# 67 Treatment of syndesmosis disruptions

**Contents**



## 67.1 Introduction

Open reduction and screw fixation is the current standard treatment for displaced injuries of the ankle syndesmosis.(1-4) Despite reduction and stable internal fixation, however, these injuries do not uniformly have excellent outcomes. There might be several reasons for that, including the mechanism of injury, method of fixation and quality of the reduction.

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. The injury force starts through either the medial malleolus or Deltoid ligament, travels laterally through the joint, tears the syndesmosis structures, and exits through the fibula. With a complete syndesmosis disruption the ankle joint is left unstable with significant negative consequence if not repaired. A proximal fibular fracture with an intraosseus ligament tear (Maissoneuve injury) may be missed if the proximal fibula is not examined.

## 67.2 Anatomy

The ankle syndesmosis is the joint between the distal tibia and distal fibula. Motion at this joint includes translation and rotation during tibiotalar dorsiflexion and plantar flexion accommodating the asymmetric talus while maintaining congruency. Three main structures provide stability at the syndesmosis: the interosseous tibiofibular ligament (IOL), the anterior inferior tibiofibular ligament (AITFL), and the posterior inferior tibiofibular ligament (PITFL).

The interosseous tibiofibular ligament represents the distal continuation of the interosseous membrane. At a level approximately 4-5 cm above the ankle joint, it forms a triangle with a lateral base and a medial apex. Inferiorly this forms the anterior inferior tibiofibular ligament which is separated from the interosseous ligament by a space. The posterior inferior tibiofibular ligament has a similar relationship. The bulk of the interosseous tibiofibular ligament ends 1-1.5 cm above the joint line at the upper margin of the distal tibiofibular joint.

The anterior inferior tibiofibular ligament forms three fascicles. The middle is the strongest and most prominent. These bundles arise in the vicinity of the anterior distal tibial (Chaput's) tubercle, and insert into the most anterior tubercle of the distal fibula. The superior bundle is proximal to the tubercles and the inferior bundle is distal to the tubercles. The middle bundle travels obliquely from Chaput's tubercle to the distal fibula at a 30° angle to the joint line.

The posterior inferior tibiofibular ligament has less distinct bundles and originates from the posterior tubercle of the tibia and attaches at the posterior tubercle of the distal fibula. The direction of the posterior inferior tibiofibular ligament is more horizontal than the AITFL.

With ankle dorsiflexion, the distal fibula will move proximally, posteriorly, and externally rotate (5)**.** Beumer et al (6) demonstrated by radiostereometry that an external rotation force will externally rotate the fibula and translate it postero-medially.

In a cadaver study, Ogilvie-Harris et al (7) showed the anterior inferior tibiofibular ligament to contribute 35% of the strength of the syndesmosis, the posterior inferior tibiofibular ligament 40% and the interosseous ligament 21%.

Any disruption of the ankle mortise can lead to 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 Ramsey and Hamilton's earlier study by demonstrating that as little as 1 mm of lateral shift of the talus in the ankle mortise resulted in a 40% loss of tibio-talar contact surface area (8). Taser et al (9) showed with CT scans that a 1 mm separation of the syndesmosis can lead to a 43% increase in ankle volume.

One possible cause of poor results after sydesmotic fixation is non-anatomic reduction. Gardner, Helfet et al reported that, even in a level 1 trauma center, there was a 52% incidence of malreduction of the tibiofibular syndesmosis in Weber C ankle fractures treated with screw fixation (10) and malreduction and that this has been demonstrated to be an independent predictor of poorer outcome measures (11).

# 67.3 Treatment of acute injuries

Takao et al (12) published the results of arthroscopic evaluations of tibiofibular syndesmosis disruption. In their report, they collected a total of 38 patients with Weber B type ankle fractures. Using AP and mortise radiography, they achieved a diagnosis of ankle syndesmosis disruption on 42% and 55% of cases respectively. With utilization of ankle arthroscopy, the percentage of diagnosis increased to 87%.

Tornetta (1) showed in a cadaver study that over-tightening of the intact fibula at the syndesmosis was hard to achieve. It is possible that a fractured fibula may prevent dorsiflexion if the fracture is not anatomic. Full dorsiflexion of the ankle during screw placement is therefore not required. Attention instead should be directed at making sure that the fibula is at proper length, correctly rotated, and reduced into the syndesmosis with no anterior, posterior, or lateral translation.

The most reliable way to assess reduction of the syndesmosis is by comparison to the opposite ankle after obtaining an AP, mortise, and lateral fluoroscopic or radiographic image. The parameters to analyze on the AP and mortise view are the tibiofibular clear space and the overlap of the fibula with the tibia at a level 1 cm proximal to the joint line. The lateral view helps to assess proper reduction of the fibula within the tibial sulcus. The fibula should have no increased anterior or posterior translation when compared to the non-injured side.

# 67.4 Screw placement, type, and technique

McBryde et al (2) in 17 paired cadaver limbs studied the best location for the syndesmosis screw, either at 2 cm or 3.5 cm from the joint line. A 3.5 mm self-tapping stainless steel cortical screw was used. The specimens were then tested to failure through an external rotation torque at 90 degrees per minute. They concluded that a screw located 2 cm proximal to the joint line provided better fixation than a more proximal one.

Thompson et al (13) studied the biomechanical difference between a 3.5 and a 4.5 mm stainless steel screw in cadavers. Three cortices were purchased. In the group with the 3.5 mm screw, five out of six specimens had the screw pull out. This is in contrast to the 4.5 mm screw group where the fibula fractured in five out of six specimens. The authors concluded that there was no biomechanical advantage to using a 4.5 tricortical screw for syndesmosis fixation instead of a 3.5 mm screw. No washers or plates were used in either fixation group.

Hoiness et al (3) followed up prospectively in a randomized population of 64 patients with the use of a single screw with 4 cortices versus 2 tricortical screws for instability of the syndesmosis. All but 3 syndesmosis injuries were related to ankle fractures. The minimum follow up was one year. Even though there was no clinical difference between the two groups at one year follow up, the authors still recommended the use of two tricortical screws as it related to improved early function.

Beumer et al (4) studied the biomechanical behavior of titanium versus stainless steel screws and crossing three versus four cortices of the ankle syndesmosis on a total of 16 fresh frozen cadavers. 225,000 cycles of axial load were applied through the ankle joint. Despite no fracture of bones or screws, they recorded widening of the syndesmosis of 1.05 mm.

Cox et al (14) studied the biomechanical behavior of 5.0 mm stainless steel screws versus PLLA-PGA bioabsorbable screws. Eight paired cadaver limbs were used. A cycling load protocol was applied followed by a test to failure. There was no difference in the mechanical behavior of the 5.0 mm bioabsorbable screw versus the 5.0 mm stainless steel screw. Mechanically a bioabsorbable screw is therefore a reasonable alternative.

# 67.5 Current Issue

Even when the syndesmotic reduction is anatomic, screw fixation has potential complications which may adversely affect outcomes. Rigid screw fixation eliminates most if not all of the normal tibio-fibular motion, potentially resulting in pain or decreased motion. Pereira showed that screw fixation limits the tibio-talar contact area throughout the range of motion of the ankle by locking the fibula and preventing the normal fibular motion (15). In addition, symptomatic hardware failure, or routine screw removal to avoid it, necessitates exposing the patient to a second operation.

To follow is a description of the following study:

**Abstract**

**Background**

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.

**Materials and Methods**
An ongoing prospective, randomized clinical trial comparing conventional screw fixation with TightRope R fiber wire fixation for syndesmosis injuries. The objective of this paper is also to provide an overview of the important anatomical and biomechanical issues relating to syndesmosis injuries.

**Results**
At medium term follow-up the TightRope R fiber wire fixation group had a statistically significant better range of motion compared to conventional screw fixation. The AOFAS ankle and hindfoot score did not show a significant difference between the two groups.

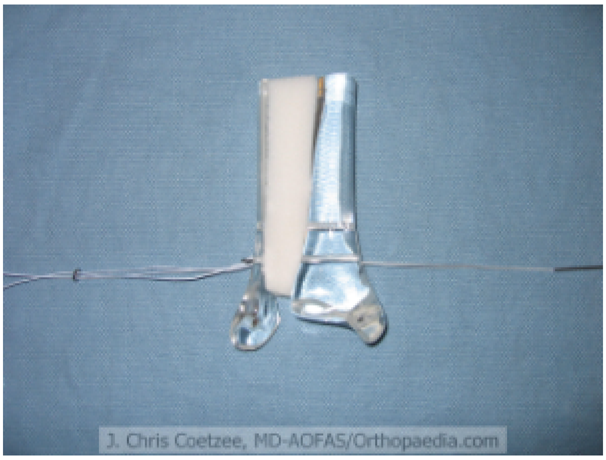


Figure 1: The TightRope system

# 67.6 Materials and Methods

Included in the study were all syndesmoses injuries less than one month old, with or without ankle fractures, in patients younger than 60 years old and a BMI less than 35.

Exclusion criteria included: 1) Age older than 60 (to avoid the potential, but unconfirmed problem of button pull-out in osteoporotic bone). 2. Diabetes needing medication. 3) Open fractures. 4) Multi-trauma. 5) Open growth plates

These patients were enrolled in a prospective, randomized clinical trial comparing traditional screw fixation to Tightrope Fiber wire (Arthrex Inc, Naples, FL, USA). Any associated ankle fractures were treated the same in both groups with conventional open reduction and internal fixation.

Evaluation was performed with clinical examination, radiography, AOFAS ankle and hindfoot Scale, visual analog scale and a functional questionnaire. The data was collected pre-op, at six and 12 weeks, 6 months, one year and then annually.

The GraphPad InStat software was used to do the statistical analysis for the study. The Mann Whitney test was used to get an unpaired two-tailed p value. A p value smaller than 0.05 was indicative of statistical significance.

**Surgical Technique**

The surgical technique for TightRope fixation of a syndesmosis injury was similar to that for screw fixation. If there was an associated fibula fracture, it was reduced and fixation placed as indicated by the fracture pattern.

For the purpose of the study we tried to limit the potential variables. In the screw fixation group all had two screws and all included 4 cortices. In the Tightrope group all but one had two Tightropes. All fibula fractures were treated with an ORIF. The reasoning behind that was to ensure adequate rotational correction of the fibula and also to prevent the potential but unconfirmed problem of superior migration/telescoping of the fibula in the Tightrope group. This meant that some of the midshaft fibula fractures that one will usually leave untreated required a plate fixation. Fibular fixation followed the standard AO principles in all cases. In a further attempt to limit variables, it was decided not to remove any screws unless a specific reason arose.

In view of the reported difficulty in achieving an accurate reduction of the syndesmosis, it was decided to do an open reduction of the syndesmosis even though it is potentially possible to do the procedure percutaneously in certain cases. The syndesmosis was exposed by dissection anterior over the fibula at the time of the open reduction and care was taken to accurately reduce the fibula into the incisura, achieving both adequate apposition and correct rotation. A large bone clamp was then placed across the ankle to compress the syndesmosis and maintain the reduction.


Figure 2: It is important have an anatomical reduction of the syndesmosis prior to applying fixation. The reduction is held with a large reduction clamp.

For the screw fixation group, the screw diameter was dependent upon the size of the fibula and ankle, and included 4.0 mm, 4.5 mm and 6.5 mm screws. The screws were inserted in the standard compression mode by overdrilling the fibula and underdrilling the tibia. The distal screw was placed 1-1.5 cm above the joint line, and the second screw 2-3 cm above the joint line. This was the same for the Tightrope placements. For the Tightropes, the 3.5 mm drill included in the TightRope system was used to drill a hole across the syndesmosis from lateral to medial. When a plate fixation was employed on the distal fibula, one or more of the screw holes could be used for the TightRope.

The TightRope needle was advanced from lateral to medial through the skin and the endobutton was followed with fluoroscopy as it passed medially. Once the endobutton passes through the medial cortex of the tibia, it was flipped by releasing pressure on the needle medially and pulling on the fiberwire suture laterally. This placed 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 construct. With the reduction clamp left in place, the two ends of the fiber wire were tensioned on the lateral side to load and compress the medial and lateral buttons and maintain reduction of the syndesmosis. Tension was maintained by tightly knotting the fiber wire over the lateral button.

**Postoperative Management**

The post-op protocol was the same for both groups. The patients were placed in a short leg cast splint and were kept non-weightbearing for two weeks. After two weeks, the splint was removed and a pneumatic Cam boot was applied. The boot was worn for activities of daily living, but some low impact activities, including biking (with minimal resistance), pool walking and swimming without kicking, were allowed without the boot if the wounds were fine. It was emphasized that there should be no external rotation force during the first six weeks, and weight was limited to 50 pounds. At six weeks, weightbearing AP, lateral, and oblique X-rays of the ankle were obtained. If the syndesmosis appeared stable and any associated fractures were healed, patients weaned out of the CAM boot and advanced their activities to include straight line walking, jogging and running. Cutting activities were delayed for 3 months, with some adjustment where recovery was quicker or slower than expected. All patients were advised to use a lace-up ankle brace when playing sports for the first 6 months after surgery.

# 67.7 Results

At this point there are 12 patients in each group with at least 18 month follow-up. No patients were lost to follow-up.
**Demographics: Table 1**

| | Screw Group | Tightrope Group |
|---|---|---|
| **Male** | 8 | 9 |
| **Female** | 4 | 3 |
| **Age** | 38 (18-55) | 35 (18-53) |
| **Weight** | 185 lbs (110-250) | 179 lbs (114-239) |

The complication rate in both groups was low. In the Tightrope group, one wire had to be removed at 6 months for ongoing irritation and superficial infection where a large suture knot rubbed on a tight fitting hockey skate. Similarly, one large fragment screw was removed due to the prominence of the screw head.

In the screw fixation group, one case a pure soft tissue disruption that was treated with 2 screws and a Deltoid repair, six required only a standard distal fibula plate and screw fixation and Deltoid repair, and five required medial malleolar fixation including one that required a mid-third fibula plate for a Massioneuve variant.

Two patients required more proximal fibular fixation, one at the middle third of the fibula and the second at the proximal third. There was also one patient that only required Tightropes, without any fractures. Seven of the 12 patients Tightrope patients required medial malleolar screws as well as a fibula plate. One of them was a revision of a failed fibula fixation that required a longer plate and 3 Tightropes.

The follow-up is still fairly short, but at a median 2.3 year follow-up there is no statistical difference in the AOFAS Ankle and Hindfoot score, even though there is a trend for the Tightrope group to do better. (P value 0.149 ) The AOFAS ankle and hindfoot score for the tight rope group was 94 (82 - 100) and the Screw fixation group was 88 (80 - 100).

**Table 2a. AOFAS Ankle And Hindfoot Score in the Screw Fixation Group**

| | Pre-op (n-12) | 6m (n-12) | 12m (n-12) | 27m (n-9) |
|---|---|---|---|---|
| **Pain** | 5 (0-20) | 24 (20-30) | 27,5 (20-40) | 33 (30-40) |
| **Function** | 9 (7-12) | 34 (28-50) | 38 (31-50) | 44 (37-50) |
| **Alignment** | 1 (0-5) | 10 (10) | 10 (10) | 10 (10) |
| **Total** | 15 (7-37) | 68 (58-90) | 75.5 (61-100) | 87 (80-100) |

**Table 2b. AOFAS Ankle and Hindfoot score in the Tightrope Group**

| | Preop (n-12) | 6 m (n-12) | 12m (n-12) | 27 m (n-8) |
|---|---|---|---|---|
| **Pain** | 5 (0-20) | 27.5 (20-40) | 32.5 (20-40) | 36 (30-40) |
| **Function** | 9 (7-12) | 38.5 (33-50) | 42.7 (37-50) | 48 (43-50) |
| **Alignment** | 1 (0-5) | 10 (10) | 10 (10) | 10 (10) |
| **Total** | 15 (7-37) | 76 (63-100) | 85.2 (65-100) | 94 (82-100) |

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. Range of motion was statistically significantly better in the Tightrope group (P value 0.054).

**Table 3**

**ROM with TightRope**

| | Normal | Syndesmosis |
|---|---|---|
| 6 months<br>N-12 | DF 12 (6-25)<br>PF 57 (43-85) | DF 7 (0-20)<br>PF 44 (29-80) |
| 18 months<br>N-12 | DF 12 (6-22)<br>PF 58 (44--84) | DF 11 (4-20)<br>PF 53( 37-80) |

**ROM with Screws**

| | Normal | Syndesmosis |
|---|---|---|
| 6 months<br>N-12 | DF 12 (2-25)<br>PF 55 (40-82) | DF 5 (0-12)<br>PF 39 (23-76) |
| 18 months<br>N-12 | DF 10 (2-25)<br>PF 55 (42-80) | DF 8 (2 - 20)<br>PF 43 (28-70) |


Figure 3: 15 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.

At this early stage, patients receiving TightRope fixation appear to have results at least equal to those with conventional screw fixation. There is 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. The patients in the tightrope group had better range of motion than the screw fixation and also subjectively less stiffness and discomfort.


Figure 4A: A typical Weber C fracture pattern as well as a medial joint space widening.


Figure 4B: Conventional fibula fixation with the use of two screws for syndesmosis fixation.

Complications thusfar in the screw fixation group include one broken screw and one screw removal for prominent instrumentation. There was one infection in the TightRope group which required removal of the implant after six months.

# 67.8 Discussion

The potential advantage of the fiber wire fixation is that it permits some of the normal rotation and proximal-distal motion of the fibula during the normal gait cycle. The literature about fiber wire fixation for syndesmoses injuries though is sparse.

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 (16) demonstrated that, in a cadaver model, a construct with only two strands of #5, non-fiberwire suture placed through bone tunnels was equivalent to a single 3.5 mm tricortical screw in resisting a distraction force at the mortise. A recent study, though, 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 to those stabilized with a 4.5 mm cortical screw across four cortices. (17)

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 (see post-op protocol above). In addition, use of two or more TightRopes may increase the rigidity of the construct while still maintaining tibio-fibular motion. Further study will be needed in this area.

There is also 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.

In 2005, Thornes et al published a consecutive series of patients treated with an early version of a suture-button implant and compared them to an earlier cohort treated with traditional screw fixation. The patients in the suture implant group all maintained their reduction and demonstrated significantly better 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 in the screw fixation group underwent implant removal, compared with none in the suture fixation group (18). This is a level 4 study with limited power. 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 the 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.

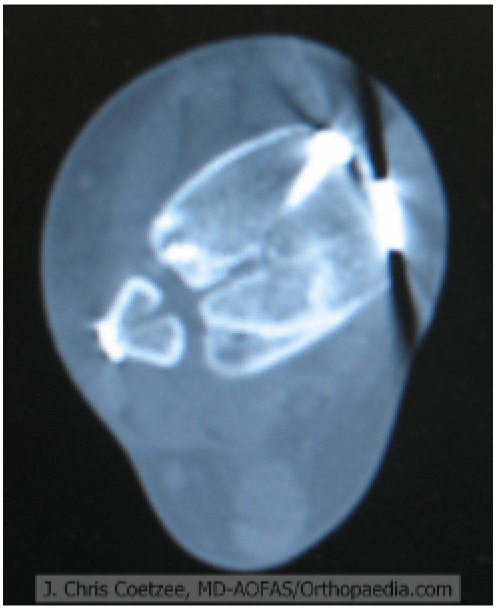


Figure 5: A CT scan showing perfect reduction of the fibula in the tibial incisura with a TightRope fixation.

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

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