Curr Rev Musculoskelet Med (2013) 6:313–319
DOI 10.1007/s12178-013-9183-x

Syndesmosis injuries of the ankle

**Angelo Del Buono · Antonietta Florio ·
Michele Simone Boccanera · Nicola Maffulli**

Published online: 14 August 2013

Abstract Ankle syndesmosis injuries are relatively frequent in sports, especially skiing, ice hockey, and soccer, accounting for 1 %–18 % of all ankle sprains. The evolution is unpredictable: When missed, repeated episodes of ankle instability may predispose to early degenerative changes, and frank osteoarthritis may ensue. Diagnosis is clinical and radiological, but arthroscopy may provide a definitive response, allowing one to address secondary injuries to bone and cartilage. Obvious diastasis needs to be reduced and fixed operatively, whereas less severe injuries are controversial. Nonoperative treatment may be beneficial, but it entails long rehabilitation. In professional athletes, more aggressive surgical treatment is warranted.

Keywords Syndesmosis injury · Diagnosis · Management · Comprehensive review

Introduction

Quenu first published a case of tibiofibular diastasis after ligamentous disruption more than a century ago [1]. The recognition of this injury promoted further research and raised many controversial topics still debated today. Ankle syndesmosis injuries are relatively frequent in sports, especially skiing, ice hockey, and soccer, accounting for 1 %–18 % of all ankle sprains [2]. Even though the real incidence has likely been underestimated, since misdiagnosis and mistreatment have been frequent, the greater awareness of these injuries and the widespread use of MRI have called the attention of physicians to this injury. The fact that no standard diagnostic criteria have been used makes diagnosis controversial, and available studies lack consistency on this matter. The pattern of lesion may therefore change, ranging from simple isolated sprains of the syndesmosis to frank diastasis that involves ligaments, bone, and cartilage within and around the ankle joint. Generally, pain is prolonged and discomfort is typical, but the main frustrating issue is the time healing takes and the time athletes are forced to be away from sport, especially considering that syndesmosis injuries are the most common cause of chronic ankle dysfunction 6 months from the trauma [3] and the time to return to sport is at least twice the time taken to recover after isolated lateral ligament sprains [4]. The evolution is therefore unpredictable: When missed, repeated episodes of ankle instability may predispose to early degenerative changes, and frank osteoarthritis may ensue [5]. Clinical tests and imaging tools have improved, but many aspects of syndesmosis injuries are still poorly understood. This article reviews the evidence-based literature on syndesmosis injuries in order to provide a comprehensive scenario for the anatomy, diagnosis, and management of these lesions.

A. Del Buono (✉) · A. Florio
Department of Orthopaedic and Trauma Surgery, Campus Biomedico University of Rome, Via Alvaro del Portillo, Rome, Italy
e-mail: angelo_delbuono@libero.it

M. S. Boccanera
Department of Orthopaedic and Trauma Surgery, Hospital "San Giovanni Evangelista", Tivoli, Italy

N. Maffulli
Department of Musculoskeletal Disorders, University of Salerno, Salerno, Italy

N. Maffulli
Centre for Sports and Exercise Medicine, Barts and The London School of Medicine and Dentistry, Mile End Hospital, 275 Bancroft Road, London E1 4DG, England, UK

Anatomy

The syndesmosis is a strong ligamentous complex that connects the distal aspect of the fibula and the tibial notch between the anterior and posterior tibial tubercles. It includes the anterior inferior tibiofibular ligament (AITFL), the interosseous ligament (IOL), the posterior inferior tibiofibular ligament (PITFL), and the transverse tibiofibular ligament (TTFL), which merges with the posterior capsule of the ankle joint [6]. The anterior and posterior aspects of the syndesmosis are formed by the AITFL and PITFL, respectively. The TTFL is a fibrocartilagenous-like structure that functions as a labrum and reinforces the posterior capsule of the ankle joint and the PITFL, deeply. The IOL is a pyramid-shaped structure that contains strong and short fanlike fibers lying in the distal tibiofibular space to form the main attachment point between the tibia and fibula [7].

Even though the ankle joint is stable, some movements occur between the fibula and tibia, especially when applying external rotation loads, when the fibula rotates externally and translates posteriorly. Specifically, the AITFL restrains the external rotation of the fibula, the PITFL is the primary restraint to the posterior translation, and the IOL, which merges proximally with the interosseous membrane, limits the lateral translation of the fibula [8]. The deep fibers of the deltoid ligament also provide some stability to the mortise by reducing the external rotation and lateral translation of the talus [6]. The inherent stability of the distal tibiofibular joint is also conferred by the bony congruence between the distal fibula and the incisura fibularis of the tibia. On the basis of the size of the tibial tubercles, this incisura may be concave (75 %), convex (16 %), irregular, and gender specific, with some differences appreciated at computed tomography (CT) between genders [9]. This variability is challenging from both a diagnostic and management viewpoint.

Biomechanics and mechanism of injury

The talus is an irregular bone, broad anteriorly and laterally, with an oblique axis. This shape makes ankle movements more complex than those of a simple hinge joint. Specifically, in ankle dorsiflexion, the distal fibula rotates externally and translates proximally and laterally to better accommodate the incongruence of the talus [10]. In the static stance phase, the ankle joint is stable and well suited to bear pressures and loads equal to the individual's body weight [11]. On the other hand, many patterns of different forces are transmitted through the foot and ankle in high-impact weight-bearing activities, and enormous pressures thus stress the mortise. This is the reason for the susceptibility to injury of the syndesmosis. From a cadaveric study, it emerged that the AITFL confers 35 %, the TTFL 33 %, the IOL 22 %, and the PITFL 9 % of the overall tibiofibular stability, with evidence of severe instability when two of the ligaments are disrupted [12]. When the AITFL is transected, the combined lateral translation (2 mm), shortening (2 mm), and external rotation (5°) of the fibula will significantly decrease the contact area between the tibia and talus, it will increase the contact pressures, and the mortise will be deformed. These parameters are all prognostic for long-term arthritis, which ensues from abnormal loading distributions [13]. The AITFL is the part of the complex most frequently torn; the PITFL (the posterior part of the syndesmosis) is the strongest portion of the complex. The main mechanism of injury is an external rotation force transmitted through the foot and ankle with the ankle dorsi-flexed and the foot pronated [6]. Specifically, the moment of talar rotation within the mortise, combined with external rotation and lateral and posterior translation of the fibula, injures sequentially the AITFL, the deep deltoid complex, the IOL, and the PITFL [14], disrupting talar stability. However, hyperdorsiflexion and inversion, combined with inversion and external rotation, may also occur [15]. Higher grades of syndesmotic injury usually occur after a trauma in external rotation; in inversion, the AITFL is mainly involved, alone or, at times, together with the ATFL.

Diagnosis

The history of the trauma and the mechanism of injury are relevant for diagnosis. Inability to weight-bear, pain during the push-off phase of gait, pain in the anterolateral aspect of the ankle, swelling, and giving way may be present [16], but none of these symptoms is specific for syndesmosis disruption and may also occur after other ankle injuries. A high ankle pain, proximal, extending up to the anterolateral aspect of the leg, may be indicative of a more severe injury [16]. Hence, the practitioner needs to maintain a high index of suspicion to glean relevant details regarding the mechanism of injury to differentiate a syndesmotic injury from other lateral ankle injuries [17, 18]. It is also imperative to document the interval between injury and clinical presentation. The temporal classification of acute (<3 weeks), subacute (3 weeks to 3 months), or chronic (>3 months) will be crucial for the management of these injuries [19].

As in all ankle injuries, physical examination must involve a systematic approach. Bruising and soft-tissue edema should be appreciated in the anterolateral aspect of the ankle. By palpation of the malleoli and other bony landmarks, including the proximal fibula, major ligamentous areas should be assessed to exclude associated problems. Many tests have been described. In the squeeze test, pain is elicited over the ankle joint as the distal tibia and fibula separate when the leg is compressed at or slightly above mid-calf level. In the external rotation test, the mechanism of injury is reproduced with the ankle dorsiflexed and the foot externally rotated: The test will be positive if the patient complains of pain. The test may also be undertaken with the patient standing and rotating the body with the foot on the ground. Pain over the anterolateral region of the ankle joint elicited in passive dorsiflexion may induce one to suspect a syndesmotic injury but is not specific. Alonso et al. studied the external rotation test, the squeeze test, and the dorsiflexion test by pairing physical therapists [20]. There was high agreement among examiners (kappa value of 0.75) when using only the external rotation test. Local tenderness, the length of the area of tenderness, and a positive squeeze test may predict injury severity and time to return to sports [16]. Local tenderness may be reported over the course of the AITFL, but it is not specific, especially in acute cases, since it is appreciated in 40 % of patients with injuries to the anterior talofibular ligament (ATFL) after ankle supination, without any evidence at arthroscopy of ligament disruption [21]. The fibular translation test, the Cotton test, and the crossover leg test have been also described [22••]. In the fibular translation test, the examiner attempts to move the fibula in the anterior–posterior plane: An increased translation, as compared with the contralateral side, and ankle pain may be indicative of a syndesmosis injury. When the Cotton test is performed, the talus is translated within the mortise in the medial–lateral plane: Increased translation and pain indicate a positive test. In the crossed-leg test, the patient is seated with the mid-fibula of the injured leg on the knee of the uninvolved leg; the involvement of the syndesmosis is suspected if pain is felt when the knee of the affected leg is pushed toward the ground. Beumer et al. assessed the ability of seven examiners to detect syndesmotic injuries using the fibular translation, Cotton, squeeze, and external rotation tests [23]. Three patients with a suspected syndesmotic injury and 9 normal ankles (12 ankles total) were examined. The following day, at arthroscopy, 2 of 3 injured ankles had a syndesmotic injury. The external rotation test had the lowest interobserver error and the highest sensitivity. The injury was missed in 25 % of examinations. Comparing MRI-confirmed syndesmotic injuries and external rotation and squeeze tests, the squeeze test has 30 % sensitivity and 93.5 % specificity, whereas the external rotation test has 20 % and 84.5 %, respectively [24]. A stabilization test consists of tightly binding the tibia and fibula together with a tape. With this maneuver, the distal syndesmosis will be considered stabilized if the pain is reduced after the patient is asked to stand, toe raise, perform a knee-to-wall test, and jump [25].

Even though some attempts have been made to improve the accuracy of these tests, there are some problems with all these studies. In fact, the resection of all the ligaments of the syndesmosis in cadavers will, on average, increase the translation of the fibula under stress by 8.8 mm in the sagittal plane and 1.5 mm in the coronal plane [24]. These findings may be appreciated clinically but do not reflect what is really detected in common injuries in athletes. In fact, most of these injuries are mild to moderate, involving only the AITFL and IOL. On the other hand, the increased translation of 0.5 mm in both the planes after resection of the AITFL alone may not be appreciated on clinical examination. Even though the rate of missed injuries is high, these clinical tests are important for suspecting the injury and promoting further investigation.

Standard radiographs of the ankle, comprising weight-bearing anteroposterior, mortise, and lateral views, should be the first set of investigations when a syndesmosis injury is suspected. A fracture or diastasis and avulsions of the distal tibia may be detected. A tibiofibular clear space greater than 6 mm located 1 cm above the plafond is suggestive of syndesmosis injury, whereas a medial clear space between the medial malleolus and the talus may be suggestive of syndesmotic and deltoid disruption [26]. The ability to accurately detect less severe injury on plain films is questionable, since it is not possible to correctly position the ankle. The use of stress views is controversial, producing a high false-negative rate in acute injuries, with low accuracy to visualize slight changes in external rotation of the fibula on stress radiographs after resection of the AITFL and IOL [27].

CT may show small avulsion fractures and provides greater accuracy than do radiographs in assessing the relationship between the tibia and fibula [28]. The contralateral limb should be examined, since a displacement difference greater than or equal to 2 mm is pathological. MRI displays the structures of the syndesmosis and, as compared with arthroscopy, has 93 % specificity and 100 % sensitivity for AITFL injuries and 100 % sensitivity and specificity for PITFL tears [29]. However, sensitivity and specificity may differ in more subtle injuries.

Ultrasound scanning is cheap and quick, and, as was observed in a controlled study, the tibiofibular clear space increases during stress ultrasonography in patients with AITFL injuries, with sensitivity and specificity comparable to those with MRI [30]. Nevertheless, ultrasonography cannot assess secondary injuries to cartilage and bone. Arthroscopy is useful for diagnosis and management of both syndesmotic and osteochondral injuries [31, 32].

Classification

Syndesmosis injuries have been classified both chronologically and radiographically. Chronologically, syndesmosis injuries may be acute (within first 3 weeks of injury), subacute (3 weeks to 3 months), and chronic (beyond 3 months).

In the system by Edwards and DeLee [33], traumatic syndesmotic diastases are classified as latent or frank. The frank diastasis may be type I, a frank diastasis with lateral subluxation of the fibula without fracture; type II, when the fibula is plastically deformed in addition and laterally subluxated; type III, which involves posterior subluxation or dislocation of the fibula; and type IV, which involves superior wedging of the talus into the mortise. The West Point Ankle Grading System classifies pure ligamentous syndesmosis injuries into three grades, based on the degree of instability, and the criteria used for its determination are ability to bear weight, the extent of the edema, the localization of tenderness, response to provocative stress tests, and evidence of radiographic widening observed. Grade I suggests no instability, grade II suggests some evidence of instability, and grade III indicates definite instability [3]. Since these grades may be thought of as a spectrum of tears instead of true categories in themselves, it may be difficult to distinguish between, for example, grade I and grade II tears. In the same way, functional treatment of grade I and grade II injuries did not show differences in their outcomes. At present, there is no classification system that allows clear definition of the degree of injury, guidance of treatment, or prediction of outcome. Clinicians base their decisions on the signs and symptoms of individual patients, their level of activity and expectations, and an interpretation of the severity of the diastasis as revealed by imaging studies.

Management

Acute syndesmotic injury

Conservative management

Syndesmosis sprains without diastasis usually heal after conservative management. In athletes, the issue is to tailor a program relying on their specific need, in order to allow them to return safely and early to their preinjury activity level. In general, a three-phase approach is used [16]. The first phase aims to protect the ankle and limit inflammation and pain, through the traditional RICE (rest, ice, compression, and elevation of the limb) formula. Concerning immobilization and weight-bearing, the level of weight-bearing recommended depends on the severity of injury and symptoms, but it should be assisted until normal gait has resumed. In the second phase (subacute phase), joint mobilization, strength training, and restoration of basic ankle functions are recommended. The third phase implies that the athlete undertakes advanced training of proprioception and neuromuscular control through sports-specific drills, such as cutting, pivoting, shuffling, and jumping. It is controversial to understand the time an athlete would be able to return to sport. This treatment provides an overall rate of good to excellent outcomes of 86 %–100 %, and almost all patients achieve full return to sports [34].

Surgery

Operative stabilization of acute injuries includes screw fixation, dynamic fixation with a suture button, or direct repair of the AITFL with or without suture anchors. The main indication to surgery is an acute syndesmotic injury with frank or latent diastases. However, there are some exceptions, such as a latent diastasis of the fibula anatomically reduced, documented on CT or MRI; a frank diastasis with posterior subluxation or dislocation of the fibula (Edwards and DeLee type III) or superior subluxation or dislocation of the talus into the mortise (Edwards and DeLee type IV) reduced after closed longitudinal traction. In adults, pure ligamentous diastases of the distal tibiofibular joint are more common than osteoligamentous avulsions from the anterior tubercle of the fibula or distal tibia. In patients with pure ligamentous injuries, indirect reduction and percutaneous fixation are frequently performed through an anterolateral approach [11]; it allows inspection of the space directly and removal of any osteofibrocartilaginous debris that may hinder anatomic reduction [35]. It is recommended to proceed with blunt dissection of the subcutaneous layer to avoid excessive traction on the branches of the superficial peroneal nerve. When accurate reduction cannot be achieved, a separate medial incision may be necessary to explore the medial compartment and free it from the interposed deltoid ligament (with repair or reattachment of the deep deltoid) or capsular tissue. The distal tibiofibular joint is reduced using bimalleolar reduction clamps, while repeated fluoroscopic examinations ensure that the fibula is reduced properly before definitive fixation. The fixation of pure ligamentous syndesmosis injuries may be rigid or semirigid. Trans-syndesmosis screws may be classically placed proximal and parallel to the ankle joint. Since some motion between the distal tibia and fibula is physiological in the rotational and proximal–distal planes, semirigid would be indicated more than a rigid fixation. Suture buttons provide adequate tension across the syndesmosis and maintain a dynamic relationship, with promising results comparable to those observed after implant of a 4.5-mm screw fixed across four cortices, with shorter rehabilitation, faster return to work, and no complications [36]. There is also biomechanical evidence that a suture button provides less syndesmotic reduction, as compared with the metallic screw, since it fails to withstand the forces imparted to the ankle, particularly rotational forces [37]. When large fragments are avulsed from the Chaput or Wagstaffe tubercle, they should be fixed with a small screw and, if possible, reinforced with a washer. When the fragment is too small to be fixed, it may be excised, and the ligament repaired with suture anchors. Thirteen percent of these injuries occur concomitantly with ankle fractures, mostly Weber C and, at times, Weber B fractures. In such instances, anatomic fixation of the fracture is necessary to allow proper reduction of the distal tibiofibular joint. If the malleolar fracture is mal-reduced, it will result in unsatisfactory reduction of the syndesmosis and unsatisfactory outcomes [38]. A syndesmosis width greater than 1.5 mm may result in poor outcomes. In fact, the reduction of the syndesmosis is the main predictor of functional outcomes after trans-syndesmosis screw fixation of ankle fractures [38]. There appears to be no clinical difference when using quadricortical or tricortical screws, but, biomechanically, two tricortical 3.5-mm screws are more stable than one screw and are recommended in heavier individuals or in highly unstable injuries. Even though two tricortical screws provide secure fixation, they are less secure than quadricortical screws. On the other hand, quadricortical screws are more likely to break because of the rigidity of the fixation and should definitely be removed prior to weight-bearing. Some authors have suggested that diastasis screw fixation is unnecessary and will not compromise the final functional results [39]. On the other hand, the severity of the injury of the medial structures of the ankle, the integrity of the deltoid ligament, the presence of medial malleolus fracture, and the level of fibular fracture should be considered in the preoperative planning. In general, an initial period of non-weight-bearing should be followed by progressive weight-bearing postoperatively. The syndesmosis screw should be removed only after healing has occurred, at least 6 weeks after surgery. When the screws are left permanently, osteolysis or breakage are likely to occur as normal motion and function of the ankle are restored [40].

Chronic syndesmosis injury

Symptoms of chronic syndesmosis injury are often vague. Persistent ankle pain, repeated giving-way episodes, stiffness, limited dorsiflexion, and impossibility of practicing sport at the preinjury level are common, with evidence of tenderness and swelling over the anterolateral aspect of the ankle [41]. Weight-bearing and stress radiographs may further confirm the suspicion, and comparison with the contralateral limb is needed. Chronic injuries make the syndesmosis unstable and may induce degenerative changes in the ankle. Surgery aiming to relieve symptoms without restoring the stability of the joint may be useful. Arthroscopy and chondroplasty may improve symptoms, in the short term, by removal of the hypertrophic layer that impinges against the lateral talar dome and of adhesions within the syndesmosis. Stability would be restored in elite athletes. Lag screws and cancellous screws have been successfully used for fixation of chronic unstable syndesmosis injuries. In athletes with chronic syndesmosis injuries without diastasis or fracture, arthroscopic debridement and percutaneous transsyndesmotic screw fixation for 8–10 weeks have been used with good to excellent results in 85 % of them at a minimum of 6 months. Reconstruction of syndesmotic ligaments aims to restore the dynamics of the distal tibiofibular joint. An autologous peroneus brevis tendon may be used to reconstruct the AITFL and PITFL. More recently, the peroneal longus tendon has been successfully used. The tendon is split and weaved through a bone tunnel into the distal tibia parallel to the fibular incisura and through two channels in the distal fibula at 45° to each other, to reproduce the AITFL, IOL, and PITFL complex. At an 18-month follow-up, 15 of 16 patients improved in pain and stability [40]. Arthrodesis of the ankle syndesmosis may also be performed as a salvage procedure in patients with pain, arthritis, and chronic syndesmotic instability. This procedure is indicated when other strategies have failed. The site of syndesmosis fusion may be stripped and packed with bone graft and fixed using two syndesmosis screws and a plate [42•]. In chronic syndesmosis injuries, the pooled success rates for screw fixation, arthrodesis, and arthroscopic debridement each exceeded 78 %, but the current evidence is limited to prospective and retrospective case series [42•].

State of art and perspective for the future

Fixation of the syndesmosis is traditionally and commonly performed with the foot in maximum dorsiflexion to allow the widest anterior part of the talus to engage into the mortise and avoid overcompression of the mortise and subsequent postoperative limitation of range of motion [19]. The number of screws used, their size, and the number of cortices fixed are also controversial. Traditionally, one or two metallic screws are used to engage across three or four cortices to stabilize the syndesmosis. One screw may be sufficient in a Weber C fracture, but an additional screw may be beneficial in acute isolated diastasis without fracture or with a Maisonneuve fracture, where the fibula fracture is not primarily fixed. Tricortical fixation is biomechanically adequate to fix the distal tibiofibular joint in position; quadricortical fixation is beneficial when screw breakage occurs, since direct access to the broken fragment from the tibial end will enable its easy retrieval. Cortical screw sizes of 4.5 and 3.5 mm have been used for fixation, although the optimal screw size has not been defined. In cases of diastasis associated with a high fibular fracture, two metallic 3.5-mm cortical screws placed parallel to and 2–4 cm proximal to the ankle joint line are used, entering from the posterolateral aspect of the distal fibula and directed 30° anterior into the tibia. When the fibula fracture is lower, the fracture is fixed anatomically before the syndesmosis is tested intraoperatively for instability by pulling laterally on the distal fibula using a bone hook [19]. If widening is demonstrated, trans-syndesmotic fixation with a single screw will suffice. Several weeks of non–weight-bearing are recommended during healing while the screw is in place. It is difficult to determine precisely when healing is complete, when the screw may be removed safely, and when weight-bearing should commence. Some investigators prefer to remove the screw 3 months postoperatively at the earliest. Others allow graduated weight-bearing starting at 6 weeks postoperatively with the screw in situ, with average time for removal at 8–10 weeks. Bioabsorbable screws are widely used because they do not need to be removed and provide clinical and functional outcomes comparable to those of metallic screws. On the other hand, biodegradable polylactic and polyglycolic screws may induce local inflammatory and osteolytic foreign-body adverse reactions. In cases of athletes with high ankle sprain without fracture in whom the length of the fibula is maintained, tightrope stabilization may be recommended. Postoperatively, an Aircast boot should be worn for 4 weeks, recommending that the patient should not weight-bear for the first 2 weeks, then weight-bear as tolerated [22••]. There is controversy with regard to whether nonoperative treatment or early surgery should be recommended for syndesmosis injuries with no evidence of widening on radiographs [22••]. However, anatomic reduction of the syndesmotic joint should be achieved and maintained until it heals.

Even though weight–bearing protocols change on the basis of the type of management, most of them provide grossly comparable outcomes. After conservative management, plaster immobilization without weight-bearing is recommended for 6–8 weeks, followed by physiotherapy [43].

After surgery, when screw fixation is undertaken, partial weight-bearing is recommended until such time as the screw will be removed [44]. The screw is removed 6–8 weeks after surgery in patients with syndesmosis injury associated with bone fractures or, when only the syndesmosis is injured, after 10–12 weeks [45]. When the lesion is repaired with a suture button, patients are instructed to practice splint-wearing and slight weight-bearing for 2–3 weeks and then partial weight-bearing as tolerated and with regard to rehabilitation. Total weight-bearing is allowed 2 months after the index surgery [46].

Conclusions

Syndesmosis injuries are difficult to diagnose and manage and may lead to significant time loss from sport and disability. Accurate diagnosis and appropriate treatment are crucial to preventing disability and the occurrence of early degenerative changes to the ankle. Obvious diastasis needs to be reduced and fixed operatively; the management of less severe injuries is controversial, with little evidence to guide management protocols. Nonoperative treatment may have good results, but it entails a lengthy rehabilitation period. In professional athletes, more aggressive surgical treatment is warranted. Arthroscopy may be a valid diagnostic tool. Diagnostic and therapeutic guidelines are still needed.

Compliance with ethics Guidelines

Conflict of Interest Angelo Del Buono, Antonietta Florio, Michele Simone Boccanera, and Nicola Maffulli declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of main importance

1. Quenu E. Du diastasis de l'articulation tibio-peronie're inferieure. Rev Chir (Paris). 1907;36:62–90.
2. Jones M, Amendola A. Syndesmosis sprains of the ankle: a systematic review. Clin Orthop Relat Res. 2007;455:173–5.
3. Gerber J, Williams G, Scoville C, Arciero R, Taylor D. Persistent disability associated with ankle sprains: a prospective examination of an athletic population. Foot Ankle. 1998;19:653–60.
4. Wright R, Barlie J, Suprent D, Matave M. Ankle syndesmosis sprains in national hockey league players. Am J Sports Med. 2004;32:1941–5.
5. Williams G, Jones M, Amendola A. Syndesmotic ankle sprains in athletes. Am J Sports Med. 2007;35:1197–207.
6. Xenos J, Hopkinson W, Mulligan M, Olson E, Popovic N. The tibiofibular syndesmosis: evaluation of the ligamentous structures, methods of fixation, and radiographic assessment. J Bone Joint Surg Am. 1995;77-A:847–56.
7. Bartonicek J. Anatomy of the tibiofibular syndesmosis and its clinical relevance. Surg Radiol Anat. 2003;25:379–86.
8. Brown K, Morrison W, Schwetzer M, Parellada A, Nothnagel H. MRI findings associated with distal tibiofibular syndesmosis injuries. Am J Roentgenol. 2004;182:131–6.
9. Elgafy H, Semaan H, Blessinger B, Wassef A, Ebraheim N. Computed tomography of normal distal tibiofibular syndesmosis. Skeletal Radiol. 2010;39:559–64.
10. Pena F, Coetzee J. Ankle syndesmosis injuries. Foot Ankle Clin. 2006;11:35–50.
11. Rammelt S, Zwipp H, Grass R. Injuries to the distal tibiofibular syndesmosis. Foot Ankle Clin. 2008;13:611–33.
12. Ogilvie-Harris D, Reed S. Disruption of the ankle syndesmosis: diagnosis and treatment by arthroscopic surgery. Arthroscopy. 1994;10:561–8.
13. Thordarson D, Motamed S, Hedman T, Ebramzadeh E, Bakshian S. The effect of fibular malreduction on contact pressures in an ankle fracture malunion model. J Bone Joint Surg Am. 1997;79:1809–15.
14. Beumer A, Valstar E, Garling E, Neising R. Effects of ligament sectioning on the kinematics of the distal tibiofibular syndesmosis. Acta Orthop Scand. 2006;77:531–40.
15. Zalavras C, Thordarson D. Ankle syndesmosis injury. J Am Acad Orthop Surg. 2007;15:330–9.
16. Nussbaum E, Hosea T, Sieler S, Incremona B, Kessler D. Prospective evaluation of syndesmotic ankle sprains without diastasis. Am J Sports Med. 2001;29:31–5.
17. Nery C, Raduan F, Del Buono A, Asaumi I, Cohen M, Maffulli N. Arthroscopic-assisted Broström-Gould for chronic ankle instability: a long-term follow-up. Am J Sports Med. 2011;39:2381–8.
18. Del Buono A, Aweid O, Coco M, Maffulli N. Ankle instability: what do we know and what is the future? Fuß Sprunggelenk. 2013;11:3–8.
19. Mak M, Gartner L, Pearce C. Management of syndesmosis injuries in the elite athlete. Foot Ankle Clin. 2013;18:195–214.
20. Alonso A, Khoury L, Adams R. Clinical tests for ankle syndesmosis injury: reliability and return of function. J Orthop Sports Phys Ther. 1998;27:276–84.
21. Van Dijk CN, Mol BW, Lim LS, Marti RK, Bossuyt PM. Diagnosis of ligament rupture of the ankle joint. Physical examination, arthrography, stress radiography and sonography compared in 160 patients after inversion trauma. Acta Orthop Scand. 1996;67:566–70.
22. •• McCollum G, van den Bekerom M, Kerkhoffs G, Calder J, van Dijk C. Syndesmosis and deltoid ligament injuries in the athlete. Knee Surg Sports Traumatol Arthrosc. 2013;21:1328–37. *This systematic review assessed how management of syndesmotic injury is related to the grade and associated injury within and around the ankle. Grade I injuries are treated nonsurgically; treatment of grade II and III injuries is controversial, with little literature to guide management*.
23. Beumer A, Swiestra B, Moulders P. Clinical diagnosis of syndesmosis instability: evaluation of stress tests behind the curtains. Acta Orthop Scand. 2002;73:667–9.
24. Candal-Couto J, Burrow D, Bromage S, Briggs P. Instability of the tibiofibular syndesmosis: have we been pulling in the wrong direction? Injury. 2004;35:814–8.

25. Wolf B, Amendola A. Syndesmosis injuries in the athlete. When and how to operate. Curr Opin Orthop. 2002;31:151–4.
26. Cesar de Cesar P, Muller E. Comparison of MRI to physical examination for syndesmotic injuries after lateral ankle sprain. Foot Ankle Int. 2011;32:10–6.
27. Press C, Gupta A, Hutchinson M. Management of ankle syndesmosis injuries in the athlete. Curr Sports Med Rep. 2009;8:228–33.
28. Gardner M, Demetrakopoulos D, Briggs S, Helfet D, Lorich D. Malreduction of the tibiofibular syndesmosis in ankle fractures. Foot Ankle Int. 2006;27:788–92.
29. Takao M, Ochi M, Oae K. Diagnosis of a tear of the distal tibiofibular syndesmosis. The role of arthroscopy of the ankle. J Bone Joint Surg Br. 2003;85-B:324–9.
30. Mei Dan O, Kotz E, Barchilon V, Massarwe S, Nyska M, Mann G. A dynamic ultrasound examination for the diagnosis of ankle syndesmotic injury in professional athletes: a preliminary study. Am J Sports Med. 2009;37:1009–16.
31. Ogilvie-Harris D, Gilbart M, Chorney K. Chronic pain following ankle sprains in the athlete: the role of arthroscopic surgery. Arthroscopy. 1997;13:564–74.
32. Rolf C, Barclay C, Riyami M, George J. The importance of early arthroscopy in athletes with painful cartilage lesions of the ankle: a prospective study of 61 consecutive cases. J Orthop Surg Res. 2006;1
33. Edwards G, DeLee J. Ankle diastasis without fracture. Foot Ankle. 1984;4:305–12.
34. Amendola A, Williams G, Foster D. Evidence-based approach to treatment of acute traumatic syndesmosis (high ankle) sprains. Sports Med Arthrosc. 2006;12:232–6.
35. Clanton T, Paul P. Syndesmosis injuries in athletes. Foot Ankle Clin. 2002;7:529–49.
36. Thornes B, Shannon F, Guiney A, Hession P, Masterson E. Suture-button syndesmosis fixation: accelerated rehabilitation and improved outcomes. Clin Orthop Relat Res. 2005;431:207–12.
37. Forsythe K, Freedman K, Stover M, Patwardhan A. Comparison of a novel FiberWire-button construct versus metallic screw fixation in a syndesmotic injury model. Foot Ankle Int. 2008;29:49–54.
38. Weening B, Bhandari M. Predictors of functional outcome following transsyndesmotic screw fixation of ankle fractures. J Orthop Trauma. 2005;19:102–8.
39. Chissell H, 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.
40. Grass R, Rammelt S, Biewener A, Zwipp H. Peroneus longus ligamentoplasty for chronic instability of the distal tibiofibular syndesmosis. Foot Ankle Int. 2003;24:392–7.
41. Tornetta P, Spoo J, Reynolds F, Lee C. Overtightening of the ankle syndesmosis: is it really possible? J Bone Joint Surg Am. 2001;83-A:489–92.
42. • Parlamas G, Hannon C, Murawski C, Smyth N, Ma Y, Kerkhoffs G, et al. Treatment of chronic syndesmotic injury: a systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc. *This meta-analysis showed that the broad surgical treatments for chronic syndesmosis injuries are screw fixation, arthrodesis, and arthroscopic debridement. The pooled rates of success for screw fixation, arthrodesis, and arthroscopic debridement were 87.9%, 79.4%, and 78.7 %, respectively*.
43. Ruedi TP, Murphy WM. AO principles of fracture management. CIC Editor 2002;559–580.
44. Schepers T. To retain or remove the syndesmotic screw: a review of literature. Arch Orthop Trauma Surg. 2011;131:879–83.
45. Schepers T, Van Lieshout EM, Van der Linden HJ, De Jong VM, Goslings JC. Aftercare following syndesmotic screw placement: a systematic review. J Foot Ankle Surg. 2013;52:491–4.
46. Qamar F, Kadakia A, Venkateswaran B. An anatomical way of treating ankle syndesmotic injuries. J Foot Ankle Surg. 2011;50:762–5.