Treatment of Syndesmosis Disruptions With TightRope Fixation

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ABSTRACT
Open reduction and screw fixation is the current standard treatment for displaced injuries of the ankle syndesmosis. Despite reduction and stable internal fixation, however, these injuries do not uniformly have excellent outcomes. In addition, screw fixation has potential disadvantages. The objective of this article was to provide an overview of the important anatomical and biomechanical issues relating to syndesmosis injuries and to present the surgical technique and potential advantages of fixation with the TightRope implant (Arthrex Inc, Naples, Fla). The short-term results of an ongoing prospective, randomized clinical trial are also presented.

Keywords: syndesmosis injuries, Weber C fractures, ankle biomechanics, TightRope fixation.

HISTORICAL PERSPECTIVE
The tibia and fibula are connected distally by the syndesmosis to provide a tight mortise for the talar dome. Ogilvie-Harris et al showed in a cadaver study that the posterior inferior tibiofibular ligament contributes 40% of the strength of the syndesmosis, with the anterior inferior tibiofibular ligament providing 35% and the interosseous ligament providing 21%. Isolated transection of the anterior tibiofibular ligament results in a 2.3-mm increase in translation of the talus. The biomechanics of the distal tibiofibular syndesmosis are of utmost importance. With ankle dorsiflexion, the distal fibula undergoes 2 to 5 degrees of external rotation and moves proximally 2 to 4 mm and posteriorly 1 to 3 mm. The movements are reversed with stance and plantarflexion. Beumer et al confirmed using radiosteometry that, when an external rotation force is applied to the ankle, the fibula externally rotates and translates posteromedially 2 to 5 mm.

Any disruption of the ankle mortise can lead to a significant dysfunction of the mechanics of the joint, and a missed, unstable injury to the ankle syndesmosis can result in rapid joint degeneration. In November 2006, Lloyd et al confirmed the results of the earlier study of Ramsey and Hamilton by demonstrating that as little as 1 mm of lateral shift of the talus in the ankle mortise resulted in a 40% loss of tibiotalar contact surface area. Taser et al showed using computed tomographic (CT) scans that a 1-mm separation of the syndesmosis can lead to a 43% increase in ankle volume.

The syndesmosis is disrupted when an external rotation torque is applied to the ankle. In most cases, a pronation/external rotation injury occurs when an external rotation force is applied to the leg with the foot firmly planted. This results in either a pure ligamentous injury or, more commonly, a syndesmosis disruption distal to a spiral fracture of the fibula. A proximal fibular fracture with an intraosseous ligament tear (Maisonneuve injury) may be missed if the proximal fibula is not examined.

Open reduction and screw fixation is the current standard treatment for displaced injuries of the ankle syndesmosis. Despite reduction and stable internal fixation, however, these injuries do not uniformly have excellent outcomes. One possible source of poorer results is nonanatomic reduction. Gardner et al reported that, even in a level I trauma center, there was a 52% incidence of malreduction of the tibiofibular syndesmosis in Weber C ankle fractures treated with screw fixation, and malreduction has been demonstrated to be an independent predictor of poorer outcome measures.

Even when the reduction is anatomic, however, screw fixation has potential complications that may adversely affect outcomes. Rigid screw fixation eliminates most, if not all, of the normal tibiofibular motion described above, potentially resulting in pain or decreased motion. In addition, symptomatic hardware failure, or routine screw removal to avoid it, necessitates exposing the patient to a second operation.
The TightRope implant (Arthrex Inc, Naples, Fla) consists of a preassembled fiber wire and 2-button construct. A no. 5 fiber-wire suture is woven between an Endobutton and a round button, resulting in 4 bridging strands of suture. Stainless steel and titanium versions are available (Figs. 1A, B).

The principle of the TightRope is that it will maintain reduction of the syndesmosis while allowing some rotational, proximal-distal, and anterior-posterior motion of the fibula with respect to the tibia.

**CLINICAL EXAMINATION**

In an acute ankle syndesmosis injury, pain and inability to weight bear are typical complaints. The pain and swelling are higher on the ankle than the more common inversion lateral ligament sprain.

Special tests have been described to assess a syndesmosis injury. These include the Hopkins (squeeze) test, external rotation under stress, palpation test, and compression of the syndesmosis with maximum dorsiflexion.14,15 A positive external rotation stress test, pain when applying an external rotation force to the midfoot area with the knee and ankle at 90 degrees, is the most reliable. The squeeze test, or Hopkins test, has proved to be the least valuable. An alternative diagnostic test requires the patient to stand on the affected leg and rotate the pelvis toward the opposite side, applying an external rotation torque to the affected ankle. This test may be more sensitive for lesser degrees of injury, but it has not been formally studied.

**IMAGING STUDIES**

Weight-bearing anteroposterior (AP), lateral, and mortise views of both ankles should be obtained. Patients with proximal fibula tenderness should also have AP and lateral views of the entire lower leg.

![FIGURE 1. A and B, The TightRope system.](image1.png)

![FIGURE 2. A and B, Anteroposterior and lateral views of a severe fracture dislocation of an ankle with obvious syndesmosis disruption.](image2.png)
Beumer et al.\(^1\)\(^6\) showed that the clear space and fibular overlap are the most valuable radiographic signs of syndesmosis injury. The clear space is defined as the area created between the lateral cortex of the tibia and the medial cortex of the fibula at 1 cm above the joint line. A clear space of more than 6 mm indicates a syndesmosis injury. A widened medial joint space is suggestive of an associated deltoid ligament injury (Figs. 2A, B).

In cases where the plain imaging is not definitive, but clinical history and examination are strongly suggestive of syndesmosis injury, further imaging may be required. Computed tomographic scans and magnetic resonance imaging scans may be of value in these more subtle cases. In addition, radiographic evaluation under anesthesia can be a valuable final test. On a mortise view, an external rotation force is applied to the ankle. If there is opening of the syndesmosis compared with the contralateral side, the diagnosis is confirmed.

**INDICATIONS AND CONTRAINDICATIONS**

Any unstable syndesmosis injury requires fixation. Non-operative treatment is reserved for subtle injuries with minimal opening noted only on stress imaging.

TightRope fixation is indicated for both isolated syndesmosis injuries as well as those associated with distal fibula fractures, if the fracture is treated with plate fixation.

TightRope fixation is not indicated for isolated treatment of Maisonneuve fractures. The TightRope will not prevent the fibula from migrating proximally at least a few millimeters. If the fracture is too high to immobilize with a plate, one should consider conventional screw fixation either alone or in combination with TightRope fixation. When used in combination with a TightRope, the screw could be removed after fracture healing, usually 6 weeks.

**TECHNIQUE**

The surgical technique for TightRope fixation of a syndesmosis injury is similar to that for screw fixation. If there is an associated fibula fracture, it should be reduced, and fixation placed as indicated by the fracture pattern. The titanium TightRope implant should be used with titanium implants, and the stainless steel TightRope should be used with stainless steel implants. In cases of syndesmosis diastases without fracture, 1 or 2 TightRopes can be used, depending on the instability pattern. It is advisable to use two in most cases.

**FIGURE 3.** It is important to have an anatomic reduction of the syndesmosis before applying fixation. The reduction is held with a large reduction clamp.

**FIGURE 4.** Fifteen months after an open reduction and fixation of the fracture. TightRope fixations were used through the bottom holes of the plate. Excellent restoration of the ankle mortise.
In view of the reported difficulty in achieving an accurate reduction of the syndesmosis, it is often advisable to do the reduction under direct visualization. In the case of an isolated syndesmosis injury, the TightRope can be placed percutaneously if adequate reduction is confirmed with multiple fluoroscopy views. When fracture fixation is necessary, the syndesmosis is exposed by dissection, anteriorly over the fibula at the time of the open reduction. In either case, care is taken to accurately reduce the fibula into the incisura, achieving both adequate apposition and correct rotation. A large bone clamp is then placed around the ankle to compress the syndesmosis and maintain the reduction (Fig. 3).

The 3.5-mm drill included in the TightRope system is used to drill a hole across the syndesmosis from lateral to medial. The ideal placement for the distal TightRope is 1 to 2 cm above the ankle joint line. When a second TightRope is used, it is placed 2 cm more proximal. When plate fixation is used on the distal fibula, one or more of the screw holes can be used for the TightRope.

The TightRope is attached to a long needle that is passed from lateral to medial through the drill hole. The needle is advanced through the skin, and the Endobutton is followed with fluoroscopy as it passes medially. Once the Endobutton passes through the medial cortex of the tibia, it is flipped by releasing pressure on the needle medially and pulling on the fiber-wire suture medially. This places the Endobutton flat against the medial cortex. The button must lay flat against the bone without any soft-tissue interposition to avoid later loosening of the construction. With the reduction clamp left in place, the 2 ends of the fiber wire are now tensioned on the lateral side to load and compress the medial and lateral buttons and maintain reduction of the syndesmosis. Tension is maintained by tightly knotting the fiber wire over the lateral button.

**Postoperative Management**

Postoperatively, patients are placed in a short-leg cast or splint and are non-weight bearing for 2 weeks. After 2 weeks, the splint is removed, and a pneumatic cam boot is applied. The boot is worn for activities of daily living, but some low-impact activities, including biking (with minimal resistance), pool walking, and swimming, may be performed without the boot. At 6 weeks, weight-bearing AP, lateral, and oblique radiographs of the ankle are obtained. If the syndesmosis appears stable and any associated fractures are healed, patients can wean out of the cam boot and advance their activities to include straight-line walking, jogging, and running. Cutting activities are usually delayed for 3 months, but this may be adjusted where recovery is quicker or slower than expected. All patients are advised to use a lace-up ankle brace when playing sports for the first 6 months after surgery.

**RESULTS**

In 2005, Thornes et al.\(^{17}\) published a consecutive series of patients treated with an early version of a suture-button implant and compared them with an earlier cohort treated with traditional screw fixation. The patients in the suture implant group all maintained their reduction and demonstrated significantly better American Orthopaedic Foot and Ankle Society (AOFAS) scores at 3 and 12 months and an earlier return to work than the screw fixation group. In addition, 12 of the 16 patients

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**TABLE 1. AOFAS Ankle and Hindfoot Scale Scores**

<table>
<thead>
<tr>
<th></th>
<th>A. Screw fixation Preoperative (n = 8)</th>
<th>6 mo (n = 8)</th>
<th>12 mo (n = 8)</th>
<th>18 mo (n = 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>5 (0–20)</td>
<td>24 (20–30)</td>
<td>27.5 (20–40)</td>
<td>33 (30–40)</td>
</tr>
<tr>
<td>Function</td>
<td>9 (7–12)</td>
<td>34 (28–50)</td>
<td>38 (31–50)</td>
<td>44 (37–50)</td>
</tr>
<tr>
<td>Alignment</td>
<td>1 (0–5)</td>
<td>10 (10)</td>
<td>10 (10)</td>
<td>10 (10)</td>
</tr>
<tr>
<td>Total</td>
<td>15 (7–37)</td>
<td>68 (58–90)</td>
<td>75.5 (61–100)</td>
<td>87 (80–100)</td>
</tr>
</tbody>
</table>

B. TightRope fixation

<table>
<thead>
<tr>
<th></th>
<th>Preoperative (n = 8)</th>
<th>6 mo (n = 8)</th>
<th>12 mo (n = 8)</th>
<th>18 mo (n = 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>5 (0–20)</td>
<td>27.5 (20–40)</td>
<td>32.5 (20–40)</td>
<td>36 (30–40)</td>
</tr>
<tr>
<td>Function</td>
<td>9 (7–12)</td>
<td>38.5 (33–50)</td>
<td>42.7 (37–50)</td>
<td>48 (43–50)</td>
</tr>
<tr>
<td>Alignment</td>
<td>1 (0–5)</td>
<td>10 (10)</td>
<td>10 (10)</td>
<td>10 (10)</td>
</tr>
<tr>
<td>Total</td>
<td>15 (7–37)</td>
<td>76 (63–100)</td>
<td>85.2 (65–100)</td>
<td>94 (82–100)</td>
</tr>
</tbody>
</table>

Values in the parentheses are ranges.

**TABLE 2. Range-of-Motion Measurements**

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Syndesmosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROM with TightRope</td>
<td>6 mo (n = 8)</td>
<td>DF = 12 (6–25)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PF = 57 (43–85)</td>
</tr>
<tr>
<td></td>
<td>18 mo (n = 5)</td>
<td>DF = 12 (6–226)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PF = 58 (44–84)</td>
</tr>
<tr>
<td>ROM with screws</td>
<td>6 mo (n = 8)</td>
<td>DF = 12 (2–25)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PF = 55 (40–82)</td>
</tr>
<tr>
<td></td>
<td>18 mo (n = 5)</td>
<td>DF = 10 (2–25)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PF = 55 (42–80)</td>
</tr>
</tbody>
</table>

Values in the parentheses are ranges. ROM indicates range of motion; PF, plantarflexion; DF, dorsiflexion.
in the screw fixation group underwent implant removal, compared with none in the suture fixation group.¹⁷

We are currently conducting a prospective, randomized study comparing traditional screw fixation of syndesmosis injuries to fixation with the TightRope implant. The study includes all syndesmosis injuries, with or without ankle fractures. Any associated ankle fractures are being treated in a conventional manner in both groups (Fig. 4).

Evaluation is being performed with clinical examination, radiography, AOFAS ankle and hindfoot scale, visual analog scale, and a functional questionnaire.

The average follow-up at this point is 18.5 months (range, 12–28 months), and there are 8 patients in each group with at least 1 year follow-up. Although these are only short-term results, in the patients with a minimum follow-up of 1 year, the AOFAS ankle and hindfoot score for the TightRope group is 94 (range, 82–100)

**FIGURE 5.** A, A typical Weber C fracture pattern as well as a medial joint space widening. B, Conventional fibula fixation with the use of a TightRope for syndesmosis fixation.

**FIGURE 6.** A, A CT scan showing perfect reduction of the fibula in the tibial incisura with a TightRope fixation. B, A CT scan showing rotational malpositioning of the fibula after screw fixation of the syndesmosis.
compared with 88 (range, 80–100) in the screw fixation group (Table 1).

At this point in the study, the patients in the TightRope group have also demonstrated better objective range-of-motion measurements and subjectively reported less stiffness and discomfort (Table 2).

At this early stage, patients receiving TightRope fixation seem to have results at least equal to those with conventional screw fixation. There is a trend toward increased ankle motion in the TightRope group, suggesting that a potential advantage of that device is that it allows for more normal motion in the syndesmoses complex (Figs. 5A, B).

Complications at this point in the screw fixation group include 1 broken screw and 1 screw removal for prominent instrumentation. There was 1 infection in the TightRope group, which required removal of the implant after 6 months.

Although the early results are promising, there have been no published, prospective, randomized studies comparing screw versus TightRope fixation yet.

### POSSIBLE CONCERNS, FUTURE OF THE TECHNIQUE

Several potential concerns have been expressed regarding TightRope fixation of syndesmosis injuries.

There is a concern that TightRope fixation might be inferior to screw fixation in maintaining reduction of the mortise. Miller et al. demonstrated, in a cadaver model, that a construct with only 2 strands of no. 5 non–fiber-wire suture placed through bony tunnels was equivalent to a single 3.5-mm tricortical screw in resisting a distraction force at the mortise. A recent study showed, which also used a cadaver model of syndesmosis injury, demonstrated a significant increase in diastasis during external rotation stress in specimens stabilized with TightRope fixation compared with those stabilized with a 4.5-mm cortical screw across 4 cortices.

Although this is a legitimate concern, there are important differences between the study conditions and the clinical situation. First of all, in the clinical situation, external rotation force is avoided in the first 6 weeks to allow initial healing of the syndesmosis (Postoperative Management). In addition, use of 2 or more TightRopes may increase the rigidity of the construct while still maintaining tibiofibular motion. Further study will be needed in this area.

There is also a concern that, over time, the buttons might pull through the cortex, rendering the fixation useless. This is especially concerning when the medial button is placed against the metaphyseal cortex. Therefore, it is important to have at least one of the TightRopes through the thicker, more proximal cortical bone.

Finally, as discussed above, in the treatment of Weber C fractures, TightRope fixation must be accompanied by plate and screw fixation of the fibula to avoid proximal migration of the distal fibula.

Despite these concerns, TightRope fixation offers significant potential advantages over conventional screw fixation. Insertion of the device is simple, both in isolation and in combination with fixation of fibula fractures. Also, because the risk of screw failure is eliminated, the potential for a second operation for implant removal, including scheduled removal, is significantly reduced. In addition, due to the flexibility of the device, the fibula is pulled into the incisura of the tibia as it is tightened, potentially leading to an improved reduction of the syndesmosis (Figs. 6A, B).

Finally, TightRope fixation offers the potential of syndesmosis stabilization without eliminating normal tibiofibular motion. This may, in turn, lead to better objective ankle motion as well as a decreased subjective stiffness and discomfort.

### REFERENCES