

# The Syndesmosis, Part I

## Anatomy, Injury Mechanism, Classification, and Diagnosis



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### KEYWORDS

- Syndesmosis • Diagnosis • Syndesmotic injury • Classification • Advanced imaging
- Stress radiographs

### KEY POINTS

- The syndesmosis has a complex osseoligamentous anatomy.
- Although the deltoid ligament is not formally part of the syndesmotic complex, concomitant injury is common and can significantly influence mortise instability.
- Diagnosis, in the absence of fracture or radiographic diastasis, can be difficult.
- Obtaining a history of injury mechanism, thorough physical examination and judicious use of adjunctive imaging modalities, aid in proper diagnosis.
- Conservative treatment modalities can be effective and should be trialed when gross instability or diastasis is not present.

### INTRODUCTION

Ankle fractures are common injuries to the lower extremity, with approximately 20% sustaining a concomitant injury to the syndesmosis.<sup>1-4</sup> Supra-syndesmotic fibula fractures, when associated with a rotational injury mechanism, have an even higher incidence. In athletes, syndesmotic injuries account for up to 25% of ankle sprains with approximately 6500 syndesmotic injuries occurring yearly based on emergency room data.<sup>5-8</sup> Given the potential difficulties in diagnosis, the true incidence of syndesmotic injuries is likely higher than previously reported. Whether occurring with or without a concomitant fracture, syndesmotic injuries have prolonged recovery times<sup>9,10</sup> and increased potential for long-term sequela.<sup>10</sup>

If persistent diastasis or dynamic instability ensues, chronic pain and dysfunction are common and often require surgical intervention.<sup>11</sup> Malreduction has been demonstrated to result in poor outcomes.<sup>11-14</sup> Ray and colleagues<sup>14</sup> demonstrated the occurrence of symptomatic osteoarthritis within 7 years after injury in 11% of ankle fractures requiring syndesmotic fixation. Proper diagnosis and treatment is essential to allow for restoration of function and to avoid long-term complications.

### ANATOMY

The syndesmosis is constituted by the distal tibia, distal fibula and 4 ligamentous structures: the anterior inferior tibiofibular ligament (AITFL), posterior inferior tibiofibular ligament (PITFL),

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interosseous ligament (IOL), and interosseous membrane (IOM).<sup>15</sup> Although the deltoid ligament (DL) is not formally a part of the syndesmotom complex, it plays a key role in mortise stability and will be further discussed in this section.

### Osseous Anatomy

The osseous anatomy consists of the incisura tibialis that articulates with the distal fibula. The proximal apex begins where the lateral tibial ridge bifurcates 6 to 8 cm proximal to the plafond forming the anterior and posterior margins that terminate distally as Chaput's and Volkman's tubercles, respectively. Corresponding fibular anatomy matches the concave shape of the incisura tibialis. Chaput's tubercle is more prominent than Volkman's tubercle and overlaps the anterior fibula.<sup>15</sup> The anterior fibular tubercle (Wagstaff-Le Fort tubercle) is more prominent than the posterior fibular tubercle.<sup>15,16</sup>

Although the tibiofibular contact area can be variable in size, it has been shown to consist of articulating cartilage facets in 100% of cadavers examined.<sup>7,15,17</sup> The presence of articular cartilage and the known dynamic nature of the syndesmosis illustrates its importance for normal ankle kinematics. Furthermore, these facets may provide visual landmarks for syndesmotom reduction when undergoing surgery.<sup>15,17</sup> The syndesmotom recess is a synovial joint contiguous with the ankle joint and bordered anteriorly by the AITFL and superiorly by the IOM.<sup>7,17</sup> Contrast leakage proximal to this synovial cavity, such as seen during arthrogram performed for suspected injury, may indicate significant syndesmotom disruption.<sup>15</sup> Similarly, proximal migration of joint fluid as seen on T2 sequencing on either coronal or MRI imaging can give a similar appearance and may indicate syndesmotom disruption (Fig. 1).

Significant anatomic variation of the osseous articulation as described elsewhere in this article above and may influence predisposition to injury and risk of malreduction.<sup>15,18</sup> Additionally, significant anatomic variation of the incisura may make assessment of malalignment difficult even with axial advanced imaging.

### Ligamentous Anatomy

The trapezoidal-shaped AITFL consists of 3 to 5 fascicles and runs distolaterally from the tibia to the fibula.<sup>7,15</sup> An anomalous distal band called Bassett ligament can exist and may cause symptomatic ankle impingement.<sup>15</sup> The AITFL

contributes approximately 35% of the tensile strength of the syndesmosis.<sup>19</sup>

The PITFL has superficial and deep components and contributes approximately 42% of syndesmotom strength.<sup>19</sup> The superficial portion is trapezoidal with multiple fascicles converging distally.<sup>7</sup> The deep portion (sometimes called the inferior transverse ligament) has more dense fibers and a thicker, rounder shape.<sup>7,15</sup> The PITFL has a broad attachment on Volkman's tubercle. Given its tibial attachment, injury often results in an osseous avulsion rather than isolated rupture with rotational injuries.<sup>15</sup> Although posterior malleolus fracture morphology can vary,<sup>20</sup> the PITFL often remains largely intact according to MRI studies.<sup>21</sup> The PITFL's osseous attachments have important implications for posterior malleolar fixation affecting stability,<sup>22</sup> syndesmotom reduction,<sup>21</sup> and functional outcomes after ankle fractures.<sup>23</sup>

The IOL originates at the distal margin of the IOM. Biomechanical studies have demonstrated that the IOL contributes up to 22% of the strength of the syndesmosis.<sup>19</sup> The IOM lies between the lateral tibial ridge and the medial fibular ridge. Distally, it terminates as the IOL at the bifurcation of the tibial ridge of the incisura tibialis. Like the IOL, the IOM also seems to be loaded particularly during stance phase.<sup>14</sup> Although it contributes to syndesmotom stability, the IOM likely plays a lesser role compared with the other ligamentous components.<sup>19</sup>

Although not an anatomic component of the syndesmosis, the DL contributes directly to mortise stability and is often injured concomitant to the syndesmosis.<sup>9,24</sup> Approximately 50% of patients with DL disruption have an associated syndesmotom injury.<sup>24</sup> Masri-Pugin and colleagues<sup>25</sup> demonstrated that isolated DL disruption with or without sectioning of the AITFL did not render the syndesmosis unstable as assessed by Cotton testing. However, the syndesmosis became unstable if the DL was disrupted in combination with the AITFL and IOL. The same researchers demonstrated that isolated disruption of the AITFL and IOL was not enough to produce coronal instability.<sup>26</sup> Concomitant DL disruption may produce instability even in the presence of intact posterior structures.<sup>25</sup> Additionally, Goetz and colleagues,<sup>27</sup> using computed tomography (CT) imaging of loaded cadaveric specimens, demonstrated differences between instability patterns in the intact state, with isolated deep DL disruption, and with disruption of both the DL and syndesmotom ligaments. These and other investigations demonstrate the complex interplay between the DL in



**Fig. 1.** A 31-year-old woman with history of chronic syndesmotic injury. T2 coronal imaging demonstrates extravasation of ankle joint fluid proximally consistent with syndesmotic disruption.

the setting of concomitant syndesmotic injury as it relates to subsequent instability.

### MECHANISM OF INJURY

Syndesmotic injury typically results from supra-physiologic ankle external rotation.<sup>9,28</sup> Although a pronated foot position at time of injury has been postulated to lead to a higher incidence, syndesmotic injury can occur regardless of specific foot position.<sup>29</sup> Lauge-Hansen's mechanistic theory of ankle fractures postulated that a pronated foot puts the medial ankle ligamentous (DL) structures on tension, thus initially creating a medial-sided osseoligamentous disruption. As external rotation continues, the AITFL is disrupted followed by the posterior ligaments. Continued abnormal loading can result in disruption of the IOM and a suprasyndesmotic fibula fracture.<sup>3,25</sup> Syndesmotic injuries commonly occur during contact sports, which involve lateral movements and may be related to external foot constraint.<sup>9,10,30</sup>

### CLASSIFICATION

There have been several classification systems to describe syndesmotic injury. A simple

grading system, based on symptoms and radiographic findings, has been used most commonly.<sup>9,10,31–33</sup> Grade I injuries demonstrate a stable syndesmosis, mild symptoms, and normal radiographs indicating ligamentous sprain. Conservative treatment as described elsewhere in this article is recommended. Grade II injuries have partial syndesmotic complex disruption with variable instability. Provocative examination tests may be positive, but radiographic findings are normal and generally conservative treatment is trialed. Given the interplay of the DL, some authors consider concomitant DL disruption, as visualized on MRI, as an indication for surgical stabilization in the setting of grade II injuries.<sup>33</sup> Some patients with grade II injuries, either after a trial of conservative treatment and/or with other mitigating factors, may be candidates for earlier surgical intervention. In grade III injuries, the entire anterior and posterior syndesmotic complex is disrupted with clear malalignment on plain radiographs requiring surgical stabilization.<sup>9,33</sup>

### DIAGNOSIS

Subtle syndesmotic injuries can be difficult to diagnose, especially in the absence of fracture. This factor is compounded by a lack of consensus on criteria and variable reliability, sensitivity and specificity of diagnostic tests.<sup>28</sup> Although radiographic diastasis and gross instability on examination are obvious, careful history taking and physical examination may elucidate more subtle instability.

### History

Although patients may recall a specific injury mechanism predisposing to syndesmotic injury,<sup>28</sup> many are often unable to recount a definitive mechanism, in contrast with patients sustaining simple inversion injuries. A history of trauma during impact or collision sports should increase the suspicion for occult syndesmotic injury. Signs and symptoms may include pain above the ankle joint, functional instability, and/or a history of protracted recovery.<sup>33</sup> Patients with chronic syndesmotic injury, although outside the focus of this work, may complain of a pain, a giving way sensation, difficulty ambulating on uneven ground, stiffness, and/or limited dorsiflexion.<sup>34</sup>

### Physical Examination

In the acutely injured patient, either with or without a concomitant malleoli fracture, physical

examination may be limited in assessing syndesmotic disruption. Patients with syndesmotic disruption classically have tenderness above the ankle joint at the level of the AITFL. They may also have tenderness with palpation of the posterior syndesmosis and associated swelling.<sup>26,31</sup> Tenderness along the entire lower leg is common with advanced disruption. Compartment syndrome should always be ruled out.

Several clinical tests have been described, mainly for patients without ankle fracture, albeit with variable sensitivity, specificity, and reliability.<sup>28,33</sup> Although they are described elsewhere in this article, these tests may be more applicable to patients without fracture. In the acutely traumatized patient, ensuring adequate neurovascular status and the absence of compartment syndrome takes priority. The external rotation stress test is performed by placing the ankle in a neutral position and externally rotating the foot with the knee flexed. Pain over the syndesmosis is considered a positive test. The dorsiflexion range of motion test involves passive ankle dorsiflexion with a positive test demonstrating reduced motion (as compared with the contralateral ankle) secondary to pain inhibition. The squeeze test is positive when proximal compression of the tibia and fibula causes pain distally at the syndesmosis. Despite these described maneuvers, Sman and colleagues<sup>28</sup> found low diagnostic accuracy of nearly all clinical tests. However, a positive squeeze test may be prognostic because it was associated with a longer time to return to sporting activities. The external rotation stress test and squeeze test both demonstrated high specificity but relatively low sensitivity for detecting injury when correlated with MRI findings. Furthermore, variable interobserver reliability has been demonstrated for most physical examination tests. As such, providers should not solely rely on physical examination to diagnose syndesmotic injury.

## IMAGING

### Plain Radiographs

Initial radiographic evaluation, especially in the acute trauma setting, should include non-weight-bearing anteroposterior (AP), mortise, and lateral views of the ankle. Weight-bearing radiographs are preferred when a malleoli fracture is ruled out. AP and lateral tibia-fibula radiographs may be required to rule out a Maisonneuve injury. Given known anatomic variability, bilateral imaging is helpful especially in cases of subtle instability. Normal parameters include

(1) tibiofibular clear space (TFCS) of less than 5 mm or less than 44% of the fibular width on AP and mortise views; (2) medial clear space of no more than 4 mm or less than 2 mm than the contralateral side; and (3) tibiofibular overlap of more than 5 mm or more than 24% of the fibular width on AP and more than 1 mm on mortise view.<sup>35</sup> These parameters are measured 10 mm above the ankle joint line. Choi and colleagues<sup>36</sup> described preoperative findings associated to syndesmotic injuries in 191 patients with supination external rotation ankle fractures. The cutoff values for predicting unstable syndesmotic injuries were medial joint space of greater than 4.5 mm and fracture height of greater than 7 mm. Fracture height was defined as the vertical height between the distal tibial articular surface and the most inferior point of the fracture line of the lateral malleolus. Although some patients may not demonstrate more than 1 mm of tibiofibular overlap on the mortise view secondary to anatomic variation, any lack of overlap should be considered a syndesmotic injury unless proven otherwise (Fig. 2).

Standard techniques to assess syndesmotic instability under stress radiographs are (1) stress the fibula in external rotation, (2) lateral stress test (Cotton) by applying a laterally directed force over the fibula, and (3) sagittal stress test by applying an anterior/posterior directed force over the fibula.<sup>37</sup> An external rotation test and sagittal stress testing can be performed during clinical assessment, but the Cotton test is an intraoperative assessment. Studies have shown that the Cotton test may be superior to external rotation testing. Jiang and colleagues<sup>38</sup> demonstrated that the Cotton test produced significant



**Fig. 2.** An 18-year-old man status post-twisting injury while skiing. Mortise view of ankle radiographs demonstrates no tibiofibular overlap suspicious for syndesmotic injury. Stress fluoroscopy was subsequently performed, which demonstrated gross instability.

widening of the TFCS and medial clear space in the presence of IOM disruption. Likewise, Stoffel and colleagues<sup>39</sup> showed in a cadaveric study that the TFCS was more than 5 mm in 86% of specimens on the lateral stress test for Weber C injuries. Both studies demonstrated that the external rotation stress test is a poor indicator of syndesmotic disruption in the setting of associated DL injury. The use of radiostereometry for the external rotation test has shown fibular displacement after syndesmotic injury in the rotational plane,<sup>40</sup> which limits the usefulness of external rotation stress test with traditional radiographs. More recently, the role of sagittal stress testing has been studied. Lateral imaging seems to have greater sensitivity than mortise views in identifying syndesmotic injuries. LaMothe and colleagues<sup>37</sup> demonstrated that sagittal displacement of the fibula was twice as sensitive as compared with applied loads in coronal motion.

Although stress radiographs have proven helpful, there are several limitations described to their use. Coronal (and to a certain extent sagittal) stress maneuvers are difficult to perform in the clinical setting given the need to apply a mechanical force on the fibula directly. This factor limits its role in the diagnosis of subtle injuries. Additionally, the lack of consistency in position and interobserver reliability when defining stability may make the test less clinically useful. Lui and colleagues<sup>41</sup> compared intraoperative stress radiographs and ankle arthroscopy for the evaluation of syndesmotic injury in acute ankle fractures. They found that 30% of cases had positive stress radiographs as compared with 66% with positive arthroscopic findings for syndesmotic injury. Furthermore, Marmor and colleagues<sup>42</sup> showed in a cadaveric study that intraoperative fluoroscopy could not adequately detect rotational syndesmotic malreduction. Although plain radiographs should be part of the initial evaluation of the traumatized ankle, they may not be sensitive enough to detect subtle syndesmotic injuries as a sole diagnostic test.<sup>43</sup>

### Computed Tomography Scans

Syndesmotic instability and malalignment is a multidimensional condition that affects the joint in the coronal, sagittal, and axial planes. CT scanning is a diagnostic tool that offers anatomic assessment in a multiplanar manner including 3-dimensional reformatting. A weight-bearing CT (WB-CT) scan adds the advantage of a more dynamic, physiologic evaluation allowing assessment in the standing position. Malhotra and

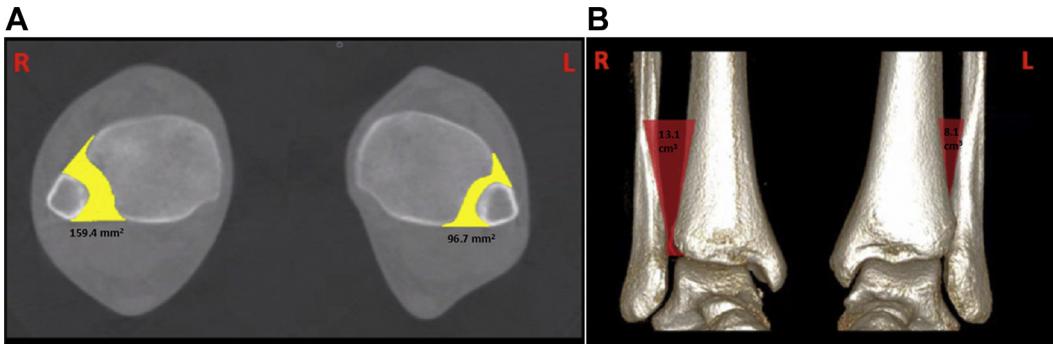
colleagues<sup>44</sup> compared supine and WB-CT images, demonstrating that the fibula translates laterally and posteriorly with external rotation in relation to the incisura in the standing position. This demonstrates potential enhanced benefit to WB-CT scans. Additional advantages include relatively low radiation exposure and reproducibility of measurements in less time by the use of automatic measurements that are generated by the device.<sup>45</sup>

There are several measurement methods described to assess the integrity of the syndesmosis on CT scan (Table 1). Lee and colleagues<sup>46</sup> evaluated the parameters to predict unstable syndesmotic injury in ankle fractures using a CT scan. They found that the syndesmotic area at 1 cm above the tibial plafond was the most reasonable parameter to predict syndesmotic injury (Fig. 3A). They described that a syndesmotic area 1.56 times larger than the contralateral side indicates a high possibility of injury. Abdelaziz and colleagues<sup>47</sup> also described that the syndesmotic area demonstrated the highest interobserver (0.96) and intraobserver agreement (>0.92) when assessing patients with unstable syndesmotic injuries. Similar results were found for fibular rotation with an interobserver and intraobserver reliability of 0.84 and more than 0.8, respectively. Volumetric measurements have recently been described. Bhimani and colleagues<sup>48</sup> reported WB-CT volumetric areas of the distal tibiofibular joint from the tibial plafond to 3 cm, 5 cm and 10 cm proximally. The authors found all volumetric measurements were significantly larger on the injured side as compared with the contralateral uninjured side (Fig. 3B). Volumetric analysis may be more accurate than previously used parameters.

Several authors have recommended obtaining bilateral ankle CT scans, especially in cases of subtle instability, given known significant anatomic variability of the syndesmosis.<sup>49,50</sup> Patel and colleagues<sup>51</sup> described reference values for the normal tibiofibular syndesmosis using WB-CT scans. In this retrospective review, the authors found that the upper limit of lateral translation in uninjured subjects was 5.27 mm, and the AP translation ranged between 1.48 mm and 3.44 mm anterior and posterior, respectively. There was no difference between the right and the left ankle, but men had significantly more lateral fibular translation. Likewise, Carrozzo and colleagues<sup>52</sup> showed that patients with a preoperative bilateral CT scan had better clinical outcomes and restoration of the tibiofibular joint anatomy as compared with those who

Table 1 Description of measurement methods in for syndesmotoc injury		
Method	Description	Definition of Injury
Anterior distance	Distance between the most anterior point of the fibula to the tibial border of the incisura in a line perpendicular to the fibular orientation line. <sup>a</sup>	
Posterior distance	Distance between the most posterior point of the fibula to the tibial border of the incisura in a line perpendicular to the fibular orientation line. <sup>a</sup>	
Middle distance	Distance between the most central point of the incisura and the nearest point of the fibula.	
Anterior tibiofibular tangential angle	The angle between the tangent to the anterior tibial surface at its most anterior point and the bisection of the vertical midline of the fibula.	
Tibiofibular line	A straight line placed along the anterolateral cortex of the fibula. The distance from the line to the anterior tubercle of the tibia determines syndesmotoc instability.	Value $\geq 2$ mm
Fibular sagittal translation	The distance between a line representing the direct anterior difference and the anterior border of tibial incisura.	Positive when the fibula is posterior to the anterior border of incisura
Syndesmotoc area	The space between the lateral cortex of the tibial incisura, the medial cortex of the lateral malleolus, and 2 lines tangential to the anterior and posterior aspects of the tibia and fibula.	
Syndesmotoc volume	Defined as the syndesmotoc area spanning from the joint line to 5 cm proximally.	An absolute volume $> 14 \text{ cm}^3$ or $> 6 \pm 1.9 \text{ cm}^3$ as compared with the contralateral ankle suggests syndesmotoc instability
Fibular rotation	Angle between a line drawn between the anterior and posterior borders of the incisura and a line drawn in the fibula representing its orientation.	Positive when the fibula is internally rotated relative to the incisura

<sup>a</sup> Fibular orientation line, sagittal line connecting the most anterior point of the fibula with its most posterior point.



**Fig. 3.** A 33-year-old woman with right syndesmotic instability after ankle dislocation with a syndesmotic area of 159.4 mm<sup>2</sup> (right) versus 96.7 mm<sup>2</sup> (left) (A). Image demonstrating syndesmotic volume up to 5 cm from the tibial plafond of 13.1 cm<sup>3</sup> (right) versus 8.1 cm<sup>3</sup> (left) using WBCT (B). R, Right side; L, Left side.

had a CT scan of the injured ankle only. The lack of established measurements to determine syndesmosis instability or appropriate postoperative reduction accurately, underscores the importance and utility of contralateral imaging to detect syndesmotic injury. Furthermore, while beyond the scope of this work, increasing research is being performed examining the accuracy and validity of current measurement techniques to assess syndesmotic alignment on axial CT imaging. Recently, Wellman and colleagues used bilateral lower extremity CT imaging and demonstrated an apparent 35% rate of syndesmotic malalignment in patients with asymptomatic ankles questioning the validity of common measurement techniques as well as previously reported rates of syndesmotic malalignment.<sup>53</sup> Despite apparent limitations of specific measurement techniques, bilateral CT affords excellent comparative imaging and WBCT may prove to be the best diagnostic test to determine syndesmotic malalignment.

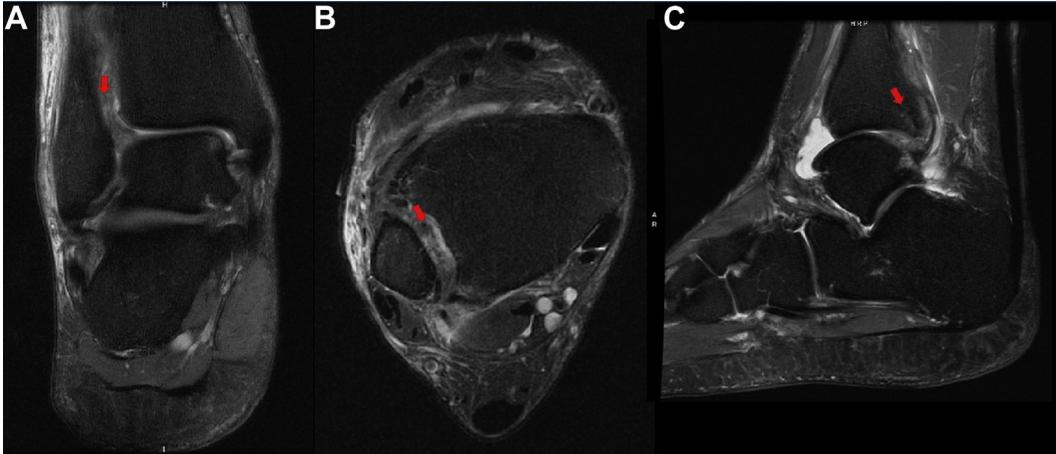
### MRI

Magnetic resonance imaging allows assessment with a high degree of sensitivity and specificity.<sup>54,55</sup> Findings vary based on acuity of injury. In the acute setting, high T2 signal in the location of the syndesmotic ligaments (associated with a wavy appearance or irregular contour) suggests complete ligament tear (Fig. 4A, B). Posterior malleolus bone edema is associated with PITFL injury and has been described in up to 93% of cases in acute injuries but only 54% of chronic conditions (Fig. 4C).<sup>56</sup> The presence of fluid signal within the distal tibiofibular joint space is considered suggestive of syndesmotic injury.<sup>57</sup> When signaling extends more than 12 mm proximal to the plafond, an IOL injury is likely present.<sup>58–60</sup>

The MRI slice orientation plays an important role in diagnosis. Ligament fiber obliqueness can lead to a false positive diagnosis of syndesmotic injury particularly when assessing the AITFL in the axial plane. Hermans and colleagues<sup>59</sup> demonstrated that, in the axial plane, the AITFL seemed to be partly discontinuous in 31% and completely discontinuous in 69% of healthy ankles. Instead, with a 45° oblique orientation the AITFL seemed to be continuous in 88% and partially discontinuous in only 12%. Another use of MRI in patients with presumed syndesmotic injury is to determine the presence of associated injuries (ie, tendon injury, lateral ligament disruption, osteochondral lesions) that may require surgical treatment and can be addressed concurrently.

### Ultrasound Examination

Ultrasound examination is a readily available, low-cost test that offers dynamic evaluation of the distal tibiofibular joint. Ultrasound examination has the advantages of high-resolution imaging with no exposure to radiation. Particularly for the assessment of the ankle joint, it is recommended to use a high-frequency transducer of 15 to 18 MHz ( $\geq 10$  MHz) with a small footprint or transducer that allows for a more precise assessment.<sup>60</sup> During evaluation, the ankle ligaments should be slightly taut and are best evaluated in the long axis. The ankle is slightly inverted and the AITFL is identified in an oblique fashion from superomedial to inferolateral. Its normal thickness ranges from 2.6 to 4.0 mm and consists of multiple fascicles that can be confused with injury.<sup>61</sup> Fisher and colleagues<sup>62</sup> reported that TFCS widening of 6 mm or greater was diagnostic for syndesmotic injury in patients with supination–external rotation ankle injuries (Figs. 5 and 6). Although historically the greatest

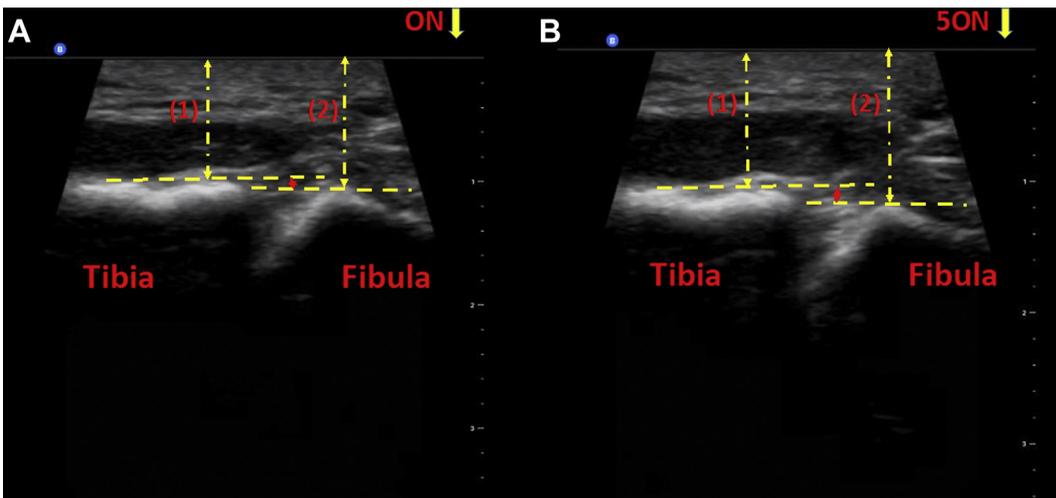


**Fig. 4.** A 40-year-old man with syndesmotic injury. Complete rupture of AITFL and IOL with irregular appearance (A & B, red arrow). Posterior malleolus bone marrow edema (C, red arrow).

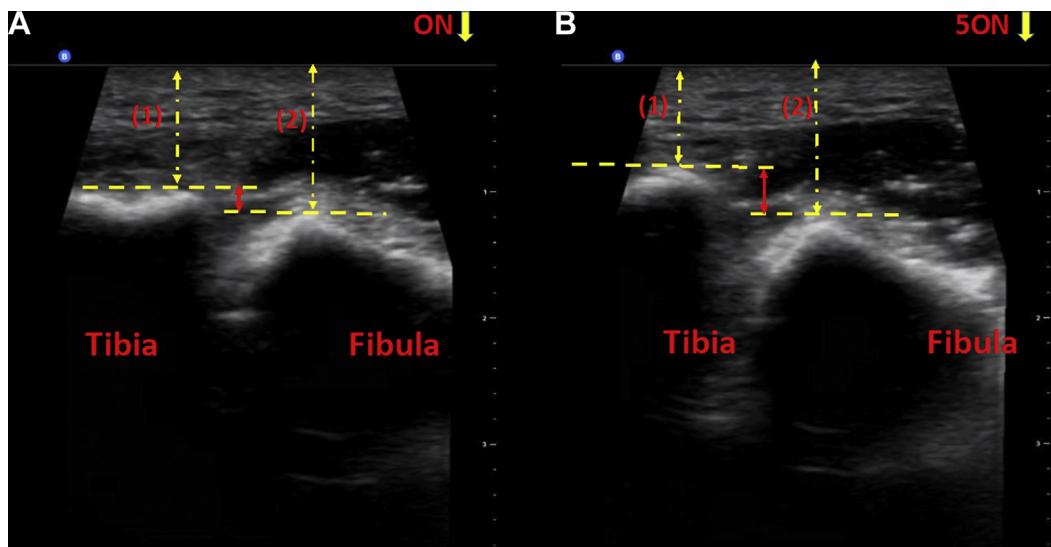
limitation of ultrasound examination has been that it is operator dependent, Hagemeyer and colleagues<sup>63</sup> described excellent intraobserver and interobserver agreement (intraclass correlation coefficient of  $>0.8$ ) in dynamic stress ultrasound examination when evaluating the syndesmosis. These findings highlight the ability of the test to diagnose syndesmotic injury, making it a viable alternative in patients with contraindications to other diagnostic tests as MRI or CT scan. Given its multiple advantages, increased familiarity and use among orthopedic surgeons may increase the use of ultrasound examination in diagnosing syndesmotic injury.

#### ARTHROSCOPIC AND INTRAOPERATIVE EVALUATION

Although a more comprehensive description of intraoperative evaluation is described in the article, we briefly include the use of arthroscopy and other modalities here given their diagnostic capabilities. Arthroscopy has hitherto been described as the gold standard in diagnosing subtle syndesmotic instability because it allows for the direct visualization of the distal tibiofibular articulation under an applied stress. Its invasive nature generally limits its use to scenarios in which there is a high index of clinical suspicion and/or if a



**Fig. 5.** Fibular translation measurements on ultrasound images under manually applied sagittal force from anterior to posterior direction in intact stage. (A) Under 0 N force. (B) Under 50 N of posteriorly directed force. (1) Distance from the ultrasound probe to the tibial osseous structure closest to the probe. (2) Distance from the ultrasound probe to the hyperechoic fibular osseous structure closest to the probe.



**Fig. 6.** Fibular translation measurements on ultrasound images under manually applied sagittal force from anterior to posterior direction after AITFL + OIL + PITFL transection. (A) Under 0 N force. (B) Under 50 N of posteriorly directed force. (1) Distance from the ultrasound probe to the hyperechoic tibial osseous structure closest to the probe. (2) Distance from the ultrasound probe to the hyperechoic fibular osseous structure closest to the probe.

patient is undergoing an operative procedure for concomitant pathology. Syndesmotic instability can readily be evaluated in the coronal and sagittal plane; rotational instability of the fibula can also occur, but is more challenging to visualize arthroscopically.

To assess coronal plane instability, the Cotton test is performed approximately 5 cm above the ankle joint with 100 N of force. This force value is based on cadaveric findings that forces greater than this amount do not result in an increased diastasis.<sup>39</sup> Other maneuvers such as external rotation tests may preferentially stress the DL.<sup>38</sup> Coronal plane measurements should be performed at the posterior one-third of the incision rather than at the anterior one-third, where instability can be masked.<sup>39</sup> Although absolute values vary, a diastasis of more than 3 mm has been suggested as an appropriate threshold to detect subtle instability but avoid overdiagnosis.<sup>39</sup> The advantage of this threshold value is that it can be assessed using a probe size readily available in standard arthroscopy instrumentation sets.

Sagittal plane motion may be more sensitive than coronal plane diastasis in diagnosing syndesmotic instability.<sup>64</sup> To evaluate this factor, 100 N of force is applied 5 cm above the ankle joint in both an AP and posterior to anterior direction. Total fibular motion or more than 2 mm is not only suggestive of syndesmotic instability, but has demonstrated high sensitivity

and specificity (77.5% and 88.9%, respectively). Quantitative algorithms that incorporate both coronal and sagittal plane motion do exist and better reflect the 3-dimensional nature of syndesmotic instability, but are cumbersome to use in practice.<sup>27</sup>

Syndesmotic testing in the operating room can be performed by direct visualization or examination, radiography with or without stress evaluation, arthroscopic assessment, ultrasound examination, and/or intraoperative CT scan. Intraoperatively, it is important to continually assess instability and/or resultant stability after fixation.

## CONSERVATIVE TREATMENT

Patients with syndesmotic injury with no evidence of instability nor diastasis can be treated nonoperatively. Some studies have suggested that isolated injury to the AITFL with an intact DL should be managed conservatively. Patients with syndesmotic injury with diastasis and/or concomitant fractures should generally be treated surgically. Conservative treatment consists of 3 stages: (1) a period of immobilization, limited weightbearing, rest, ice, elevation, compression, anti-inflammatories and therapeutic modalities, (2) functional and proprioceptive rehabilitation with associated brace wear, progression to full weightbearing and activity modification, and (3) progressive return to play.<sup>65</sup>

Electric stimulation and massage has been demonstrated to be efficacious.<sup>33</sup> Doughtie and colleagues<sup>66</sup> in a survey study reported that the most important modalities for reducing recovery time after syndesmotic sprains in National Football League athletes were immobilization followed by corticosteroid injection, ice, and rest.

Syndesmotic injury and injury severity have been associated with significant prolonged recovery times and delayed return to play. Knapik and colleagues<sup>67</sup> reported a return to competition in 2 to 6 weeks after stable syndesmotic injuries in professional football players. Miller and colleagues<sup>68</sup> found that athletes with intact IOM had an average return to play of 12.6 days and those with an IOM injury had an average of 19.6 days. Likewise, the presence of heterotopic ossification after syndesmotic injury has been associated with higher rate of reinjuries, such as lateral ankle sprains and syndesmosis sprains.

Novel therapeutic modalities for conservative treatment of sport-related injuries have been described recently. However, the long-term impact is unknown and few comparative investigations exist. Dry needling is a relatively new procedure that involves using a needle to regulate trigger points.<sup>67</sup> Salom-Moreno and colleagues<sup>69</sup> described better functional outcomes after proprioceptive rehabilitation combined with dry needling compared with proprioceptive rehabilitation alone in patients with chronic lateral ankle instability. Blood flow restriction therapy is considered to assist in decreasing muscle atrophy and is increasingly being implemented for a variety of orthopedic conditions. In theory, this technique promotes protein synthesis through activation of the rapamycin complex (MTORC1) pathway via metabolic stress or muscle swelling.<sup>70</sup> Levels of growth hormone also have been seen to spike with blood flow restriction and low load training, which may facilitate collagen synthesis.<sup>71</sup>

There have been recent investigations into whether cortisone or platelet-rich plasma injections may improve symptoms. Periligamentous cortisone injections may in general be considered safe but only for short-term treatment and with limited application.<sup>72</sup> Local anesthetic injections have also been performed in high level athletes to assist with symptom relief with no significant known effects long-term. Platelet-rich plasma injections have limited data to date. Laver and colleagues<sup>73</sup> performed a randomized control trial using platelet-rich growth factors for high-level athletes with AITFL injury.

Athletes in the treatment group demonstrated a faster return to play from 41 days as compared with 60 days in the control group. Differences in residual pain also improved in the treatment group compared with the control. Similarly, Samra and colleagues<sup>74</sup> performed a level I investigation examining the role of platelet-rich plasma for syndesmotic sprains in rugby players and found that the return to play was 20 days sooner in the platelet-rich plasma group than in the control group. Further research in the usefulness of biologics as an adjuvant therapy in the conservative treatment of syndesmotic injury is warranted.

## SUMMARY

The syndesmosis has a complex osseoligamentous anatomy and is commonly injured when associated with rotational ankle fractures. Even in the absence of concomitant fracture, syndesmotic injuries are common and likely underdiagnosed. Diagnosis, in the absence of radiographic diastasis, can be difficult. Obtaining a thorough history and physical examination as well as judicious use of adjunctive imaging modalities aid in diagnosis. Proper and timely diagnosis is critical in initiating appropriate treatment and optimizing outcomes. Conservative treatment modalities can be effective and should be trialed when surgery is not indicated.

## CLINICAL CARE POINTS

- The clinician cannot rely on a single test to diagnose syndesmotic injury. The clinical diagnosis should comprise clinical history with physical findings.
- Given the anatomic variability of the syndesmosis, imaging of the contralateral ankle provides very valuable information, especially in absence of fracture or frank diastasis.
- Stress radiographs can be difficult to perform in the clinical setting and they are not easily reproducible given the wide variation of the technique.
- Weight-bearing CT is a diagnostic tool that offers a dynamic and three-dimensional evaluation of the syndesmosis.
- Magnetic resonance imaging has a high sensitivity for acute syndesmotic injury and is useful to determine the presence of associated injuries.

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