Acute Syndesmosis Injuries Associated with Ankle Fractures
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Abstract
Ankle syndesmosis injuries frequently occur with ankle fractures, but their treatment remains controversial. Although specific clinical and radiographic diagnostic measures are generally well-accepted, there remains a lack of consensus with respect to the treatment of these injuries. Controversy arises at almost every phase of treatment including: type of fixation (screw size, type of implant), number of cortices required for fixation, and need for hardware removal. Regardless of fixation technique chosen, the most important goal should be anatomic reduction and restoration of the syndesmosis and ankle mortise as this is the only significant predictor of functional outcome.

Ankle fractures are among the most commonly treated fractures in adults, and syndesmosis instability is often associated with fibula fractures above the level of the distal syndesmosis ligaments (Weber type C). Syndesmosis injuries are important to detect, because they lend stability to the ankle joint. Despite the frequency and importance of these injuries, the management of ankle syndesmotic injuries has remained controversial since the first description in the 18th Century. Numerous studies investigating the distal tibiofibular joint exist in the literature, yet there is no consensus regarding the definitive surgical treatment of acute syndesmosis injuries. This applies to injuries that occur both with and without ankle fractures. Injuries to the syndesmosis fall within a spectrum ranging from simple isolated sprains to diastasis with complete disruption and disruption associated with fractures. This review focuses on syndesmosis injuries that occur associated with fibula fractures, with and without medial malleolus fractures.

Anatomy and Biomechanics
The ankle joint is comprised of the distal fibula, distal tibia, and the dome of the talus. The bony architecture and the supporting syndesmotic ligaments stabilize the distal tibiofibular joint. The main function of the ligament complex is to maintain the integrity between the tibia and fibula, as well as resist axial, rotational, and translational forces. The ankle syndesmosis is made up of four ligaments, including the anterior inferior tibiofibular ligament (AITFL), the posterior inferior tibiofibular ligament (PITFL), the transverse tibiofibular ligament (TTFL), and the interosseous ligament (IOL), a distal extension of the interosseous membrane (Fig. 1). Ogilvie-Harris and colleagues demonstrated the contribution of each ligament to the stability of the syndesmosis, with the AITFL providing 35%, the TTFL 33%, the IOL 22%, and the PITFL 10%. They proposed that injury to two of these ligaments may lead to instability. Xenos and associates demonstrated in a cadaveric study that dissection of the AITFL led to a 2.3 mm diastasis of the distal tibiofibular joint. When the distal 8 cm of the IOL was dissected, an additional 2.2 mm increase occurred. When the final two ligaments, TTFL and PITFL, were cut, the total diastasis was 7.3 mm.

Mechanism of Injury
External rotation forces applied to the foot are thought to be the main mechanism of injury to the ankle syndesmosis
with the foot in a pronated or supinated position. In the Lauge-Hansen classification,\textsuperscript{6} supination-external rotation, pronation-abduction, or pronation-external rotation types can be associated with syndesmosis injuries. Other mechanisms such as eversion, inversion, internal rotation, pronation, and plantar flexion have been reported. The external rotation force begins on the medial side with an injury to the deltoid ligament or a medial malleolus fracture. The force transmits laterally with the talus externally rotating and pushing the fibula, stretching the AITFL until rupture occurs. With continued external rotation, the IOL and PITFL are stressed and ruptured. The force continues in a proximal direction along the interosseous membrane and finally exits through the fibula, resulting in fracture. Pankovich,\textsuperscript{7} in his description of Maisonneuve fractures of the fibula, described these stages and stressed the importance of the medial ankle disruption in producing a complete lesion.

**History and Physical Examination**

As with all injuries, a thorough history and physical examination are important. Patients with ankle fractures with and without syndesmosis injuries often present in the same manner. There is pain, ecchymosis, and significant swelling in the lateral aspect of the ankle, with an inability to bear weight. Patients commonly report a twisting injury, which may or may not be associated with participation in sports. Tenderness and crepitus is usually present upon palpation. There is often medial-sided swelling indicative of a deltoid injury or medial malleolus fracture.

Specialized tests exist to help diagnose syndesmosis inju-

![Image](image1)


![Image](image2)

**Figure 2** Anteroposterior (A), mortise (B), and lateral (C) radiographs demonstrating widening of the syndesmosis.
In a cadaveric study, Harper and Keller evaluated the tibiofibular overlap. These studies also are useful in evaluating the integrity of the syndesmosis. These include the tibiofibular clear space and the modified dorsiflexion-compression test, which actually results in increased ankle range of motion with compression over the malleoli during active dorsiflexion. All four tests were performed on each patient by two separate examiners and the results compared. This study showed that the squeeze test was the least valuable despite a fair interrater reliability, since it is usually negative. The external rotation test was the most reliable, as it was frequently positive and had the best interrater reliability.

Imaging

Syndesmotic injuries associated with ankle fractures can often be diagnosed with conventional radiographs. Anteroposterior (AP), lateral, and mortise views of the ankle are taken (Fig. 2). An AP and lateral of the whole lower leg should be obtained in anyone with proximal fibula tenderness to rule out Maisonneuve injuries (Fig. 3). Computed tomography (CT) scans and magnetic resonance imaging (MRI) demonstrate very high specificity and sensitivity and may be useful adjuncts in cases of subtle syndesmosis injuries. Specific criteria based on anatomic and clinical studies also are useful in evaluating the integrity of the syndesmosis. These include the tibiofibular clear space and the tibiofibular overlap.

In a cadaveric study, Harper and Keller evaluated the normal and widened syndesmosis radiographically. They demonstrated that in a normal tibiofibular relationship, the tibiofibular clear space was less than 6 mm in the AP and mortise views. The overlap was greater than 6 mm in the AP view and 1 mm in the mortise view. The investigators concluded that the tibiofibular clear space in either the AP or mortise views is the most reliable parameter.

Ostrum and colleagues later defined gender-specific absolute values and non-gender specific ratios, adjusting the values reported by Harper and Keller. They reported these values for an intact syndesmosis: 1. tibiofibular clear space less than 5.2 mm in females, 6.5 in males; 2. tibiofibular overlap of greater than 2.1 mm in females and 5.7 mm in males; 3. a ratio of tibiofibular overlap to total fibular width greater than 24%; and 4. a ratio of tibiofibular clear space to total fibular width less than 44%.

Pneumaticos and associates cautioned the use of the tibiofibular overlap as a radiographic parameter, as they demonstrated that this measurement changes with rotation. The clear space, however, remained the same, with rotation ranging from 5° of external rotation to 25° of internal rotation. The investigators concluded that the tibiofibular clear space is the most reliable parameter for measuring widening of the syndesmosis on plain radiographs.

Ebraheim and coworkers showed that all tibiofibular diastases of 2 or 3 mm created in a cadaveric model could be seen on CT, while plain radiographs missed all of the 2 mm diastases and half of the 3 mm diastases, showing that CT is much more sensitive for the detection of minor syndesmotic injuries. However, Nielson and colleagues demonstrated that tibiofibular clear space, as seen on the AP radiograph, had no correlation with ligament injury on MRI, and also that tibiofibular overlap measured on AP or mortise views was not associated with injury to either the AITFL or PITFL on MRI. Tibiofibular overlap on the mortise view did correlate with an interosseous membrane tear, but the clinical significance of this was unclear in light of the lack of correlation with other tears in the syndesmotic complex. These radiographic measurements had both low sensitivity and specificity in predicting syndesmotic injury. The investigators concluded that there was minimal evidence that the tibiofibular relationship seen on prereduction radiographs was useful in diagnosing syndesmotic injuries.

When a syndesmotic injury is suspected clinically but not confirmed on conventional radiographs, a stress view may be obtained. This is the equivalent of an external rotation test but performed radiographically by holding the ankle in maximum dorsiflexion and the tibia in 15° of internal rotation while applying an external rotation force to the foot. Alternatively, a gravity stress view may be obtained by performing an AP radiograph with the leg horizontal (medial side up) and without support under the ankle. The resultant displacements are then compared to the contralateral uninjured extremity. Although stress views are conventionally performed on a mortise image, lateral views may allow for easier interpretations, as Xenos and associates demonstrated...
larger posterior displacement of the fibula in the sagittal plane than in the coronal plane.

**Treatment**

Syndesmosis injuries occur frequently with ankle fractures. But when do they require surgical fixation? Boden and coworkers\(^\text{19}\) stated that fibula fractures with syndesmosis disruptions 3 to 4.5 cm proximal to the plafond require trans-syndesmotic fixation if the ankle is unstable with a medial deltoid injury. However, with medial malleolus fractures, achieving rigid fixation of both the medial and lateral malleoli may circumvent the need for syndesmosis fixation. The need for syndesmosis stabilization should then be assessed clinically and radiographically in the operating room. The Cotton test was created to assess instability.\(^\text{20}\) The test was originally described as stabilizing the distal tibia and applying a lateral force to the foot, looking for any lateral translation of the foot. However, determining instability was difficult. Therefore, a modification of this test is now used.\(^\text{16}\)

After fixation of the malleoli, the distal fibula is grasped with a pointed reduction clamp and pulled laterally under fluoroscopic visualization. Assessment of the syndesmosis stability is then achieved under direct visualization (Fig. 4).

After a diagnosis is made of an unstable ankle fracture with syndesmosis injury, most clinicians would agree that surgical fixation would be the optimal means of management. Yet controversy still exists regarding the placement of the syndesmotic screw, the size of the screw, the number of cortices, the number of screws, and the necessity in removal of the screws.

Multiple biomechanical studies have sought to locate the optimal site for syndesmotic fixation. McBryde and colleagues\(^\text{21}\) concluded from a cadaver study that a screw located 2 cm proximal to the joint line provided improved fixation over one placed 3.5 cm above the joint line. In contrast, Miller and associates\(^\text{22}\) examined both screw and suture fixation in cadavers at 5 cm and 2.5 cm proximal to the joint line and found significantly increased holding strength at 5 cm over 2.5 cm. Recently, Kukreti and coworkers\(^\text{23}\) retrospectively evaluated the clinical and radiographic outcomes in two groups of patients: those who had a syndesmotic screw placed through the syndesmosis (2 cm from the plafond) and those who had a screw placed proximal to the syndesmosis (more than 2 cm but fewer than 5 cm above the plafond). They concluded that there was no significant difference between the two groups in clinical or radiographic outcome.

The issue of the number of cortices or the screw diameter continues to be debated. Proponents of three cortices argue that it provides greater physiologic motion, thereby, improving ankle biomechanics. This lends to reduced screw breakage. Those who favor four cortices, argue that four cortices are needed to provide rigid fixation for improved stability. Also, with screw breakage, removal is made easier by allowing access to the screw from both the medial and lateral

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**Figure 4** Clinical (A) and radiographic (B) examples of the Cotton test for determining syndesmotic stability intraoperatively.
sides. In a recent prospective, randomized study, Hoiness and Stromsoe24 demonstrated that fixation with two tricortical screws improved early function with less pain at 3 months than one quadricortical screw. No difference was noted after one year. No loss of fixation occurred in either group. Thompson and Gesink25 demonstrated that a 4.5 mm syndesmosis screw provided no biomechanical advantage over a 3.5 mm screw. In contrast, Hansen and colleagues26 demonstrated that a 4.5 mm quadricortical screw provided better fixation than a 3.5 mm quadricortical screw. Beumer and associates,27 in a biomechanical study, found no difference in fixation of the syndesmosis with three or four cortices; however, early weightbearing led to syndesmotic widening. In a prospective, randomized study of 120 patients, Moore and coworkers28 showed no difference in loss of reduction, screw breakage, or need for hardware removal when either three or four cortices of fixation were used, although there was a trend toward higher loss of reduction with tricortical fixation when patients were not compliant with weightbearing restrictions. Nousiainen and colleagues29 showed no difference in syndesmotic width, tibiotalar rotation, or ankle range of motion with either three or four cortices of purchase. Although different screw constructs do not appear to have any significant effect on overall outcome, anatomic reduction of the syndesmosis, regardless of technique used, is associated with a significant improvement in functional outcome.30

The need for screw removal is another question that has remained unanswered. Biomechanical studies demonstrate that the distal tibiofibular joint is dynamic. Scranton and associates31 showed that in normal gait, the fibula moves distally 2.5 mm during stance and push off. Close32 demonstrated that there is 1 mm of mortise widening and 2° of fibular external rotation during ankle dorsiflexion. Needleman and coworkers33 demonstrated in a cadaveric study that a 4.5 mm screw placed across four cortices decreased tibiotalar external rotation and anterior and posterior talar translation. They concluded that a syndesmosis screw should be removed prior to weightbearing, as resumption of full weightbearing and activity would cause fatigue fracture of the screws. However, in the previously referenced study by Moore and colleagues,28 regardless of whether three or four cortices were engaged, screws were not removed routinely. The group with three cortices of fixation had 8% hardware failure, while the four cortices’ group had 7% hardware failure. All were asymptomatic and no screws had to be removed. These investigators concluded that retention of syndesmotic screws, even with mechanical failure, does not pose a clinical problem.

With the thought that metallic syndesmotic screws could alter normal tibiofibular joint mechanics and a second operation would be required for removal of the screws, alternative techniques of syndesmosis fixation have been introduced more recently to avoid this issue. Bioabsorbable screws made of either polyglycolic acid or polylactic acid, or both, demonstrated sufficient fatigue and failure strength to allow syndesmosis healing with no loss of reduction in cadaveric and clinical studies.34-37 Other clinical studies have demonstrated no difference in pain, motion, duration of sick leave, or return to previous activity when comparing bioabsorbable to metallic syndesmosis screws.38,39 Thornes and associates40 introduced the utility of suture-endobuttons for syndesmosis fixation. They concluded that a suture endobutton was perhaps the ideal implant to stabilize the disrupted syndesmosis due to its strength to resist diastasis and allow early mobilization during healing, yet still allows physiologic micromotion of the tibiofibular joint. Routine removal is not required, but it is easily removed in the event of an infection. In a cadaveric study, Thornes and coworkers used the suture endobutton technique with No. 5 nonabsorbable, braided suture and showed no difference in the rate of failure, compared to a 4.5 mm cortical screw with four cortices of fixation.40 The suture technique gave more consistent results. Thornes and colleagues followed the cadaveric study with a retrospective study41 and demonstrated improved functional outcome scores, a faster return to work, and less pain at 3 and 12 months with the suture-endobutton compared to a metallic screw. No patients required a second operation for implant removal. They recommended this technique as the treatment of choice for patients with syndesmotic injuries.

Conclusion

While there are many different techniques available to stabilize the syndesmosis injury, the most important consideration in treating syndesmosis injuries associated with ankle fractures is the need for anatomic reduction and restoration of the distal tibiofibular relationship and ankle mortise, as this is the only significant predictor of functional outcome.30 In the face of an associated fibula fracture, restoring the fibular length is critical prior to syndesmosis fixation, as malreduction of the syndesmosis most commonly occurs due to inadequate restoration of the fibular length.42 Further study is required in order to determine the most appropriate type of syndesmotic stabilization given the associated injuries.

Disclosure Statement

None of the authors have a financial or proprietary interest in the subject matter or materials discussed, including, but not limited to, employment, consultancies, stock ownership, honoraria, and paid expert testimony.

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