British Medical Bulletin, 2014, **111**:101–115
doi: 10.1093/bmb/ldu020

Evaluation and management of injuries of the tibiofibular syndesmosis

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**This article bears witness to the great dedication that Prof Pau Golano put to his work. His great skill as a leading anatomist made us understand the fine relationship between the various structures of the ankle, and will serve generations of physicians.

Accepted 10 July 2014

Abstract

Introduction: Injury to the tibiofibular syndesmosis often arises from external rotation force acting on the foot leading to eversion of the talus within the ankle mortise and increased dorsiflexion or plantar flexion. Such injuries can present in the absence of a fracture. Therefore, diagnosis of these injuries can be challenging, and often stress radiographs are helpful. Magnetic resonance imaging scans can be a useful adjunct in doubtful cases. The management of syndesmotic injuries remains controversial, and there is no consensus on how to optimally fix syndesmosis. This article reviews the mechanism of injury, clinical features and investigations performed for syndesmotic injuries and brings the reader up-to-date with the current evidence in terms of the controversies surrounding the management of these injuries.

Sources of data: Embase, Pubmed Medline, Cochrane Library, Elsevier and Google Scholar (January 1950–2014).

Areas of controversy: The management of syndesmotic injuries remains controversial, and there is no consensus on: (i) which ankle fractures require syndesmotic fixation, (ii) the number or the size and the type of screws that should be used for fixation, (iii) how many cortices to engage for fixation, (iv) the level of screw placement above the ankle plafond, (v) the duration for which the screw needs to remain *in situ* to allow the tibiofibular syndesmosis to heal and (vi) when should patients weight bear.

Areas of agreement: (i) A high proportion of syndesmotic fixations demonstrates malreduction of the syndesmosis, (ii) no need to remove screws routinely, (iii) two screws appear to better one alone and (iv) if syndesmosis injury is not detected or not treated long term, it leads to pain and arthritis.

Growing points: (i) How to assess the adequacy of syndesmotic reduction using imaging in the peri-operative period, (ii) the use of bio-absorbable materials and Tightrope and (iii) evidence is emerging not to remove syndesmotic screws unless symptomatic.

Areas of timely for development research: (i) A bio-absorbable material that can be used to fix the syndesmosis and allow early weight bearing, and (ii) there is a need for developing a surgical technique for adequately reducing the syndesmosis without the exposure to radiation.

Key words: management, injuries, tibiofibular syndesmosis, diastasis

Introduction

A syndesmotic injury of the tibiofibular joint arises from an external rotation force acting on the foot leading to eversion of the talus within the ankle mortise, and increased dorsiflexion or plantar flexion.[1,2] It can also occur in the absence of ankle fractures, and up to '11% of all trauma related to the ankle joint without a fracture has syndesmotic disruption'.[3,4] The diagnosis of these injuries requires considerable experience, and stress radiographs and magnetic resonance imaging (MRI) scans can act as useful adjuncts in doubtful cases. Specific clinical examination tests used to diagnose syndesmotic injuries include the external rotation, the squeeze test and the dorsiflexion–compression tests.[5]

Intra-operatively, following open reduction and internal fixation of an ankle fracture, a hook test can be performed to evaluate the integrity of the syndesmosis. The hook test involves applying a force to the syndesmosis using a bone hook under fluoroscopy (AP view) and subsequent widening of the syndesmosis is highly suggestive of tibiofibular diastasis.[6]

However, once the diagnosis has been established by these clinical and/or intra-operative tests, there seems to be no consensus about the optimal management of these injuries. There is no universal agreement on which particular injuries/fractures need syndesmotic screws, or on how many cortices should be engaged. Furthermore, there is still an ongoing debate on the ideal size of the screw, the optimum level of placement of the screw(s) above the ankle joint, the preferred composition of the syndesmotic screw and as to when the patients should be allowed to bear weight post-operatively. This article, therefore, reviews the mechanism of injury, clinical features, the investigations performed for these injuries and brings the reader up-to-date with the current evidence and thinking with respect to the management of the syndesmotic injuries.

Anatomy of the tibiofibular syndesmosis

The fibula is held in its incisura fibularis on the distal tibia by four ligaments, forming the tibiofibular syndesmosis complex. These ligaments are named in turn as the anterior-inferior tibiofibular ligament (AITF), posterior-inferior tibiofibular ligament, inferior transverse tibiofibular ligament and the interosseous ligament. These ligaments ensure that the tibia and fibula along with the joint stay in close contact while weight bearing, and the joint remains a stable construct in the ankle mortise.[7]

The movement of the fibula in different positions of the ankle joint is another area in which there is no universal agreement on the exact motion of the fibula except during dorsiflexion and plantar flexion. In dorsiflexion, the fibula shifts laterally and posteriorly while in plantar flexion it moves medially and anteriorly.[8,9]

In cadavers, fixation of the tibiofibular syndesmosis with screws reduced the normal range of fibula motion considerably, particularly in sagittal and horizontal translation.[8] The normal physiological movement of the fibula during ankle motion is up to 2 mm.[9]

Mechanism of injury

The syndesmotic ligaments virtually prevent the lateral translation of the fibula. Therefore, disruption of one of these ligaments can lead to instability of the joint and deranged axial movement.[10–12] Numerous mechanisms can lead to disruption of the tibiofibular syndesmosis. However, the most frequent mode of injury is external rotation,[3,13–15] eversion of the talus and hyperdorsiflexion.[13,15] When an external rotational force is transmitted to the syndesmosis, there is an increased risk of a syndesmotic diastasis, especially when the axis of the ankle joint lies in a neutral position.[3]

Normally, there is minimal movement of the talus within the ankle mortise. However, when an external rotation force is applied, the talus rotates in a similar proportion to the force applied. Large forces acting on it will result in lateral displacement of the fibula. This in turn can lead to a syndesmotic diastasis, and commonly the antero-inferior tibiofibular ligament gives way first, as it is the weakest of the syndesmotic ligaments.[16] In sport, an external rotation injury can arise when a force is applied to lateral aspect of the leg with a planted foot.[13] When a force of 87 N is applied to the syndesmosis, it will produce a lateral diastasis of 2 mm.[11] In addition to the tears of the syndesmotic ligaments, the deltoid ligament can be completely torn when a substantial force is applied to it. Usually, the total rupture of the syndesmotic ligaments with an external rotation force is associated with a Weber type B or C fracture and a Maisonneuve fracture.[14,15] Other reported mechanisms leading to injury of these ligaments include pronation,[17] internal rotation[18] and plantar flexion.[19]

Evaluation

Clinical assessment

This should consist of a comprehensive history including mechanism of injury followed by a thorough physical examination. Once a satisfactory history has been obtained, then the external rotation test (Fig. 1A), squeeze test, dorsiflexion compression test (Fig. 1B) or heel thump test (Fig. 1C) can be performed depending on the clinician's preference. The external rotation test (Kleiger's test) is performed with the patient seated, the knee and the proximal tibia isolated while an external rotation force is applied to the ankle in a neutral position. Pain elicited at the tibiofibular syndesmosis suggests that the syndesmosis is not intact.[20]

In the squeeze test (Fig. 1D), the assessor applies pressure with their hands around the mid-point of the calf on the affected limb. If pain is experienced in the tibiofibular syndesmosis, it may be indicative of an injury.[3]

However, these tests are of limited use in the presence of pain or swelling from an associated fracture.[21] These clinical tests do unfortunately lack a high predictive value to diagnose a syndesmotic injury. Among these, the external rotation test appears to have the lowest false-positive rate.[5,22] Although there is no consensus of how to best assess the integrity of the syndesmosis intra-operatively, some authors support the external rotation test, while biomechanical studies found the bone hook test to be more reliable.[23] Furthermore, these tests have poor inter-observer reliability,[5,21,22] highlighting the importance of combined clinical examination, imaging and in some cases arthroscopic evaluation of the syndesmosis to diagnose an injury to this complex.

Investigations: plain radiographs

This is the first line of investigation, usually in the accident and emergency department. Adequate plain radiographs should consist of three views of the ankle: anteroposterior (AP), mortise and a lateral view. In addition, an AP and a lateral radiograph of the whole tibia and fibula should be obtained to exclude proximal fractures in suspected cases. Clinicians may use one of several classifications depending on the fracture pattern, and these may include the Weber's or the AO-Muller classification system. In addition, at plain radiography, three measurements should be obtained: (i) the tibiofibular clear

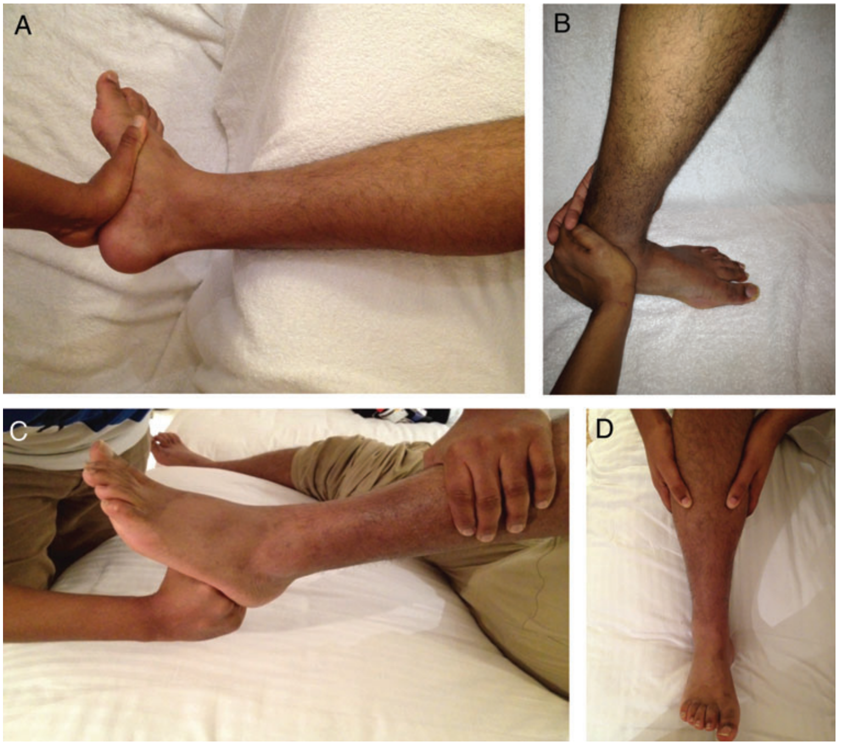

Fig. 1 (**A**) External rotation test. (**B**) Dorsiflexion compression test: ankle is in maximal dorsiflexion with the patient weight bearing and force is applied over both malleoli. If syndesmotic injury is present then pain may be elicited over distal fibula. The test above can be useful in sprains where a patient can tolerate examination. (**C**) Heel thump test: one hand holds tibia while the hand applies direct force from the heel in line with axis of the tibia. Pain over the syndesmosis is suggestive of an injury. (**D**) Calf squeeze test.

space, (ii) the tibiofibular overlap and (iii) the increased medial clear space. These classifications and the measurements assist to detect and confirm the presence of a syndesmotic injury[24] (Table 1).

The measurements for assessing the integrity of the syndesmosis on plain radiographs were derived from cadaveric studies, and one of the main limitations of these evaluations is that the position in which the ankle is held may influence the measurements and therefore providing incorrect readings. A recent prospective study using an MRI scan as gold standard to diagnose syndesmotic injuries found that the tibiofibular clear space and tibiofibular overlap did not correlate with a syndesmotic injury.[25] To overcome inter-observer error, they used the same radiologist who had 11 years of work experience reporting radiographs. Nevertheless, if findings on plain radiographs are not conclusive, then further imaging with a CT or an MRI scan is warranted.

Although CT scans are superior to plain radiographs in detecting subtle syndesmotic injuries, MRI superseded CT scanning because of their accuracy, high specificity and sensitivity and is now the investigation of choice in doubtful cases.[25–27] The specificity and sensitivity of MRI scans in detecting syndesmotic injuries is 93 and 100%, respectively, with subsequent confirmation at arthroscopy.[17] MRI axial views provide the optimal visualization and clinical information about the integrity of the syndesmosis.[28] Hermans *et al.*'s MRI study of the tibiofibular syndesmosis found that an oblique MRI image plane can be of additional value to the axial views.[29]

Table 1 Criteria to diagnose syndesmotic and deltoid injury on plain radiographs

Plain radiological assessment of the syndesmotic integrity	Method	Significance
Tibiofibular clear space AP and mortise view	Measure the distance between lateral border of the posterior tubercle of the tibia and the medial border of the fibula malleolus at 1 cm above the tibia plafond	In an intact distal tibiofibular syndesmosis, this should be <6 mm but if disrupted it is >6 mm
Tibiofibular overlap AP and mortise view	Measure the distance medial border of the lateral malleolus and the lateral border of the at 1 cm above the tibial plafond	With an intact syndesmosis, it should be >6 mm on AP view, and on mortise view, it should be >1 mm. If values are greater, it suggests syndesmotic injury
Medial clear space Mortise view with the ankle in neutral position	Measure the distance between the medial border of talus and lateral border of medial malleolus at the level of talar dome	The distance should be equal or less than that of between the talar dome and the tibial articular surface. If the value is greater than 4 mm on AP, it can often indicate a rupture of the deltoid ligament

Arthroscopic examination can diagnose 100% of syndesmotic injuries when compared with other modalities such as MRI scans and plain radiographs.[26,30] In the presence of fractures, it is very rare to routinely use MRI to assess syndesmotic integrity, as this can be done intra-operatively.

Arthroscopy is superior to intra-operative stress radiographs as well in detecting syndesmotic injuries and provides valuable information about instability in different planes.[31] However, it is not used routinely, and the hook test is used to assess the integrity of the syndesmosis following fixation of ankle fractures intra-operatively.

Examination under anaesthesia

Where the ankle joint is significantly swollen and tender to examine clinically, or where the fracture cannot be reduced under sedation and requires further manipulation under anaesthesia in theatre, stress tests should be undertaken to assess the integrity of the syndesmosis. Examination under anaesthesia can be useful to assess and plan the management of syndesmotic injuries. Assessment of the syndesmosis should be carried out routinely while reducing or fixing fractures of the ankle.

Management

Management of syndesmotic injuries without an ankle fracture

There have been a limited number of publications on ankle syndesmotic injuries without a fracture. There should be a high index of suspicion in patients with ankle sprains because if missed, these injuries may lead to long-term problems such as pain and instability. In the absence of an associated ankle fracture, syndesmotic injuries can be managed conservatively. Generally, a syndesmotic diastasis is either evident at the time of injury (frank diastasis) or may present as a latent injury, both of which can be managed non-operatively.[32,33] Edwards and DeLee, in 1984, described four types of syndesmotic diastasis without a fracture in a small study of six patients based on radiographic evidence. In type I, there is lateral distal fibular subluxation without plastic deformation of the fibula. Type II is the same as type I injuries, but with plastic deformation of the fibula. Type III describes posterior rotatory subluxation. In contrast, type IV results from proximal talar migration.[32] They advocated that only types I and II should undergo open reduction and internal fixation. This classification, though useful, has not been validated, but it does provide with a description of the possible patterns of injury. Furthermore, syndesmotic sprains without diastasis or joint instability should be managed non-operatively with a non-weight bearing cast. However, it should be noted that syndesmotic injuries without a fracture that are treated non-operatively always take longer to heal.[13,34]

Management of syndesmotic injuries with a fracture

The purpose of fixation of a diastasis of the syndesmosis and its associated fracture is to maintain ankle stability and correct alignment of bones while allowing healing. Historically, the use of syndesmotic screws was very common in Weber B and C fractures, at approximately 40 and 80%, respectively.[35–37] However, recently there has been a decline in the use of syndesmotic screws in ankle fractures, especially in the distal Weber C fractures.[38–40]

Currently, the only consensus for their use appears to be firstly in high fibular fractures (>4.5 cm above the articular surface), as this correlates with significant interosseous membrane disruption that makes the fracture unstable.[41,42] Second, syndesmotic fixation is warranted when the hook test demonstrates a syndesmotic diastasis intra-operatively. However, despite mounting evidence, there is still no consensus on the appropriate management of this injury (Table 2).

Diastasis screw: size and number

Currently, there is no gold standard for the appropriate size of the screw for ankle diastasis, and commonly either 3.5 or 4.5 mm cortical screws are used. In a recent questionnaire-based study, Bava *et al.* asked the orthopaedic trauma and foot and ankle fellowship directors and members of the Orthopaedic Trauma Association and the American Orthopaedic Foot and Ankle Society about their preferred size for the diastasis screw. Just over 50% stated that they used 3.5 mm cortical screws, and others either used 4.5 mm cortical screws or a suture fixation device.[57] Similar studies were carried out in Europe (Great Britain and Belgium). In Belgium, a national survey showed most surgeons used one single 3.5-mm tricortical diastasis screw for Weber B fractures and placed screws 2.1–4 cm above the tibia plafond. They only used two screws in high fibular fractures (Maisonneuve fracture).[58] Despite numerous studies, the evidence is still split between the use of either 3.5 or 4.5 mm cortical screws, and it appears to depend on surgeons' experience and preference. Often studies are conducted using either 3.5[59–61] or 4.5 mm cortical screws[15,45,59] without strong evidence for either size. Both 3.5 and 4.5 mm cortical screws exhibit similar biomechanical characteristics and there does not seem to be any superiority of the 4.5 mm over the 3.5 mm cortical screw in fixation of the syndesmosis.[43]

Conversely, 4.5 mm cortical screws may be easier to remove in an outpatient clinic setting, and its use on four cortices gives considerable support against shear stresses applied to the distal syndesmosis during weight bearing.[44]

Cadaveric studies have compared the use of a single diastasis screw versus two cortical screws, and their results support the use of two screws, as they provide a better construct biomechanically.[45,62]

Number of cortices and level of placement

The number of cortices engaged with the diastasis screws varies with different studies: there is no strong evidence to support three cortices over four and *vice versa*.[62] A recent study comparing the engagement of three cortices versus four did not show any clinically significant difference between the two groups at 1 year in terms of pain and function.[49]

Some authors and also the AO Foundation advocate that the ideal placement of diastasis screws should be 2–3 cm proximal to the tibial plafond and should be inserted parallel to it and to each other.[60,63] Interestingly, the placement of diastasis screws at 2, 3 and 5 cm proximal to the ankle joint has no significant impact on the end result.[46]

Material of the screw and other alternatives

The material that diastasis screws are made from is a growing field in research. This has been fuelled by the need to remove the widely used metallic screws if the patient presents with loosening, pain or failure of the screw.

Table 2 Recent studies

Subject	Study	Year	Country	Follow-up (months)	Number	Aim of study	Conclusion
Screw sizes	Thompson and Gesink	2000	USA	Cadaveric	24 (12 pairs of legs)	To biomechanically compare syndesmosis fixation with 3.5- and 4.5-mm stainless steel screws	No biomechanical advantage of a 4.5-mm screw over 3.5-mm[43]
	Hansen *et al.*	2006	USA	Cadaveric	18	To analyse shear stress via axial load on 3.5- and 4.5-mm quadricortical syndesmotic screws	Results indicated that maybe 4.5 mm screws provided statistically better resistance when a shear stress force was applied to the syndesmosis[44]
Number of screws	Xenos *et al.*	1995	USA	Cadaveric	25	To evaluate methods of syndesmotic fixation	Fixation of the syndesmosis with two screws is superior to one diastasis screws[45]
Screw placement	Kureti *et al.*	2005	UK	35	36	Comparing screws placed trans-syndesmotic versus just above the syndesmosis	No significant difference in terms of clinical and radiological outcomes[46]
Number of cortices	Karapinar *et al.*	2007	Turkey	At least 12	46	To compare three or four cortex syndesmotic fixation in Weber C	No difference at 1 year and suggest to use three-cortex fixation as there is less syndesmotic space obliteration after surgery[47]
	Moore *et al.*	2006	USA	5	120	A comparison of three and four cortices of screw fixation without hardware removal	Advocates the use of three or four cortices in syndesmotic fixation[48]
	Hoiness and Stromsoe	2004	Norway	12	64	To assess short-term functional results in two types of syndesmotic fixation, comparing the traditional rigid quadricortical syndesmotic screw fixation with a more dynamic tricortical screw fixation	Syndesmosis fixation with two tricortical screws is safe and improves early function but at 1 year there is no difference[49]
Screw removal and weight bearing	Hsu *et al.*	2011	Taiwan	19	52	Retrospective study on treatment of syndesmotic diastasis	Removal of syndesmotic screws at 6 weeks may prevent breakage but however removing it may result in re-occurrence of syndesmotic diastasis[50]

Continued

Table 2 Continued

Subject	Study	Year	Country	Follow-up (months)	Number	Aim of study	Conclusion
	Manjoo *et al.*	2010	Canada	15	76	The purpose of this study is to determine whether functional outcomes and radiographic results after ankle fracture are affected by the status of the syndesmosis screw	An intact syndesmosis screw was associated with a worse functional outcome compared with loose, fractured or removed screws[51]
	Bell *et al.*	2006	Singapore	15	30	Comparing syndesmotic screw removal prior to weight bearing versus leaving them *in situ* indefinitely	Screws should be removed prior to weight bearing to reduce the risk of screw breakage[52]
	Moore *et al.*	2006	USA	5	120	A comparison of three and four cortices of screw fixation without hardware removal	No difference in outcome between removed or retained scews[53]
Screw material	Hu *et al.*	2010	China	6	47	To compare the clinical effect of poly-DL-lactic acid absorbable screws and titanium metallic screws in ankle diastasis	Poly-DL-lactic acid absorbable are effective and reliable[54]
	Kaukonen *et al.*	2005	Finland	35	28	Comparing metallic versus bioabsorbable syndesmotic screws	Polylevolactic acid screws worked as well (or slightly better) as metallic screws[55]
	Thordarson *et al.*	2001	USA	3	32	Bioabsorbable versus stainless steel screw for fixation of the syndesmosis	There were no wound complications in either group and no difference in functional outcome[56]

Cox and colleagues compared fixation of the tibiofibular syndesmosis using 5 mm bio-absorbable screws versus the same diameter stainless steel screws. The 5-mm co-polymer (poly-L-lactic acid/poly-glycolic acid) bio-absorbable diastasis screws imparted the same biomechanical stability as the stainless steel screws.[64] A randomized prospective blinded study compared metallic screws with a bio-absorbable polylevolactic acid screw in ankle fractures with syndesmotic disruption. The results were equivalent, and the polylevolactic acid screws were actually marginally superior to the metallic screws in restoring the syndesmotic integrity.[55] Although these results are promising, caution must be exercised, as the long-term sequelae of bio-absorbable materials include osteolysis,[55] and late foreign body reaction.[65,66]

In addition, in some patients, polymeric debris has penetrated the joint leading to damage of the joint and osteoarthritis.[67] Another method that has been used with some success is the bolt fixation technique in which a 3-mm fully threaded bolt screw is used to stabilize the syndesmosis during open reduction and internal fixation (ORIF) and the bolt was removed on weight bearing.[68]

The Tightrope device has also been used for fixation of the ankle diastasis; it involves the use of a non-biodegradable FibreWire held at either end by two cortical metal buttons. One of the main advantages of this method is that there is no need to remove it routinely, and patients can return to full activity with it *in situ*. This has the added benefit of saving both time and the cost to remove them and permits early mobilization. A recent study with 49 patients, which is the largest study for this implant, reported a satisfactory outcome after 2 years following the use of Tightrope.[69] Although it is an advantageous technique that does not require removal of hardware, some authors have reported the potential need for further intervention secondary to soft tissue irritation from the knot.[69,70]

Despite this minor possibility of soft tissue irritation, there is a slowly emerging body of evidence that this method is a good treatment option. A recent systematic review compared Tightrope fixation to the gold standard of syndesmotic screws for fixing the syndesmosis. The Tightrope produced similar functional outcome to the syndesmotic screws. Intriguingly, the results also showed that Tightrope was superior to syndesmotic screws as patients were able to return to work and there were fewer requirements to remove implants.[71] These findings are further supported by both cadaveric and non-cadaveric studies.[52,70,72,73] The Tightrope may well become the treatment of choice in the future.

Removal of screw versus weight bearing

On average, the syndesmosis takes 8–12 weeks to repair. There is no consensus on whether to allow weight bearing prior to removal of the screw, or the duration that screws should remain *in situ*. The difficulty with weight bearing while the screws are *in situ* is the increased risk of loosening, breakage and pain. Therefore, some authors advocate removal of the screws prior to weight bearing.[52,74] However, others suggest no significant difference in outcome between the retained and removed screws.[49,75] Taylor *et al.* followed athletes with syndesmotic sprains who had a fixation with diastasis screws. In this case series, patients were allowed to undertake a range of motion exercises within a week of diastasis fixation. This was then followed with gradual weight bearing with patients returning to full activity on average 41 days post-fixation. This cohort evidenced no screw breakage during full activity or prior to removal.[18] Furthermore, Hamid *et al.* found that patients with broken screws had an optimum clinical outcome in comparison with those with intact or removed syndesmotic screws and advocated leaving the syndesmotic screws *in situ* indefinitely.[76] In this study, 68% of the patients had evidence of radiolucency around the diastasis screw, which may indicate micromovements occurring, although this had no effect on the overall clinical outcome.[76] A recent review looked at seven studies [one randomized controlled trial (RCT), one quasi-RCT and five retrospective studies] with a total of 472 patients; of these, 80 had broken or loose diastasis screws. Overall, there were no significant differences between retained or removed screws.[77] Removal of diastasis screw(s) that are not broken at 4–6 months is only probably acceptable in symptomatic patients.[77] In addition, removal of diastasis screws carries 22.4% complication rate, encompassing infection (9.6%), re-occurrence of diastasis (6.6%) and screw breakage during removal (6.6%).[78]

Hsu *et al* evaluated retrospectively 42 patients who had undergone ORIF of syndesmotic injury and evaluated outcomes 6 weeks, 3, 6 and 9 months after removal of the screws. Interestingly, 15.7% (3/19) of the patient who had screws removed at 6 weeks demonstrated recurrence of diastases, which did not have significant impact on ankle function. Jordan *et al.* illustrated that, following screw removal, the radiographic parameters for assessing syndesmosis changed demonstrating an element of diastasis. Conversely, this did not alter the ankle mortise.[79] Nevertheless, caution should be exercised and a large randomized study is warranted. In our practice, we do not routinely remove syndesmotic screws.

Accuracy of syndesmotic fixation; is there role for posterior malleolus fixation?

It is difficult to assess the accuracy of reduction of the fibula in the incisura on both fluoroscopy and post-operative plain radiographs. There is still no optimum way to assess congruency of the fibula and the fibula incisura intra-operatively. Some authors advocate the use of CT scan routinely post-ORIF of syndesmotic diastasis. One study in which a routine CT scan was undertaken for both ankles for comparative purposes found that up to 42% of their post-fixation patients had residual diastasis.[80] It is often quoted that a difference in measurements of >2 mm between the fibula and anterior and posterior aspects of the incisura fibularis on CT scan indicates diastasis. Furthermore, Gardner *et al.* found that of 25 patients who underwent ORIF of a syndesmotic diastasis, 6 patients had a syndesmotic diastasis post-fixation on plain radiographs and 4 of these patients a CT scan that demonstrated malreduction of the syndesmosis. Overall, CT scans confirmed that 52% of those post-ORIF patients lacked congruity of the fibula within the incisura.

Perhaps a solution to the malreduction of the syndesmosis is to use real-time CT intra-operatively, as this will allow anatomical fixation of the syndesmosis. Frankie *et al.* retrospectively evaluated the use of CT scanning in a theatre in confirming the reduction of the syndesmosis after fixation under flourscopy.[81] This study demonstrated that 82 of 251 consecutively fixed syndesmotic injury were malreduced, which prompted a revision surgery. This was beneficial, as 77 of the 82 patients had improved reduction following revision. The authors did not follow up these patients and did not evaluate them functionally; also, they did not assess complications and did not ascertain whether this approach justifies the use of additional radiation and surgery. Alternatively, one could consider routinely imaging the contralateral limb to evaluate the fixation of the syndesmosis.

Anatomical studies have attempted to shed light on the morphometric characteristics of the fibular incisura and the optimum reduction position for the fibula in syndesmotic injuries. They have not, to date, managed to find the exact steps that will provide anatomical reduction of the syndesmosis. This just highlights an additional issue in the management of syndesmotic injury, which can lead to suboptimal outcome, and therefore further research is warranted.[82]

From our experience and the current rationale, we believe that in the presence of a posterior malleolus fracture and syndesmotic diastasis, one should fix the posterior malleolus first as this may obviate the need for syndesmotic screws. This is true if the posterior-inferior tibiofibular ligament is intact, as it will provide more often than not a stable syndesmotic construct. On balance, this ligament is the most powerful one of the syndesmosis ligaments and can provide up to 42% of the strength of the syndesmosis.[8]

Management of chronic tibiofibular syndesmosis injuries

The diagnosis of chronic injury to the tibiofibular syndesmosis may not be easy to diagnose on plain radiographs. Although advanced imaging such as MRI scans have very good specificity and sensitivity. Ankle arthroscopy in experienced hands can reveal ankle syndesmotic injury with better accuracy and detection rate than conventional modalities.[26,30,41] Patients with a suspected syndesmotic injury should be consented at the time of arthroscopy for both arthroscopic debridement and reconstruction of the ankle syndesmosis to reduce the risk of a second general anaesthetic and re-admission to hospital. Arthroscopic features of chronic syndesmotic injury include hypertrophy of the syndesmotic ligaments, chondral lesions on the talar dome and increased movement of the fibula on probing the syndesmosis. The reconstruction of the syndesmosis can be carried out using various tendons such as peroneus longus, semitendinosus and gracilis. In addition, arthroscopy is useful prior to open reconstructive surgery as it allows the surgeon to rule out the presence of significant arthritis or other pathology that might account for symptoms if previous investigations were inconclusive.

The only meta-analysis on the management of chronic syndesmotic diastasis analysed the three most common treatment options, namely screw fixation, arthroscopic debridement and arthrodesis.[83] The pooled success rates were 87.9% for screw fixation, 79.4% for arthrodesis and 78.7% for arthroscopic surgery. Although the data suggest a good overall success rate, one has to be cautious, as most of studies had small number of patients and were retrospective. In addition, follow-up was short, and some studies lacked control groups. Chronic or recurrent diastasis may lead to an increase in the medial clear space, which can also result from inadequate restoration of fibula length during surgery. In clinical practice, close scrutiny and careful restoration of fibula length, alignment and rotation will reduce the risk of developing diastasis medial clear space. Routinely, in our practice we image the contralateral ankle and use it as the reference during surgery.

Operative options

In chronic AITF ligament injury, the ligament should be repaired if there is adequate tissue; if the ligament is intact but lax following its suture, diastasis screws may be deployed to protect the repair. However, in the absence of sufficient ligamentous tissue the aim is to reconstruct the normal anatomy of the syndesmosis using an autograft. Morris *et al.* used free a semitendinosus autograft on eight patients to reconstruct the AITF ligament with a mean follow-up of 39 months, demonstrating a favourable outcome.[84] Yasui *et al.* recommend the use of an autogenous gracilis tendon to reconstruct the AITF ligament in four consecutive patients with chronic syndesmosis disruption secondary to pronation external rotation injury.[85] Another option for AITF ligament reconstruction is the use of the peroneus longus tendon.[86,87] There is a role for reconstruction of the ligaments, as it can reduce the long-term risk of pain, ankle instability and post-traumatic arthritis.

Depending on the surgeon's experience and choice, one option is to fuse the syndesmosis, although it may limit dorsiflexion and interfere with normal biomechanics. Conversely, other authors have indicated syndesmosis fusion to be an acceptable treatment choice in chronic syndesmotic diastasis.[4,88] Olson *et al.*, in 10 patients, found arthrodesis of the syndesmosis to be a good option as a salvage procedure after a failed primary fixation.[89] The overall functional and radiographic measurements improved considerably with patients stating that they would be happy to have the surgery again. This level IV study had an average follow-up of 41 months, and in all of the patients, the primary indication of arthrodesis was fibula non-union. This further supports the use of this procedure as a salvage option and may indeed in the long term reduce the development of osteoarthritis or the need for total ankle arthrodesis.

Outcomes

Correct diagnosis and prompt management of tibiofibular injury and its associated ankle fractures influence the long-term outcome and reduce disability.[41,90] In the absence of appropriate treatment, tibiofibular syndesmotic injuries can result in chronic pain, osteoarthritis and joint instability.[9,10] Obtaining and maintaining an anatomical reduction is the key to a good functional outcome, because a 1-mm lateral displacement of the talus results in a loss of 42% tibiotalar contact area, which in turn reduces stability and function of the joint.[91]

Summary

Tibiofibular syndesmotic injuries often occur as a consequence of an external rotation injury. Careful history taking and good clinical examination and appropriate imaging will suffice in identifying a syndesmotic injury. Immediate appropriate treatment of an acute syndesmotic injury produces a very good outcome in the long-term and the return to normal activity. Operative fixation can be achieved using 3.5 or 4.5 mm cortical screws that engage three or four cortices. No definitive conclusions can be drawn regarding duration of weight bearing, the optimal composition of the screws, time of removal of screws and indeed whether the screws should be removed at all. Recent publications support our routine practice in which diastasis screws are not removed routinely unless patients are symptomatic. There is emerging evidence that Tightrope is a viable alternative to a diastasis screw, without the problems of breakage and removal.

The tibiofibular syndesmosis plays an important role in contributing to the biomechanical stability of the ankle joint, and, although a large amount of research has been performed, there are still no agreed guidelines on the optimal management for the tibiofibular syndesmotic injury. However, if there is a clinical suspicion of syndesmotic injury, then fixation should be undertaken. To achieve a consensus, appropriately powered RCTs with long-term follow-up and adequate outcome measures would be required.

References

1. Brosky T, Nyland J, Nitz A, Caborn DNM. The ankle ligaments: consideration of syndesmotic injury and implications for rehabilitation. *J Orthop Sports Phys Ther,* 1995;21:197–205.
2. Lin CF, Gross ML, Weinhold P. Ankle syndesmosis injuries: anatomy, biomechanics, mechanism of injury, and clinical guidelines for diagnosis and intervention. *J Orthop Sports Phys Ther,* 2006;36:372–84.
3. Hopkinson WJ, St Pierre P, Ryan JB, et al. *Syndesmosis sprains of the ankle. Foot Ankle,* 1990;10:325–30.
4. Katznelson A, Lin E, Militiano J. *Ruptures of the ligaments about the tibio-fibular syndesmosis. J Injury,* 1983;15:170–2.
5. Alonso A, Khoury L, Adams R. Clinical tests for ankle syndesmosis injury: reliability and prediction of return to function. *J Orthop Sports Phys Ther,* 1998;27:276–84.
6. van den Bekerom MP, et al. *Syndesmotic stabilization in pronation external rotation ankle fractures. Clin Orthop Relat Res,* 2010;468:991–5.
7. Bartonícek J. Anatomy of the tibiofibular syndesmosis and its clinical relevance. *Surg Radiol Anat,* 2003;25: 379–86.
8. Huber T, Schmoelz W, Bolderl A. Motion of the fibula relative to the tibia and its alterations with syndesmosis screws: a cadaver study. *Foot Ankle Surg,* 2012;18: 203–9.
9. Ahl T, Dalén N, Lundberg A, et al.. *Mobility of the ankle mortise.* A roentgen stereophotogrammetric analysis. *Acta Orthop Scand* 1987;58:401–2.
10. Ogilvie-Harris DJ, Reed SC. Disruption of the ankle syndesmosis: diagnosis and treatment by arthroscopic surgery. *Arthroscopy,* 1994;10:561–8.
11. Ogilvie-Harris DJ, Reed SC, Hedman TP. Disruption of the ankle syndesmosis: biomechanical study of the ligamentous restraints. *Arthroscopy,* 1994;10:558–60.
12. Snedden MH, Shea JP. *Diastasis with low distal fibula fractures: an anatomic rationale. Clin Orthop Relat Res,* 2001;382:197–205.
13. Boytim MJ, Fischer DA, Neumann L. *Syndesmotic ankle sprains. Am J Sports Med,* 1991;19:294–8.
14. Lauge-Hansen N. Fractures of the ankle. II. Combined experimental–surgical and experimental–roentgenologic investigations. *Arch Surg.* 1950;60:957–85.
15. Wuest TK. *Injuries to the distal lower extremity syndesmosis. J Am Acad Orthop Surg.* 1997;5:172–81.
16. Kelikian H, Kelikian AS. *Correlative Anatomy of the Ankle Joint: Disorders of the Ankle.* Kelikian H, Kelikian AS (eds). Philadelphia: WB Saunders, 1985.
17. Magee DJ. *Orthopaedic Physical Assessment.* Philadelphia: WB Saunders, 1997.
18. Taylor DC, Englehardt DL, Bassett FH 3rd. *Syndesmosis sprains of the ankle. The influence of heterotopic ossification. Am J Sports Med,* 1992;20:146–50.
19. Fritschy D. *An unusual ankle injury in top skiers. Am J Sports Med.* 1989;17:282–6.
20. Zalavras C, Thordarson D. *Ankle syndesmotic injury. J Am Acad Orthop Surg,* 2007;15:330–9.
21. Van den Bekerom MP, Lamme B, Hogervorst M, et al.. *Which ankle fractures require syndesmotic stabilization? J Foot Ankle Surg.* 2007;46:456–63.
22. Beumer A, Swierstra BA, Mulder PG. Clinical diagnosis of syndesmotic ankle instability: evaluation of stress tests behind the curtains. *Acta Orthop Scand,* 2002; 73:667–9.
23. Stoffel K, Wysocki D, Baddour E, et al. Comparison of two intraoperative assessment methods for injuries to the ankle syndesmosis. A cadaveric study. *J Bone Joint Surg Am* 2009;91:2646–52.
24. Harper MC, Keller TS. *A radiographic evaluation of the tibiofibular syndesmosis. Foot Ankle* 1989;10: 156–60.

25. Hermans JJ, Wentink N, Beumer A, et al. Correlation between radiological assessment of acute ankle fractures and syndesmotic injury on MRI. *Skeletal Radiol* 2012; 41:787–801.
26. Oae K, Takao M, Naito K, et al. Injury of the tibiofibular syndesmosis: value of MR imaging for diagnosis. *Radiology* 2003;227:155–61.
27. Ebraheim NA, Taser F, Shafiq Q, Yeasting RA. Anatomical evaluation and clinical importance of the tibiofibular syndesmosis ligaments. *Surg Radiol Anat* 2006;28:142–9.
28. Brown KW, Morrison WB, Schweitzer ME, et al. MRI findings associated with distal tibiofibular syndesmosis injury. *AJR Am J Roentgenol* 2004;182:131–6.
29. Hermans JJ, Beumer A, Hop WCJ, et al. Tibiofibular syndesmosis in acute ankle fractures: additional value of an oblique MR image plane. *Skeletal Radiol* 2012;41: 193–202.
30. Takao M, Ochi M, Oae K, et al. Diagnosis of a tear of the tibiofibular syndesmosis. The role of arthroscopy of the ankle. *J Bone Joint Surg Br* 2003;85:324–9.
31. Lui TH, Ip K, Chow HT. Comparison of radinterosseous ligamentogic and arthroscopic diagnoses of distal tibiofibular syndesmosis disruption in acute ankle fracture. *Arthroscopy* 2005;21:1370.
32. Edwards GS Jr, DeLee JC. *Ankle diastasis without fracture*. Foot Ankle 1984;4:305–12.
33. Clanton TO, Paul P. *Syndesmosis injuries in athletes*. *Foot Ankle Clin* 2002;7:529–49.
34. Wright RW, Barile RJ, Surprenant DA, et al. *Ankle syndesmosis sprains in national hockey league players*. *Am J Sports Med* 2004;32:1941–5.
35. Grath GB. Widening of the ankle mortise. A clinical and experimental study. *Acta Chir Scand Suppl* 1960;263: 1–88.
36. Mast JW, Teipner WA. A reproducible approach to the internal fixation of adult ankle fractures: rationale, technique, and early results. *Orthop Clin North Am* 1980;11:661–79.
37. Lindsjo U. *Operative treatment of ankle fractures*. *Acta Orthop Scand* 1981;189:1–131.
38. Kennedy JG, et al. Evaluation of the syndesmotic screw in low Weber C ankle fractures. *J Orthop Trauma* 2000; 14:359–66.
39. Beumer A, et al. Effects of ligament sectioning on the kinematics of the distal tibiofibular syndesmosis: a radiostereometric study of 10 cadaveric specimens based on presumed trauma mechanisms with suggestions for treatment. *Acta Orthop* 2006;77:531–40.
40. Boden SD, Labropoulos PA, McCowin P, et al. Mechanical considerations for the syndesmosis screw. A cadaver study. *J Bone Joint Surg Am* 1989;71:1548–55.
41. Chissell HR, Jones J. The influence of a diastasis screw on the outcome of Weber type-C ankle fractures. *J Bone Joint Surg Br* 1995;77:435–8.
42. Fallat L, Grimm DJ, Saracco JA. Sprained ankle syndrome: prevalence and analysis of 639 acute injuries. *J Foot Ankle Surg* 1998;37:280–5.
43. Thompson MC, Gesink DS. Biomechanical comparison of syndesmosis fixation with 3.5- and 4.5-millimeter stainless steel screws. *Foot Ankle Int* 2000;21: 736–41.
44. Hansen M, Le L, Wertheimer S, et al. Syndesmosis fixation: analysis of shear stress via axial load on 3.5-mm and 4.5-mm quadricortical syndesmotic screws. *J Foot Ankle Surg* 2006;45:65–9.
45. Xenos JS, Hopkinson WJ, Mulligan ME, et al. The tibiofibular syndesmosis. Evaluation of the ligamentous structures, methods of fixation, and radiographic assessment. *J Bone Joint Surg Am* 1995;77:847–56.
46. Kukreti S, Faraj A, Miles JN. Does position of syndesmotic screw affect functional and radinterosseous ligamentogical outcome in ankle fractures? *Injury* 2005;36:1121–4.
47. Karapinar H, Kalenderer O, Karapinar L, et al. Effects of three- or four-cortex syndesmotic fixation in ankle fractures. *J Am Podiatr Med Assoc* 2007;97:457–9.
48. Moore JA Jr, Shank JR, Morgan SJ, et al. Syndesmosis fixation: a comparison of three and four cortices of screw fixation without hardware removal. *Foot Ankle Int* 2006;27:567–72.
49. Hoiness P, Stromsoe K. Tricortical versus quadricortical syndesmosis fixation in ankle fractures: a prospective, randomized study comparing two methods of syndesmosis fixation. *J Orthop Trauma* 2004;18:331–7.
50. Hsu YT, Wu CC, Lee WC, et al. Surgical treatment of syndesmotic diastasis: emphasis on effect of syndesmotic screw on ankle function. *Int Orthop* 2011;35:359–64.
51. Manjoo A, Sanders DW, Tieszer C, et al. Functional and radiographic results of patients with syndesmotic screw fixation: implications for screw removal. *J Orthop Trauma* 2010;24:2–6.
52. Cottom JM, Hyer CF, Philbin TM, et al. Treatment of syndesmotic disruptions with the Arthrex Tightrope: a report of 25 cases. *Foot Ankle Int* 2008; 29:773–80.
53. Zamzami MM, Zamzam MM. Chronic isolated distal tibiofibular syndesmotic disruption: diagnosis and management. *Foot Ankle Surg* 2009;15:14–9.
54. Hu YL, Yuan WQ, Wang LF, et al. A prospective randomized trial of poly-DL-lactic acid absorbable and metallic screws for treatment of syndesmotic disruptions. *Nan Fang Yi Ke Da Xue Xue Bao* 2010;30:2360–2.

55. Kaukonen JP, Lamberg T, Korkala O, et al. Fixation of syndesmotic ruptures in 38 patients with a malleolar fracture: a randomized study comparing a metallic and a bioabsorbable screw. *J Orthop Trauma* 2005;19:392–5.
56. Thordarson DB, Samuelson M, Shepherd LE, et al. Bioabsorbable versus stainless steel screw fixation of the syndesmosis in pronation-lateral rotation ankle fractures: a prospective randomized trial. *Foot Ankle Int* 2001;22:335–8.
57. Bava E, Charlton T, Thordarson D. Ankle fracture syndesmosis fixation and management: the current practice of orthopedic surgeons. *Am J Orthop (Belle Mead NJ)* 2010;39:242–6.
58. Schepers T, van Zuuren WJ, van den Bekerom MPJ, et al. The management of acute distal tibio-fibular syndesmotic injuries: results of a nationwide survey. *Injury* 2012;43:1718–23.
59. Kaye RA. Stabilization of ankle syndesmosis injuries with a syndesmosis screw. *Foot Ankle* 1989;9:290–3.
60. McBryde A, Chiasson B, Wilhelm A, et al. Syndesmotic screw placement: a biomechanical analysis. *Foot Ankle Int* 1997;18:262–6.
61. Seitz WH Jr, Bacher EJ, Abram LJ, et al. Repair of the tibiofibular syndesmosis with a flexible implant. *J Orthop Trauma* 1991;5:78–82.
62. Beumer A, Campo MM, Niesing R, et al. Screw fixation of the syndesmosis: a cadaver model comparing stainless steel and titanium screws and three and four cortical fixation. *Injury* 2005;36:60–4.
63. Hahn DM, Colton CL. *Malleolar fractures*. In: Rüedi TP, Murphy WM (ed). *AO Principles of Fracture Management*, Vol. 2. New York: Thieme, 2000, 559–81.
64. Cox S, Mukherjee DP, Ogden AL, et al. Distal tibiofibular syndesmosis fixation: a cadaveric, simulated fracture stabilization study comparing bioabsorbable and metallic single screw fixation. *J Foot Ankle Surg* 2005;44:144–51.
65. Partio EK, Hirvensalo E, Bostman O, et al. Absorbable rods and screws: a new method of fixation for fractures of the olecranon. *Int Orthop* 1992;16:250–4.
66. Yoshino N, Takai S, Watanabe Y, et al. Delayed aseptic swelling after fixation of talar neck fracture with a biodegradable poly-L-lactide rod: case reports. *Foot Ankle Int* 1998;19:634–7.
67. Böstman OM. Osteoarthritis of the ankle after foreign-body reaction to absorbable pins and screws: a three- to nine-year follow-up study. *J Bone Joint Surg Br* 1998; 80:333–8A.
68. De Vil J, Bonte F, Claes H, et al. *Bolt fixation for syndesmotic injuries*. *Injury* 2009;40:1176–9.
69. Naqvi GA, Shafqat A, Awan N. Tightrope fixation of ankle syndesmosis injuries: clinical outcome, complications and technique modification. *Injury* 2012;43:838–42.
70. Qamar F, Kadakia A, Venkateswaran B. *An anatomical way of treating ankle syndesmotic injuries*. *J Foot Ankle Surg* 2011;50:762–5.
71. Schepers T. Acute distal tibiofibular syndesmosis injury: a systematic review of suture-button versus syndesmotic screw repair. *Int Orthop* 2012;36: 1199–206.
72. Cottom JM, Hyer CF, Philbin TM, et al. Transosseous fixation of the distal tibiofibular syndesmosis: comparison of an interosseous suture and endobutton to traditional screw fixation in 50 cases. *J Foot Ankle Surg* 2009;48:620–30.
73. Klitzman R, Zhao H, Zhang LQ, et al. Suture-button versus screw fixation of the syndesmosis: a biomechanical analysis. *Foot Ankle Int* 2010;31:69–75.
74. Bell DP, Wong MK. Syndesmotic screw fixation in Weber C ankle injuries—should the screw be removed before weight bearing? *Injury* 2006;37:891–8.
75. Needleman RL, Skrade DA, Stiehl JB. *Effect of the syndesmotic screw on ankle motion*. *Foot Ankle* 1989;10: 17–24.
76. Hamid N, Loeffler BJ, Braddy W, et al. Outcome after fixation of ankle fractures with an injury to the syndesmosis: the effect of the syndesmosis screw. *J Bone Joint Surg Br* 2009;91:1069–73.
77. Schepers T. *To retain or remove the syndesmotic screw: a review of literature*. *Arch Orthop Trauma Surg* 2011; 131:879–83.
78. Schepers T. Complications of syndesmotic screw removal. *Foot Ankle Int* 2011.
79. Jordan TH, Talarico RH, Schuberth JM. The radiographic fate of the syndesmosis after trans-syndesmotic screw removal in displaced ankle fractures. *J Foot Ankle Surg* 2011;50:407–12.
80. Mukhopadhyay S, Metcalfe A, Guha AR, et al. *Malreduction of syndesmosis—are we considering the anatomical variation*. *Injury* 2011;42:1073–6.
81. Frankie J. Intraoperative three-dimensional imaging in the treatment of acute unstable syndesmotic injuries. *J Bone Joint Surg Am* 2012. 2011.
82. Gardner MJ, Demetrakopoulos D, Briggs SM, et al. Malreduction of the tibiofibular syndesmosis in ankle fractures. *Foot Ankle Int* 2006;27:788–92.
83. Parlamas G. Treatment of chronic syndesmotic injury: a systematic review and meta-analysis. *Knee Surg Sports Traumatol Arthrosc* 2013.
84. Morris MW, Rice P, Scheider TE. Distal tibiofibular syndesmosis reconstruction using a free hamstring autograft. *Foot Ankle Int* 2009;30:506–11.
85. Yasui Y, Takao M, Miyamoto W, et al. Anatomical reconstruction of the anterior inferior tibiofibular ligament for chronic disruption of the distal tibiofibular

syndesmosis. *Knee Surg Sports Traumatol Arthrosc* 2011;19:691–5.
86. Grass R, Rammelt S, Biewener A, et al. Peroneus longus ligamentoplasty for chronic instability of the distal tibiofibular syndesmosis. *Foot Ankle Int* 2003;24:392–7.
87. Lui TH. Tri-ligamentous reconstruction of the distal tibiofibular syndesmosis: a minimally invasive approach. *J Foot Ankle Surg* 2010;49:495–500.
88. van Dijk CN. *Syndesmotic injuries*. *Tech Foot Ankle Surg* 2006;5:34–7.
89. Olson KM, Dairyko GH Jr, Toolan BC. Salvage of chronic instability of the syndesmosis with distal tibiofibular arthrodesis: functional and radiographic results. *J Bone Joint Surg Am* 2011;93:66–72.
90. Leeds HC, Ehrlich MG. Instability of the distal tibiofibular syndesmosis after bimalleolar and trimalleolar ankle fractures. *J Bone Joint Surg Am* 1984;66:490–503.
91. Ramsey PL, Hamilton W. *Changes in tibiotalar area of contact caused by lateral talar shift*. *J Bone Joint Surg Am* 1976;58:356–7.