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Understanding Syndesmotic Injury: Anatomy, Biomechanical Considerations, and Modern Treatment Approaches"(A Review of Literature)

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Abstract-

Injuries to the distal tibiofibular syndesmosis pose a diagnostic and therapeutic challenge due to their subtle presentation and the essential role of the syndesmotic ligaments in maintaining ankle stability. Disruption of this joint can significantly alter fibular motion and talar positioning, leading to prolonged recovery or chronic instability if not identified early. Clinical tests offer useful information but may lack sensitivity, making advanced imaging important when suspicion remains high. Treatment depends on the severity and stability of the injury, ranging from rehabilitation for low-grade sprains to surgical stabilization when complete ligament disruption or associated fractures are present. Both screw fixation and suture-button constructs can achieve reliable outcomes when anatomic reduction is restored. Emerging techniques, such as arthroscopy-assisted reduction and targeted ligament repair, continue to refine management of more complex cases. Early recognition and an individualized treatment approach remain central to achieving good long-term function.

Introduction-

Syndesmotic injuries, usually called as high ankle sprains, can present a significant challenge because they involve the stabilizing ligaments between the distal tibia and fibula rather than the more commonly injured lateral ligaments. Even a partial injury to this joint can alter the mechanics of the ankle and lead to persistent pain or instability if it remains unidentified. The

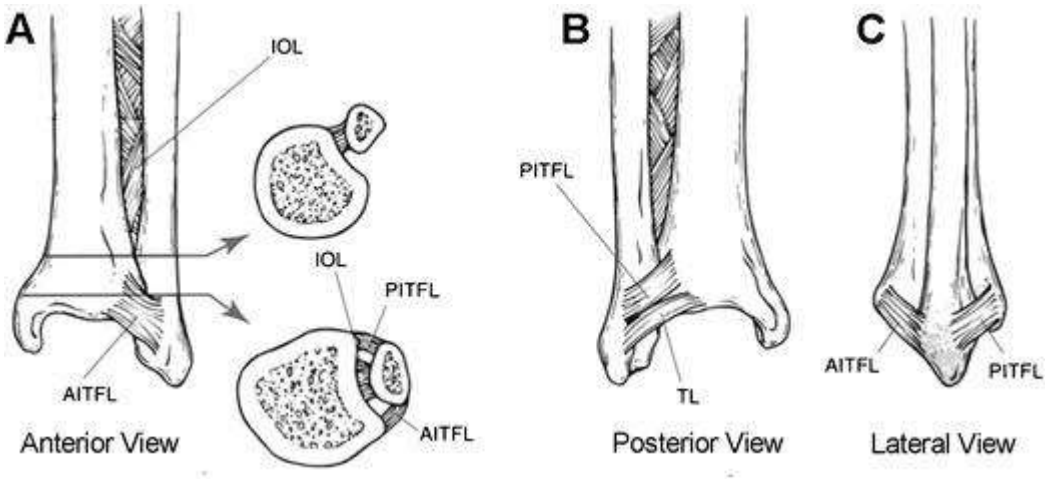
anatomy of the syndesmosis is complex, and its function depends on the coordinated support of several ligaments that limit rotation and translation of the fibula during weight-bearing.

In many cases, the early signs of a syndesmotic injury are subtle. Standard physical examination tests may be uncomfortable but not always conclusive, and plain radiographs can appear normal despite meaningful ligament damage. Because of this, advanced imaging—most commonly MRI or CT—is often required to determine the extent of the injury and whether the joint remains stable. The treatment approach ranges widely, from conservative care for low-grade sprains to operative fixation for more severe or unstable injuries.

This review brings together the key anatomical considerations, diagnostic methods, and treatment strategies for managing syndesmotic injuries, with attention to both established practices and current developments in surgical and non-surgical care.

Anatomy-

The tibiofibular syndesmosis is a fibrous joint joining the fibula to the tibia and stabilized by four primary ligaments: the anterior inferior tibiofibular ligament (AITFL), the interosseous ligament (IOL), the transverse ligament (TL), and the posterior inferior tibiofibular ligament (PITFL) [1]



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 approximately 0.5–1.0 mm thick that is contiguous with the articular surfaces of the respective bones[2]

The convex fibular part of the syndesmosis is congruent with the concave incisura on the tibial side 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 functions as a fulcrum about which the distal fibula spins around its longitudinal axis in a lateral direction. The width of the syndesmotic recess is normally 2 mm[3]

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 .[4]

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.[5]

On the medial side of the 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 [6]

Diagnosis -

Clinical diagnosis

When no fracture is present, clinical findings will include ankle pain, tenderness directly over the anterior syndesmosis, and positive squeeze and external rotation tests.[1]The squeeze test is 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 .[7]It is important to note that this test can be painful proximally in the presence of a Maisonneuve injury.[8]

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[8]

Radiographic diagnosis

Radiographic evaluation should include weight bearing (where tolerated by the patient) and three views of the ankle joint (anteroposterior, 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.[1]

Evidence of syndesmotic injury is not always apparent on static injury radiographs[9]

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[9]

Standing x-rays can give an indication of anatomic normal for an individual patient, which can vary considerably[10]

In the absence of an optimal plain radiographic 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 %), as compared with AP x-ray (63 %) and mortise x-ray (71 %)[11]

CT scanning is more accurate than radiographs in showing the relationship of the distal tibia and fibula[12]

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 but is not always feasible for diagnosis[11]

Classification-

Class 1

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.[1] These patients will have tenderness at the syndesmosis [13] External rotation and squeeze tests can be negative [14]

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.[1]

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). All clinical tests are positive. Grade III injuries require operative stabilization.[9]

Conservative treatment-

This includes rest, elevation, compression, and anti-inflammatory medication. Treatment also can include therapeutic modalities such as electric stimulation and massage

At about 4–6 weeks post-injury, patients can be placed into a lace-up ankle brace and begin a more intensive functional rehabilitative program guided by symptom tolerance. For more significant stable syndesmotic injuries, the lace-up brace should be worn for six more weeks to minimize symptoms[15]

Lower grade (grades I and II) isolated syndesmotic sprains can generally be successfully treated nonsurgically, since they do not result in diastasis and complete ligamentous disruption[16]

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.

Hunt et al. has recommended that repeated successful performance of a single-leg hop test is a reliable sign of the patient's injury status[1]

To enhance the outcomes in non-operative syndesmosis injuries, Laver et al. evaluated using plasma-rich plasma (PRP) ultrasound injections in the AITFL in the 16 elite athletes. They found that there was a difference (p = 0.006) in time to return to play between the (PRP) injection group (41 days) and the control group (60 days) . Further, their results showed a difference in residual pain between the treatment and control group (62.5 vs. 12.5%), respectively[17]

Another non-operative treatment option once can be considered is a periligamentous corticosteroid injection of the tibiotalar joint for a syndesmotic injury . However, even though it has been shown to be safe and effective, it is only meant to be a short term treatment plan[18]

For higher grade injuries, surgical treatment is likely superior to nonoperative treatment, even for purely ligamentous injuries[19]

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 [14]

Surgical treatment-

Unstable syndesmotic injuries need to be treated operatively with some combination of rigid (plate or screw/washer) or "dynamic" (suture button) fixation.[20]

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 short- and long-term outcomes.[1]

Outcomes of both treatments are generally very good. The most important clinical predictor of outcome is consistently reported as anatomic reduction of the syndesmosis[21]

Trans-syndesmotic screws-

Trans-syndesmotic screws are a highly effective method for achieving stable fixation, allowing the syndesmotic ligaments to heal with appropriate aftercare.There exists an extensive

literature pertaining to the technical attributes of syndesmotic screw materials and configuration.[1]

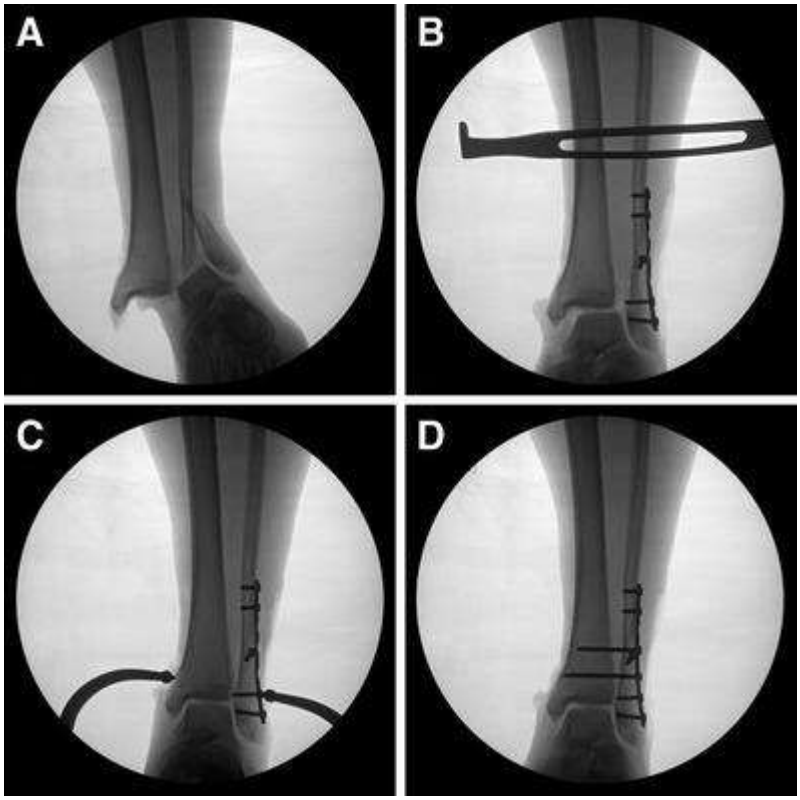
Classical AO teaching recommends that a syndesmosis screw should be inserted at 25°–30° to the coronal plane of the ankle beginning at least 1 cm above the ankle joint in the proximity of the physeal scar[20]

one or two screws starting between 2.1 and 4.0 cm above the tibial plafond[22]

The majority of studies regarding screw fixation for the syndesmosis have looked at patients with combined ankle fractures and syndesmosis instability.[23]

McBryde et al. performed a cadaveric study that found that less syndesmotic widening was found at 2.0 cm when compared with 3.5 cm proximal to the tibiotalar joint. Furthermore, they recommend to place the syndesmotic screw at 2.0 cm above the tibiotalar joint[23]

Verim et al. had contradicting recommendations due to their biomechanical evaluation of syndesmotic screw position using CT scan data of an ankle of a 3-dimensional finite element. They found that the von Mise stress (effective stress where yielding is estimated to occur in ductile materials) was lowest when the screw was placed at 3–4 cm above the tibiotalar joint and highest 2.0–2.5 cm above the tibiotalar joint. They recommended placement of the syndesmotic screw at 3–4 cm above the tibiotalar joint. This may also decrease damage to the tibiofibular articulation at the incisura.[24]



Rates of fixation failure do not appear to be different when stainless steel screws are compared with titanium screws [9]Larger, 4.5-mm screws provide greater resistance to shear

stress than do 3.5-mm screws[25]Two syndesmotic screws provide superior stability, as compared with one.[26]

Biomechanical stability and outcomes are no different when three-cortical is compared with four-cortical screw placement [27]

Complications with screw fixation-

Significant malreduction of the tibiofibular syndesmosis has been reported in up to half of patients treated with syndesmotic screws[28]

There is some controversy regarding the necessity for screw removal .The screw should be removed due to idea of restoring normal function and stress transfer mechanism of the normal ankle joint at around 8–12 weeks postoperatively[29]

Screws should be left in place for at least 3 months, and removal can be justified when (1) the screw results in local tenderness or other physical complaints, (2) dorsiflexion is hindered, or (3) the patient prefers removal after informed discussion that includes concerns for potential hardware breakage or loosening. [1]

Westermann et al. found that with anterior off-axis clamping, the mean sagittal malreduction was 2.7 ± 2.0 mm with screw fixation. They also found a difference in posterior off-axis clamping; the sagittal malreduction was 7.2 ± 2.3 mm with screw fixation.[30]

Suture button-

“Dynamic” fixation of the syndesmosis with a suture button device has recently gained popularity due to a number of as yet unproven and predominantly hypothetical benefits, including the following: allowing physiological micromotion of the tibiofibular joint, no routine necessity for secondary surgery involving implant removal, the facilitation of early weight bearing, and the possible earlier return to work or sport[30,31]

The suture button frequently marketed as “TightRope” , a relatively new surgical implant, is a low-profile system that consists of a No. 5 fiber-wire loop, which can be tensioned and secured between two metallic endobuttons 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[32]

Early short-term studies of the suture button device have suggested it to enable outcomes comparable to syndesmotic screw fixation, and as such it is now considered to be a viable alternative to positioning screw fixation.[33]

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.

The use of a suture device provides equivalent or improved clinical outcomes, as compared with a four-cortical syndesmotic screw.[34]

In a comparative study done my Coetzee et. Patients in the TightRope group have demonstrated better objective range-of-motion measurements and subjectively reported less stiffness and discomfort. AOFAS ankle/hindfoot scores were higher in the suture button technique at an average of 18 months follow-up, although this did not reach statistical significance [35]

Fixation with a suture button provides a more accurate method of syndesmotic stabilization, as compared with screw fixation, with equivalent clinical outcomes[36]

Complications with Suture Button/TightRope-

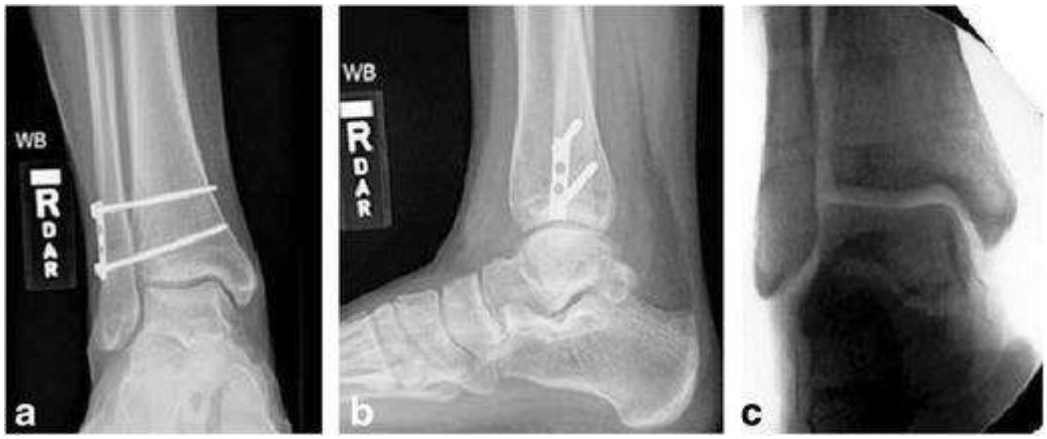
Although an advantage of the suture button technique is mitigating the need for implant removal, there are several reports of infection, skin irritation, and granuloma formation warranting removal. In a recent study of 102 injuries treated with suture button fixation, 8 % required removal for pain, infection, or implant loosening[37]

Still, this is a lower removal rate than that associated with screw fixation as quoted by Hamid et.al[38]

With anterior off-axis clamping, the mean sagittal malreduction was 1.0 ± 1.0 mm with suture button fixation. They also found a difference in posterior off-axis clamping; the sagittal malreduction was 05 ± 1.4 mm with suture button fixation [30]

New techniques-

New treatment for isolated unstable syndesmotic injury is to perform arthroscopy to debride the interposed tissue in the syndesmosis and facilitate reduction. This also has the added benefit of diagnosing and treating any acute osteochondral defects at the time of surgery. At the very least, these injuries can be documented since they may correlate with a worse prognosis. This is followed by direct reduction under fluoroscopic control and then placement of two 4.0 mm quadricortical screws through a small one third tubular plate starting approximately 1.5 cm proximal to the joint line . These screws are placed in a slightly divergent orientation to maximize fixation (pullout) strength[33]



If there are still remnants of the AITFL in place, then anatomical suture repair or imbrication of the anterior syndesmotic ligament is recommended, along with syndesmotic screw placement to protect this repair for at least 6 to 8 weeks[39]

When patients have chronic instability or continue to have syndesmosis instability after fixation, they will have a higher chance of nonunion. A syndesmosis fusion can then be used as a salvage procedure in this setting. Olson et al. looked at treating chronic syndesmotic instability after ankle fractures with reduction and arthrodesis of the distal tibiofibular articulation in 10 patients with a mean follow-up of 41 months (range, 29 to 44). The mean AOFAS ankle-hindfoot clinical rating score increased from 37 ± 15 preoperatively to 87 ± 11 at final follow-up ($p < 0.005$). All the patients were satisfied with their results and treatment.[40]

Conclusion-

Syndesmotic injuries demand careful assessment and a solid understanding of the anatomy and mechanics of the distal tibiofibular joint. While mild and stable sprains can usually be managed successfully with conservative treatment and a structured rehabilitation program, higher-grade injuries or those associated with fractures require surgical stabilization to restore the normal relationship between the tibia and fibula. Both screw fixation and suture-button devices have proven effective, and the choice often depends on surgeon preference, injury pattern, and patient needs. Across all treatment methods, the most important factor influencing long-term outcomes is precise anatomic reduction of the syndesmosis. Newer techniques—particularly arthroscopy-assisted reduction and ligament repair—offer additional tools for managing complex cases and addressing associated cartilage injuries. When chronic instability persists even after treatment, fusion of the distal tibiofibular joint may serve as a good salvage option. With accurate diagnosis and thoughtful selection of treatment, most patients can expect a good functional recovery.

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