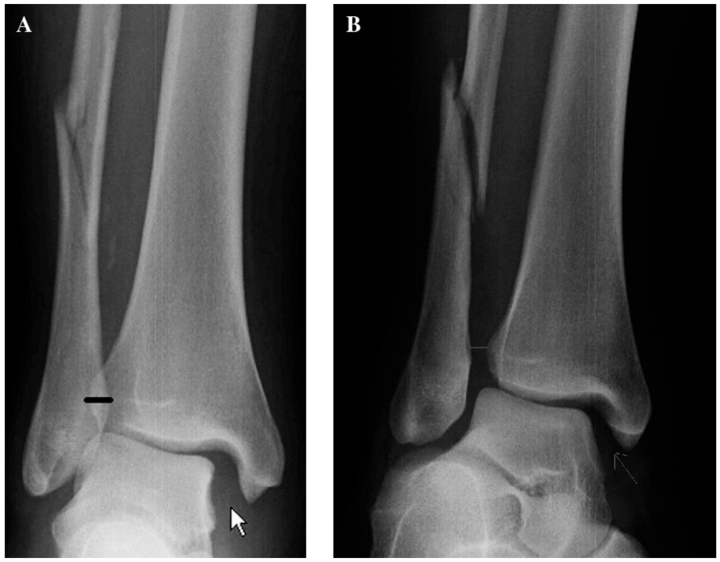

Figure 3: (a) ankle with syndesmotic injury. (b) Note the widened medial clear space,loss of tibiofibular overlap, and widening of the distal tibiofibular syndesmosis.

- **Radiographic parameters of syndesmotic injury: [Figure 3]**

- **Tibiofibular clear space**

1. Distance between the medial border of the fibula and the latera lborder of the posterior raspect of the tibial incisura.
2. Should be measured 1 cm proximal to the plafond.
3. Should be less than 6 mm in both the AP and mortise views.

- **Tibiofibular overlap**

1. Overlap of the lateral malleolus and the anterior tibial tubercle.
2. Measured 1 cm proximal to the plafond.
3. In the AP view,the overlap should be greater than 6 mm or 42 % of the width of the fibula .
4. In the mortise view, it should be at least 1 mm.
5. Absence of tibiofibular overlap can be present as an anatomic variant[22].

- **Medial clear space (MCS)**

1. Distance between the lateral border of the medial malleolus and the medial border of the talus, measured at the level of the talar dome.
2. In the mortise view, MCS should be equal to or less than the superior clear space between the talar dome and the tibial plafond [19].
3. An increase in MCS indicates a deltoid ligament injury.

4. Increased tibio fibular clear space is considered the most reliable indicator of syndesmotic injury [27].

Classification:

Classification systems of the severity of acute syndesmosis injury have been developed by several authors[16, 28]. There is general agreement that there are three grades, rated from grade I to III from least to most severe. While these classification schemes have similarities, there are also important differences between the scales. Of note, all of the sescales incorporate clinical findings, but there is no current classification system that uses anatomic location or severity of ligamentous injury as defined by MRI or ultrasound, and no system provides adequate treatment guidance or prognosis.

Grade I:

There is general agreement that grade I injuries are clinically mild, with a stable syndesmotic joint and normal radiographs. There is incomplete injury to the lateral ligaments. These patients will have tenderness at the syndesmosis. External rotation and squeeze tests can be negative[28], although Gerber et al. indicated that one of these two tests should be positive [16].

Grade II:

Grade II injuries are generally associated with complete AITFL and IOL disruption. Radiographs are normal, and external rotation and squeeze tests are positive. However, there is no consensus regarding joint stability. Scranton suggests that grade II injuries are unstable, whereas Wolf and Amendola indicate that they can be either stable or unstable. Laboratory data suggest that injury to the PITFL and transverse ligament are the key to syndesmotic stability. No current classification system helps differentiate between grade II injuries requiring stabilization and those that do not. Since the decision to stabilize surgically depends on stability, the optimal classification system would account for this and likely include MRI findings as a more accurate tool than radiographs.

Grade III:

A grade III injury is a complete injury to the lateral ligaments (AITFL,IOL,PITFL) and deltoid ligament avulsion .The joint is clearly unstable with plain radiographs (greater than 2 mm of medial clear space widening and/or widened syndesmosis)[29]. All clinical tests are positive. Grade III injuries require operative stabilization.

Ankle fractures with syndesmotic injuries:

The large majority of data on the surgical treatment of syndesmosis injuries are in fracture-associated syndesmotic disruptions. Approximately one in seven ankle fractures are associated with an injury to the syndesmosis. Rotational ankle injurie scan result in particularly high mechanical forces when they occur in high-impact and collision activities, especially when they occur at high speeds and in patients with high body mass index. When forces are great enough, fractures can occur at the medial and posterior malleoli, the fibula proximal to the syndesmosis articulation, and/or the attachment sites of the syndesmotic ligaments (i.e., Chaput's and Wagstaff 's tubercle). These injuries are described in the most commonly recognized fracture classifications based on fracture location (i.e., Lauge Hansen pronation external rotation injuries, supination external rotation injuries, and Danis Weber C injuries)[30].It is important to note that at least 20 % of syndesmotic injuries are associated with Weber B fracture patterns[31]. While the most common fracture location in syndesmotic injury is the distal third of the fibula,the fracture level syndesmosis. This usually involves rupture of the AITFL and interosseous membrane, with PITFL disruption (or posterior malleolus injury) in severe injuries. Disruption of the syndesmotic ligaments can also result in a fracture at the proximal fibula, or "high fibular fracture," referred to as a Maisonneuve injury. Maisonneuve fractures generally occur with extensive rupture of the interosseous membrane[9]. These are indicative of severe trauma to the syndesmotic ligaments.

Ligamentous syndesmotic injuries:

Sports activities played at high speeds, on uneven terrain, or artificial surfaces with cleated sports shoes can create or increase the likelihood of dorsiflexion and external rotation of the foot and ankle relative to the tibia[31, 32]. Such injuries typically occur during impact and collision activities that involve jumping and landing maneuvers (i.e., football, soccer, basketball, rugby, skiing, hockey, etc.), which are known to result in external rotation torque, increasing the incidence of syndesmotic ankle sprain. Ligamentous injuries to the syndesmosis are commonly referred to as "high ankle sprains," since they occur proximal to the more common inversion lateral ankle sprains. These injuries can be generally classified as incomplete ligamentous injuries (i.e.,"sprain")or complete ligamentous disruption. Complete ligamentous injuries are rare without fracture but are generally repaired surgically[32]. High ankle sprains are less common than "inversion" lateral ankle sprains, comprising around 10 % of all ankle sprains[15, 33], but represent up to 25 % of ankle sprains in collision sports such as American football[16, 32, 34]. As compared with inversion sprains, high ankle sprains are more likely to create long-term dysfunction[16] and require much more time for recovery [15, 35].

Treatment of syndesmotic injuries:

Conservative treatment:

Lower grade(grades Iand II) isolated syndesmotic sprains can generally be successfully treated non surgically, since they do not result in diastasis and complete ligamentous disruption[32]. However, these can take up to 3 times longer to heal than inversion ankle sprains. Injuries that occur in conjunction with a fracture and those with clear destabilization of the mortise generally require surgical treatment of the fracture. In these injuries, syndesmosis instability can be assessed intra-operatively in order to determine the need for syndesmosis stabilization. For appropriate injuries, conservative management of stable injuries has shown good results[16, 36] and generally involves the typical three-phase approach. Nassbaum et al. [36] treated 60 collegiate athletes with clinically detected "high ankle sprains" with a rehabilitation program that included short period (1–4 days) of non-weight-bearing and immobilization in a boot, followed by an aggressive rehabilitation schedule. The mean return to sport was 13.4 weeks, and time to return was statistically related to the interosseous tenderness length positive squeeze test. Since they did not obtain MRI scans, it is possible that some athletes in their series may have had minor lateral ligament sprains, which can clinically simulate syndesmotic injuries and have a tendency to recover much faster. For higher grade injuries, surgical treatment is likely superior to non-operative treatment, even for purely ligamentous injuries.Compared grade III syndesmotic injuries treated surgically with conservative treatment in a cast, and while there was little long-term difference in symptoms and athletic performance, return to play was, on average, 3 weeks faster in the surgical group. For grade II injuries, where there is no evidence of instability on plain radiographs or stress testing but MRI or ultrasound studies suggest a higher grade injury (i.e., complete syndesmosis ligament disruption, deltoid injury, etc.) with possible dynamic instability, arthroscopy is a useful tool for accurately assessing the injury for dynamic instability, and stabilization can be instituted at the same time as necessary [37].

Surgical treatment:

Most syndesmotic injuries that occur with fractures of the fibula and/or posterior malleolus will require surgical stabilization. Isolated ligamentous injuries that result in complete syndesmotic disruption of the syndesmosis are not common, but they also require surgical stabilization to optimize shortand long-term outcomes. While a number of techniques have been described for stabilization of the syndesmosis [38-44], the most commonly used methods by far, according to recent literature, are screws and suture buttons[6, 39, 45-53]. Outcomes of both treatments are generally very good. The most important clinical predictor of outcome is consistently reported as anatomic reduction of the syndesmosis[31, 50, 54]. The unplanned reoperation rate for syndesmotic injuries has been reported in large series to be as high as 27 %[55]. In a study by Symeonidis et al.[55], the most common causes of reoperation was missed syndesmotic injuries (47 %), failure to achieve anatomic reduction (31 %), and loss of reduction due to fixation failure (21 %) .

Trans-syndesmotic screws [Figure 4]:

Trans-syndesmotic screws are a highly effective method for to heal with appropriate aftercare. There exists an extensive literature pertaining to the technical attributes of syndesmotic screw materials and configuration. Rates of fixation failure do not appear to be different when stainless steel screws are compared with titanium screws[56]. Larger, 4.5mm screws provide greater resistance to shear stress than do 3.5-mm screws[57], but cadaver testing suggests that there is no biomechanical advantage based on screw type during pronation external rotation injury[58]. Two syndesmotic screws provide superior stability, as compared with one[43], but biomechanical stability and outcomes are no different when three-cortical is compared with four-cortical screw placement[47, 56, 58, 59]. The position of the foot during insertion of the syndesmotic screw does not impact final ankle range-of-motion or clinical outcome [60, 61].

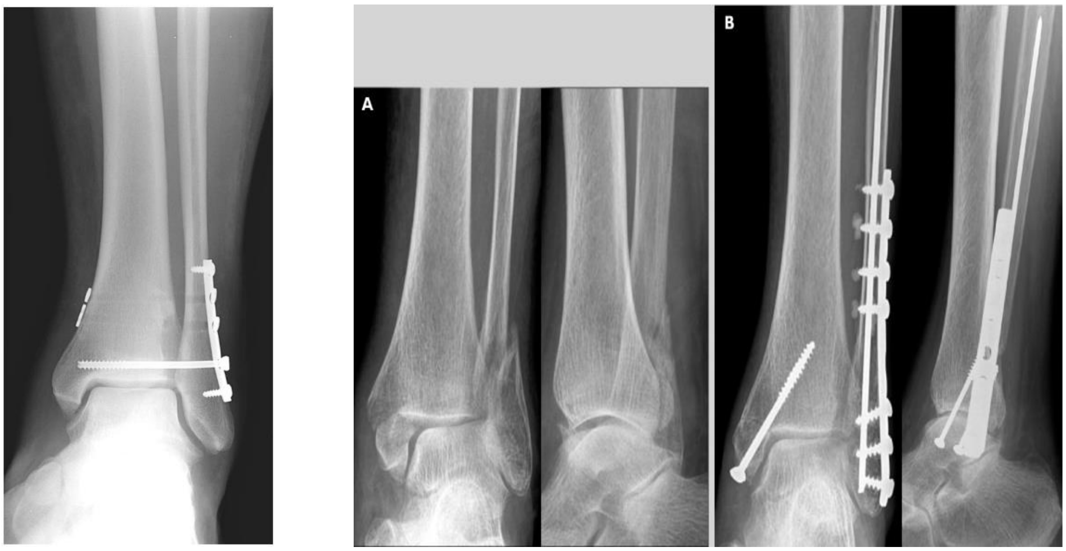

Figure 4: Trans-syndesmotic screws.

Complications with screw fixation:

Significant mal-reduction of the tibiofibular syndesmosis has been reported in up to half of patients treated with syndesmotic screws[25, 47, 50]. Mal-reduction has been found to be a primary predictor of clinical outcome[31, 50, 54, 62]].There is some controversy regarding the necessity for screw removal too[63]. Recent studies suggest that removal of syndesmotic screws does not impact clinical outcome .Infact, paradoxically ,patients with broken screws have slightly better out comes than do those with intact screws[63-65]. Furthermore, a complication rate of up to 15.8 % (wound infection or recurrent diastasis)has been reported after screw removal[66]. In general, screws should be left in place for at least 3 months, and removal can be justified when the screw results in local tenderness or other physical complaints, dorsiflexion is hindered, or the patient prefers removal after informed discussion that includes concerns for potential hardware breakage or loosening. According to Schepers[65], when one or two syndesmotic screws are placed tricortically, the need for hardware removal is 10 %.

Suture button fixation:

The suture button (marketed as the "TightRope" by Arthrex Inc, Naples, FL), a relatively new surgical implant, is a low profile system that consists of a No. 5 fiber-wire loop (Arthrex), which can be tensioned and secured between two metallic endo-buttons placed against the outer cortices of the tibia and fibula (or fibular plate, if present). This device provides stabilization of the ankle mortise and reduces the need for subsequent procedures for device removal and, theoretically, late diastasis. A number of biomechanical studies have shown strength equivalent or only slightly inferior to screws[46, 67]. However, it is not clear whether the forces used in these studies approximate those transmitted during regular ambulation or that might occur during sporting activities. While the clinical literature on suture button is encouraging[42, 50, 51, 68], it is also limited. In fact, a JAAOS review article on syndesmosis injuries published only 6 years before this article makes no mention of the suture button device[44]. The use of a suture device provides equivalent [69] or improved[42, 69] clinical outcomes, as compared with a four cortical syndesmotic screw. Co[69]published their preliminary results of a prospective randomized trial comparing suture button with screw fixation. They suggest that "patients in the Tight Rope group have demonstrated better objective range-of-motion measurements and subjectively reported less stiffness and discomfort." AOFAS ankle/ hind foot scores were higher in the suture button technique at an average of 18 months follow-up, although this did not reach statistical significance [69]. Naqvi et al. [50] recently showed, in a prospective cohort study, that fixation with a suture button provides a more accurate method of syndesmotic stabilization, as compared with screw fixation, with equivalent clinical outcomes. Supporting evidence from previous studies [31, 63], syndesmotic mal-reduction was the most important independent predictor of clinical outcomes [50]. This underscores both the importance of accurate syndesmotic reduction and the potential benefit that suture button devices may play in optimizing reduction.

Complications with Tight Rope:

Although an advantage of the suture button technique is mitigating the need for implant removal, there are several reports of infection, skin irritation, and granuloma formation warranting removal. In a recent study of 102 injuries treated with suture button fixation, 8 % required removal for pain, infection, or implant loosening[52]. Still, this is a lower removal rate than that associated with screw fixation[64]. Despite the higher than anticipated complication rate requiring removal of the suture button, it is done so through a small wound with few complications. Further well-designed, prospective studies are needed to confirm the long-term clinical outcomes of suture button fixation.

CONCLUSIONS

Traumatic injuries to the distal tibiofibular syndesmosis are relatively common and can be associated with ankle fractures or occur as purely ligamentous injuries, as often seen in contact sports. Syndesmotic injuries can create a diagnostic and therapeutic challenge for musculoskeletal physicians. Recent literature has added considerably to our understanding of injury mechanics and treatment outcomes with new technologies. Injury classification should facilitate prognosis, return to play and surgical decision making. The suture button device appears to have advantages over screws with improved reduction, maintenance of reduction, sufficient biomechanical strength, and no need for routine removal. However, further prospective and long-term clinical data on the suture button device are needed.

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