

# Tightrope fixation of syndesmotic injuries in Weber C ankle fractures: a multicentre case series

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## Abstract

**Background** No general consensus has yet been established for the gold standard treatment of ankle syndesmotic complex injuries. Recent literature has documented the success of ankle tightrope fixation for heterogeneous ankle fracture patterns, resulting in syndesmotic complex injuries. We present a multicentre case series assessing the clinical, radiological and functional outcomes of patients with Weber C ankle fractures treated with the Arthrex TightRope<sup>®</sup> fixation system.

**Method** We performed a retrospective analysis of all adult patients with Weber C ankle fractures who were treated

with the Arthrex TightRope<sup>®</sup> fixation system at four centres over a 3-year period. All patients were followed up for a mean of 14 months (range 12–26). Outcomes measures were assessed subjectively using functional scores (AOFAS and Olerud and Molander) and objectively using radiological measurements, complication rates and revision surgery rates.

**Results** Thirty-six patients met our eligibility criteria. The mean age at operation was 31 years (range 18–65). There were 20 males and 16 females. No patients were lost to follow-up. The ankle tightrope maintained satisfactory reduction in the ankle mortise in 97% of cases. Of these 35 successfully treated cases, no evidence of re-displacement on follow-up radiographs of the syndesmotic complex was observed at an average of 10.8 months (range 6–12). Post-operative mean medial clear space was 3.1 mm, and mean tibio-fibular overlap was 10.1 mm. The mean American Orthopaedic Foot and Ankle Society (AOFAS) score was 88.8 (range 67–98) at a mean follow-up of 14 months (range 12–26). The overall complication rate was 6% (one failure requiring revision surgery and one medial sided skin irritation requiring removal of suture button). No infections or wound complications occurred.

**Conclusion** Tightrope fixation is a safe alternative to screw fixation for syndesmotic complex injuries in Weber C ankle fractures. We have shown that it has low complication rates and a high patient satisfaction.

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## Introduction

The presence of syndesmotom complex injuries following all ankle fractures has been reported to be 1 in 10 cases [1, 2]. The syndesmotom complex plays a key role in maintaining the ankle mortise. The ankle joint is particularly sensitive to mal-reduction in the ankle mortise as 1 mm of lateral shift of the talus results in 40% loss of tibio-talar contact area [3]. Disruption of the ankle mortise therefore leads to joint instability and accelerated joint degeneration. No consensus has been reached on the gold standard treatment for syndesmotom complex injuries [4]. The most commonly adopted method employs the use of one or two diastasis screws across the distal tibio-fibular joint. Recent evidence suggests that intact screws across the distal tibio-fibular joint can worsen functional outcome [5]. As a result, many patients with diastasis screws are often considered for elective removal of metalwork by the operating surgeon. Removal of metalwork in this way has been shown to be costly [2] and subjects the patient to additional peri-operative and post-operative risks. There is increasing evidence highlighting a number of issues with the use of diastasis screws. Gardner et al. [6] reported more than 50% incidence of mal-reduction in the syndesmotom complex in Weber C fractures treated with screw fixation. Mal-reduction is known to be an independent predictor of poorer outcomes [7]. Widening of the syndesmotom complex and joint instability following diastasis screw removal have also been reported [8].

Ankle tightrope fixation is an alternative method for stabilisation of the distal tibio-fibular joint using a suture and button construct. Following satisfactory reduction in the distal tibio-fibular joint, a drill hole is established that spans both cortices of the tibia and fibula at the level of the syndesmotom complex. A suture is passed through this drill hole and secured on both the medial and lateral sides with metallic buttons. Biomechanical studies indicate that the tightrope construct allows some movement at the distal tibio-fibular joint and therefore acts like a dynamic physiological reconstruction of the syndesmotom complex [9]. As such, patients undergoing tightrope fixation do not routinely need to undergo a subsequent operation to remove the hardware. This has profound implications in terms of reducing healthcare costs and waiting list burden.

Following the introduction of tightrope fixation for treatment of syndesmotom complex injuries, there has been a surge in its use. Review of the current literature revealed only three prospective randomised controlled trials investigating its efficacy [11, 12, 26]. The majority of data advocating its use are based on cadaveric models and cohort studies using heterogeneous ankle fracture patterns with syndesmotom complex injuries [4, 13, 25, 27].

The aim of this study was to assess the efficacy of the Arthrex TightRope® fixation system for Weber C ankle fractures. We report results of a multicentre case series assessing the rates of failed fixation, complication and re-operation as well as the functional outcome of patients undergoing this under-utilised form of dynamic fixation.

## Materials and methods

Retrospective assessment of all patients with Weber C ankle fractures treated with the Arthrex TightRope® fixation system between October 2008 and October 2011. Patients were enrolled from four separate district general hospitals within the London geographical region.

### Inclusion criteria

All patients who sustained a distal fibula fracture above the level of the syndesmotom complex (Weber C-type injury), patient aged 18–60 years and independently mobile prior to injury.

### Exclusion criteria

Open fractures, high-energy injuries, long-term steroid use, peripheral vascular disease and peripheral neuropathy.

### Operative technique

The patient was placed in the supine position with a sandbag under the ipsilateral buttock. Fluoroscopic guidance was used intra-operatively to confirm satisfactory reduction in the ankle mortise. Stabilisation of the syndesmotom complex was achieved by using Arthrex (Naples, Florida) TightRope® fixation system [10]. The number of tightropes used was left to the discretion of the operating surgeon. Fixation of associated fibula fractures using a bridging plate (AO technique) was only performed if the fracture was within 15 cm from the tip of the lateral malleolus. All associated medial malleolus fractures were fixed using two partially threaded cancellous screws (AO technique).

### Post-operative regime

All patients were immobilised in a below-knee plaster and advised to non-weight bear post-operatively for a total of 6 weeks. All patients were offered standard physiotherapy following removal of plaster immobilisation.

## Data collection

Data were collected retrospectively from patient notes, prospectively from questionnaires given to patients during clinic reviews and via telephone interviews conducted following consent from the patient. All patients were followed up and assessed at a minimum of 12 months following their initial operation.

## Outcome measures

The primary outcome measure was set as maintained reduction in ankle mortise following surgery. Radiographic assessment was made using radiographs obtained through the Picture Archiving and Communications System (PACS). Assessment of the medial clear space distance was made on mortise views of the ankle. Tibio-fibular overlap was assessed on AP views of the ankle. Pre-operative, 2–6 week post-operative and 3–6 months post-operative measurements were recorded. Radiograph measurements were taken by both an orthopaedic surgeon and a musculoskeletal radiologist in order to reduce the risk of error.

The secondary outcome measures include functional outcome scoring, complications and need for further operative intervention. The American Orthopaedic Foot and Ankle Society (AOFAS) score was adopted in this study following its use in previous studies of this nature [9]. The Olerud and Molander ankle score was also employed [14]. Independent physiotherapists obtained functional scores in order to reduce bias.

## Results

Within the four centres, 47 patients with were treated with Arthrex ankle tightrope fixation over 3-year period. Thirty-six (77%) patients were eligible for enrolment into this study following application of the inclusion and exclusion criteria.

## Demographics

The mean age at time of operation was 31 years (range 18–65). There were 20 male and 16 female patients. Five patients (14%) patients were regular smokers.

## Time to surgery

All patients underwent open reduction and internal fixation within 14 days of sustaining the injury. Mean time to surgery was 3.2 days (range 1–14).

## Intra-operative

Fixation was achieved using a single tightrope in 21 (58%) patients and double tightrope in 15 (42%) patients. Fifteen (42%) patients underwent fixation of the associated fibula fracture. Eight (22%) patients required fixation of an associated medial malleolus fracture.

Nine separate surgeons performed the operations: 2 consultant level and 7 registrar level (on consultant-supervised lists). Fifteen cases were performed under the care of a dedicated foot and ankle team. All patients made an uneventful post-operative recovery.

One intra-operative complication was encountered. This arose when the drill hole for the second tightrope was placed too close in proximity to the first. This resulted in damage to the first tightrope. Due to adequate fixation of the second tightrope, the damaged tightrope was removed and not replaced. This patient made a good recovery post-operatively and was noted to have a good functional outcome on follow-up.

## Post-operative

Patients were immobilised in a below-knee plaster and kept non-weight bearing for a mean 7.3 weeks (range 6–10). All patients had a clinical assessment at a minimum of 12 months. The mean face-to-face follow-up time was 14 months (range 12–26). No patients were lost to follow-up.

## Primary outcome: reduction in ankle mortise

Tightrope fixation was successful in correcting and maintaining a reduced ankle mortise in 35 out of 36 cases (97%). The mean medial clear space on radiological assessment was 3.1 mm. Reduction was successfully maintained once the patients commenced full weight bearing with a mean medial clear space of 3.0 mm on 6 months post-operative radiographs. Failure of tightrope fixation was found in one (2.8%) patient within this case series. Inadequate ankle mortise reduction with a medial clear space of 6 mm was found on repeat radiographs at 2 weeks post-operative follow-up.

All 36 patients were contacted at a mean of 14 months (range 12–26) following their surgery. Only one (2.8%) patient was dissatisfied with their surgery. This patient required revision surgery for failed ankle tightrope fixation at 2 weeks post-operation. The remaining 35 patients (97.2%) expressed a strong preference to ankle tightrope fixation as it negated the need for a subsequent operation to remove the diastasis screw(s).

## Secondary outcomes: functional outcome

The mean Olerud and Molander score was 85 (range 70–100). The mean American Orthopaedic Foot and Ankle Society (AOFAS) score was 88.8 (range 67–98). Two (5.6%) patients had given up recreational sport following their injury. The remaining patients had returned to pre-injury level of activity. Eleven (30.6%) patients played regular sport prior to their injury and had returned to doing so following their surgery.

## Secondary outcome: complications/further operations

There were no wound infections or venous thromboembolisms in this case series. One (2.8%) patient required revision surgery at 2 weeks post-fixation. Revision fixation in this case utilised diastasis screws rather than repeat tightrope fixation. Clinic follow-up time for this patient spanned a total of 12 months. Despite radiographs at 12 months showing evidence of synostosis of the distal tibio-fibular joint, the patient

**Table 1** Summary of main findings of study—patient demographics, fixation methods, radiological measurements, post-operative functional scores and patient satisfaction ratings

|  |                     |                   |
|--|---------------------|-------------------|
| Age (in years): mean (range)               | 31 (18–65)          |                   |
| Gender                                     | 20 males:16 females |                   |
| Fibula plated                              | 15 (42%)            |                   |
| Number of tightropes used                  | 1                   | 21 patients (58%) |
|  | 2                   | 15 patients (42%) |
| Time to FWB (in weeks): mean (range)       | 7 (4–12)            |                   |
| Medial clear space (in mm): mean (range)   | Pre-op              |                   |
|  | 7.1 (4–17)          |                   |
|  | Post-op             |                   |
|  |                     | 3.1 (2.7–6)       |
| 6 Months post-op                           |                     | 3.0 (2.7–3.6)     |
| Tibia–fibula overlap (in mm): mean (range) | Pre-operation       |                   |
|  | 2.7 (0–5.5)         |                   |
| Post-operation                             |                     | 10.1 (2.5–12.2)   |
| AOFAS score: mean (range)                  | 88.8 (67–98)        |                   |
| OM score: mean (range)                     | 85 (70–100)         |                   |
| Patient satisfaction                       | Excellent           | 22 61%            |
|  | Very good           | 9 25%             |
|  | Good                | 4 11%             |
|  | Fair                | 0 0%              |
|  | Poor                | 1 2.8%            |

F Female, M Male, FWB Full weight bearing, mm millimetres, AOFAS American Orthopaedic Foot and Ankle Society, OM Olerud and Molander

was noted to have a good functional outcome. One (2.8%) patient underwent removal of tightrope fixation at 6 months due to medial sided irritation when wearing certain footwear. Removal of tightrope did result in symptom resolution for this patient. Two (5.6%) patients treated with tightrope fixation only reported that they could feel the button on the fibula side but this caused them no problems. Four (11.1%) patients with fibular plates reported occasional irritation from the plate but did not wish to undergo further operations for plate removal (Table 1).

## Discussion

We report successful reduction in the ankle mortise in 97% ( $n = 35$ ) of cases treated with ankle tightrope fixation within this study. Previous studies have reported similar failure of fixation rates [12, 16, 18]. Cadaveric studies have shown that diastasis screws are better than tightrope fixation in maintaining distal tibio-fibular joint reduction [21]. A recent cadaveric study has shown reduced post-fixation displacement in deliberately mal-reduced distal tibio-fibular joints when using tightrope fixation compared to diastasis screws [27]. Clinical studies have demonstrated the success of ankle tightrope fixation with limited rates of failure. Table 2 summarises the results from previous studies using the suture button technique of fixation. Rigby and Cottom [18] reported two revision surgeries in their case series of 37 patients, and however, they do not describe in detail the reasons for this. Furthermore, all ankle fractures with syndesmotic complex injuries were included for this study.

In this case series, we found a relatively low rate of complications. Overall re-operation rate was found to be 5.6% ( $n = 2$ ). Qamar et al. [17] reported a superficial infection rate of 12.5% ( $n = 2$ ) and re-operation rate of 6.3% ( $n = 1$ ). Naqvi et al. [22] report a re-operation rate of 6.1% ( $n = 3$ ) in their case series of 49 patients. Reported complications range from osteomyelitis and sinus formation [22] to heterotopic ossification of the syndesmotic complex [16]. The most commonly reported complication is skin irritation and often necessitates removal of the tightrope device [18].

In our study, there were no superficial or deep infections found. Our study group included only three smokers and two ex-smokers. Smoking has been associated with a six-fold increase in rates of developing deep infection [15]. Most previous studies have not considered this to be an important confounding factor in the analysis of their outcomes. We believe the two key factors contributing to variations in the observed complication rates are 1) patient selection and 2) surgical technique.

**Table 2** Summary of the published literature reporting failure/revision rates of ankle tigh trope fixation

| Authors          | No. of patients | No. of failures/revisions | Percentage |
|------------------|-----------------|---------------------------|------------|
| Qamar [17]       | 16              | 0                         | 0          |
| Naqvi [22]       | 49              | 0                         | 0          |
| Degroot [16]     | 24              | 0                         | 0          |
| Rigby [18]       | 37              | 2                         | 5.4        |
| Storey [19]      | 102             | 2                         | 2.0        |
| Thornes [20]     | 16              | 0                         | 0          |
| Willmott [23]    | 6               | 0                         | 0          |
| Cottom [9]       | 25              | 0                         | 0          |
| Coetzee [11]     | 12              | 0                         | 0          |
| Seyhan [24]      | 15              | 0                         | 0          |
| Kortekangas [12] | 21              | 1                         | 4.8        |
| Laflamme [26]    | 65              | 0                         | 0          |
| This study       | 36              | 1                         | 2.8        |

Comparison can be made with our study

### Patient selection

Half of the complications reported by Willmott et al. [23] in their study of six patients were in a paediatric patient. The retention of fixation in the skeletally immature bone was deemed undesirable given the potential risk of iatrogenic growth deformities. As such, we set the minimum inclusion age at 18 years. A maximum inclusion age of 65 years was also adopted. This reflected the relatively poorer bone quality in the ageing adult population. We felt that poor bone quality could jeopardise the quality fixation of the tigh trope device and increase risk of failure (i.e. cut-out of the button from the medial side).

### Surgical technique

Particular attention was paid intra-operatively to soft tissue handling by all surgeons within this study. Other key technical considerations that were taken during this study were (1) minimising lateral side knot, particularly in thin individuals and (2) burying knots under the fascia layer. Many surgeons will develop their own specific techniques to minimise the irritation caused by the side knots. Naqvi et al. [22], who have reported similar complication rates to our study, describe a technique whereby the knot is passed posterior to the fibula and over-sewn with fascia to ensure adequate soft tissue coverage. The recent introduction of knotless tigh trope fixation systems has addressed the issue of knot prominence and irritation [28]. Nonetheless, this new technology is costly and therefore may not be widely available.

In our study, we observed a mean OM score of 85. This is comparable with previous studies that have reported OM scores of 75 at 1 year [12] and 84.2 at 6 months [26]. The mean AOFAS score on follow-up within our case series was

88.8. This falls within the range of AOFAS scores (78–97) reported by previous studies [11, 12, 16–18, 20, 22, 24, 26] at a variety of post-operative periods (6–24 months). Furthermore, we found that patient outcome was not related to the number of tigh tropes used and the presence of concomitant fibula fracture plating.

The use of ankle tigh trope fixation for syndesmotic complex injuries is an attractive option as it provides a more physiological reconstruction when compared to diastasis screws that allow for no movement at the distal tibio-fibular joint. It can also avoid the need for patients to undergo a second operation [9, 25]. Ankle fracture morphology and severity can vary significantly, and therefore, outcomes from surgery are often determined by the fracture pattern and patient biology [15]. When establishing the role of new technologies, it is imperative to maintain consistent criteria to allow objective assessment. Previous studies [16–20, 26] have examined the outcomes of ankle tigh trope fixation on heterogeneous fracture patterns. This makes interpretation of the results more prone to error. In this case series, only Weber C-type ankle fractures were included and therefore reducing the potential for selection bias. The results from our study suggest that the use of ankle tigh trope fixation is an acceptable alternative to the use of diastasis screws for Weber C ankle fractures in adults. These findings are consistent with previous studies that have used heterogeneous fracture pattern indications.

We acknowledge some limitations within our study. The relatively low numbers of patients within this case series limit our ability to make sound conclusions with regard to the effect of concomitant fibula fracture plating and number of tigh tropes used on clinical outcome. The relatively short follow-up period (mean of 14 months) may lead to misrepresentation of the true long-term outcomes of this

dynamic form of syndesmotic fixation. First-generation Arthrex TightRope<sup>®</sup> fixation systems were employed in our case series. Introduction of the knotless tightrope fixation system [28] has addressed concerns regarding prominent lateral knots [22] causing soft tissue irritation and leading to subsequent re-operation.

## Conclusion

Weber C ankle fractures can be treated successfully with ankle tightrope fixation with low risk of complications in well-selected patients. Whilst previous studies present results from heterogeneous fracture patterns, we have demonstrated the efficacy of ankle tightrope fixation for a specific indication. Our results support the current literature for the continued use of this form of dynamic fixation. We believe that future studies should focus on comparing the efficacy of ankle tightrope fixation between different ankle fracture morphologies with syndesmotic complex injuries in order to form robust and reliable indications of its use.

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**Author's contribution** Mr. A. Anand contributed to data collection/study write-up; Mr. R. Wei contributed to study write-up; Mr. A. Patel contributed to data collection; Mr. V. Vedi contributed to data analysis; Mr. G. Allardice contributed to data collection/study supervisor; and Mr. B.S. Anand contributed to data collection/study supervisor.

**Compliance with ethical standards**

**Conflict of interest** The authors declare no conflict of interest.

**Ethical approval** This study was passed through hospital research and development boards and did not require formal ethical approval.

## References

- Court-Brown CM, McBirnie J, Wilson G (1998) Adult ankle fractures—An increasing problem? *Acta Orthop Scand* 69(1):43–47
- Lalli TAJ, Matthews LJ, Hanselman AE, Hubbard DF, Bramer MA, Santrock RD (2015) Economic impact of syndesmosis hardware removal. *The Foot* 25(3):131–133
- Ramsey PL, Hamilton W (1976) Changes in tibiotalar area of contact caused by lateral talar shift. *J Bone Jt Surg Am* 58(3):356–357
- Wang C, Ma X, Wang X, Huang J, Zhang C, Chen L (2013) Internal fixation of distal tibiofibular syndesmotic injuries: a systematic review with meta-analysis. *Int Orthop* 37(9):1755–1763
- Manjoo A, Sanders DW, Teszer C, MacLeod MD (2010) Functional and radiographic results of patients with syndesmotic screw fixation: implications for screw removal. *J Orthop Trauma* 24(1):2–6
- Gardner MJ, Demetrakopoulos D, Briggs SM, Helfet DL, Loric DG (2006) Malreduction of the tibiofibular syndesmosis in ankle fractures. *Foot Ankle Int* 27(10):788–792
- Van Vlijmen N, Denk K, Van Kampen A, Jaarsma RL (2015) Long-term results after ankle syndesmosis injuries. *Orthopaedics* 38(11):1001–1006
- Hakkalamani S, Prasanna VK, Meda K (2007) Syndesmotic screw removal in Weber ‘C’ ankle fractures. *Inj Extra* 38(1):14
- Cottom JM, Hyer CF, Philbin TM, Berlet GC (2008) Treatment of syndesmotic disruptions with the Arthrex Tightrope: a report of 25 cases. *Foot Ankle Int* 29:773–780
- Arthrex TightRope<sup>®</sup> and Fracture Fixation. <http://www.arthrex.com/foot-ankle/tightrope>. Accessed 31 May 2016
- Coetzee JC, Ebeling P (2009) Treatment of syndesmoses disruptions: a prospective, randomized study comparing conventional screw fixation versus TightRope<sup>®</sup> fiber wire fixation—medium term results. *SA Orthop J* 8:32–37
- Kortekangas T, Savola O, Flinkkilä T, Lepojärvi S, Nortunen S, Ohtonen P, Katisko J, Pakarinen H (2015) A prospective randomised study comparing TightRope and syndesmotic screw fixation for accuracy and maintenance of syndesmotic reduction assessed with bilateral computed tomography. *Injury* 46(6):1119–1126
- Den Daas A, van Zuuren WJ, Pelet S, van Noort A, van den Bekerom MPJ (2012) Flexible stabilization of the distal tibiofibular syndesmosis: clinical and biomechanical considerations: a review of the literature. *Strateg Trauma Limb Reconstr* 7(3):123–129
- Olerud C, Molander H (1984) A scoring scale for symptom evaluation after ankle fracture. *Arch Orthop Trauma Surg* 103(3):190–194
- Näsell H, Ottosson C, Törnqvist H, Lindé J, Ponzer S (2011) The impact of smoking on complications after operatively treated ankle fractures—a follow-up study of 906 patients. *J Orthop Trauma* 25(12):748–755
- Degroot H, Al-Omari AA, El Ghazaly SA (2011) Outcomes of suture button repair of the distal tibiofibular syndesmosis. *Foot Ankle Int* 32:250–256
- Qamar F, Kadakia A, Venkateswaran B (2011) An anatomical way of treating ankle syndesmotic injuries. *J Foot Ankle Surg* 50:762–765
- Rigby RB, Cottom JM (2013) Does the Arthrex TightRope<sup>®</sup> provide maintenance of the distal tibiofibular syndesmosis? A 2-year follow-up of 64 TightRopes<sup>®</sup> in 37 patients. *J Foot Ankle Surg* 52(5):563–567
- Storey P, Gadd RJ, Blundell C (2012) Complications of suture button ankle syndesmosis stabilization with modifications of surgical technique. *Foot Ankle Int* 33(09):717–721
- Thornes B, Shannon F, Guiney AM, Hession P, Masterson E (2005) Suture-button syndesmosis fixation—accelerated rehabilitation and improved outcomes. *Clin Orthop Relat Res* 431:207–212
- Forsythe K, Freedman KB, Stover MD, Patwardhan AG (2008) Comparison of a novel FiberWire-button construct versus metallic screw fixation in a syndesmotic injury model. *Foot Ankle Int* 29(1):49–54
- Naqvi GA, Shafqat A, Awan N (2012) Tightrope fixation of ankle syndesmosis injuries: clinical outcome, complications and technique modification. *Inj J Care Inj* 43(6):838–842
- Willmott HJS, Singh B, David LA (2009) Outcome and complications of treatment of ankle diastasis with tightrope fixation. *Inj J Care Inj* 40(11):1204–1206
- Seyhan M, Donmez F, Mahirogullari M, Cakmak S, Mutlu S, Guler O (2015) Comparison of screw fixation with elastic fixation methods in the treatment of syndesmosis injuries in ankle fractures. *Injury* 46(2):19–23

25. Schepers T (2012) Acute distal tibiofibular syndesmosis injury: a systematic review of suture-button versus syndesmotic screw repair. *Int Orthop* 36(6):1199–1206
26. Laflamme M, Belzile EL, Bédard L, van den Bekerom MP, Glazebrook M, Pelet S (2015) A prospective randomized multi-center trial comparing clinical outcomes of patients treated surgically with a static or dynamic implant for acute ankle syndesmosis rupture. *J Orthop Trauma* 29(5):216–223
27. Westermann RW, Rungprai C, Goetz JE, Femino J, Amendola A, Phisitkul P (2014) The effect of suture-button fixation on simulated syndesmotic malreduction: a cadaveric study. *J Bone Jt Surg Am* 96(20):1732–1738
28. Arthrex Knotless TightRope® Syndesmosis. <http://www.arthrex.com/foot-ankle/knotless-tightrope-syndesmosis>. Accessed 31 May 2016