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Operative Techniques in
Orthopaedics

From "Low" to "High" Athletic Ankle Sprains: A Comprehensive Review

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Generally, most Grade I-III acute lateral ligament injuries can be treated conservatively. Yet despite a propensity of research regarding ankle sprains some controversy still exists as regarding the optimum treatment of grade III injuries in athletes. Physical exercise therapy combined with progressive weight bearing is a fundamental component of the functional treatment of acute lateral ligamentous injury. Generally, early active range of motion exercises is followed by strengthening exercises, proprioception, and functional exercises. Most re-injuries are probably related to inadequate neuromuscular training during the rehabilitation phase. Treatment of grade III lateral ligament injury especially in athletes remains controversial. Reviews comparing surgery vs conservative treatment have failed to demonstrate a clearly superior method. Thus, functional treatment might be preferred over surgery in most cases. However, surgical treatment may be beneficial in certain professional athletes on an individual basis. The advantage of surgical repair is significantly less objective instability when compared to non-operative treatment and this factor has been found to be predictive for future ankle sprains. Recent arthroscopic surgical techniques have been described as part of the therapeutical options in the treatment of mainly chronic ankle instability. Also, new data on the role of the calcaneo-fibular ligament in this regard highlights key points that need to be addressed before deciding for optimal treatment.
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Epidemiology and Mechanism

"*Low*" *ankle sprains* have an estimated of 30,000 per day in the USA[1] that accounts for almost 2 million per year and similar numbers appear for Europe.[2] In addition, 20%-40% of all sports-related injuries in the USA are ankle sprains.[3] This high incidence of ankle sprains can be partly explained by the natural tendency of the ankle joint to go into inversion, and the relative weakness of the lateral ligaments. The most common mechanism of injury is inversion of a plantar-flexed foot. An ankle sprain can be defined as any tear to the ankle ligaments and can range from microscopic, to complete tears.[4]

Syndesmotic ligament injury is a special subset of ankle sprains, and often is referred to as a "high ankle sprain." In comparison therefore, we might use the term "low" ankle sprains while referring to lateral ankle ligament sprains.

The anterior talo-fibular ligament (ATFL) is the most commonly injured ankle ligament during a "low" ankle sprain, accounting for almost 90%-95%.[5] With more severe injury progression, rupture of the ATFL is followed by injury to the calcaneo-fibular ligament (CFL) and lastly, generally in case of a serious trauma, to the posterior talo-fibular ligament (PTFL). Recently, a magnetic resonance imaging (MRI) study demonstrated that 41% of the patients with an ankle inversion injury, damaged both the ATFL and CFL, whereas only 5% had injured the PTFL.[6]

Return to activity after a sustained ankle sprain has been shown to be dependent on the severity of the initial injury and

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the presence of any concomitant pathology.[7] High rates of re-injury after a primary sprain have been shown, with up to 34% of patients suffering a second sprain within 3 years of their initial injury.[7]

Repeated ankle sprains can lead to attenuation of the ATFL and the overall lateral ligamentous complex. This may render those tissues incompetent and leads to chronic ankle instability that can supervene in 10%-20% of the cases.[8]

Up to 40% of the patients in the general population will report residual symptoms after classic treatment for an acute ankle sprain[7,9]; including chronic pain and recurrent instability.

"High" ankle sprains are reported to occur in 1%-18% of patients with an ankle sprain.[5,10] However, this is probably an underestimate, as 20% of athletes with an acute ankle sprain have evidence of syndesmotic injury on MRI.[11] Male gender, elite performance, and a planovalgus alignment are risk factors for syndesmotic injury in athletes.[12,13] Syndesmotic injuries can occur with ankle sprains only, fractures, or both. In fact, 23% of ankle fractures are reported to have combined syndesmotic injuries.[14] The associated fractures are commonly either of the fibula or of the posterior and medial malleoli. Syndesmotic injury should be increasingly suspected if there is an associated fracture of the proximal fibula (Maisonneuve fracture, Fig. 1) and they are associated with prolonged pain, disability, and an unpredictable time away from sports.[15]

Figure 1 Maisonneuve fracture.

The general mechanism of injury for syndesmotic ankle sprains is a forceful external rotation of the foot and ankle with the ankle in dorsiflexion and the foot pronated.[16] Whilst the talus rotates in the mortise, the fibula rotates externally, moves posteriorly and laterally, separating the distal tibia and fibula. This will sequentially cause tears of the anterior inferior tibio-fibular ligament (AITFL), the deep deltoid ligament or might alternatively cause a malleolar fracture. This shall be in turn followed by a tear of the interosseous ligament (IOL) and finally the posterior inferior tibio-fibular ligament (PITFL).[16,17] Severity of syndesmotic injury varies, ranging from a partially torn AITFL to a complete disruption of all ligaments with mortise widening. It has been shown that combined deltoid and syndesmosis injury will critically compromise talar stability.[18] The magnitude of force and its duration will determine the extension of syndesmotic and interosseous injury proximally[13] and this may eventually lead to a Maisonneuve fracture. Another injury mechanism for syndesmotic ankle sprains is hyperdorsiflexion. Forced dorsiflexion of the ankle causes the wider anterior talus to act as a wedge that can cause injury to the syndesmotic ligaments.

Clinical Features

"Low" Ankle Sprain

Clinically, patients will recount a sudden twisting of the ankle. Those with lateral ligamentous rupture report more immediate swelling and are more frequently obliged to halt their activities, compared to those without a rupture.[19] Ankle sprains usually are accompanied by an audible snap or crack. In a recent systematic review, it was found that application of the Ottawa rules is highly valuable for excluding coexisting fractures.[20] ATFL laxity could be evaluated by the anterior drawer test, whereas the talar tilt test helps in recognizing CFL instability. However, manual stress tests might be less reliable in the acute phase, because of pain and swelling. A delayed physical examination (4-5 days) has been shown to give better diagnostic results and is considered the gold standard in the diagnosis of acute lateral ligament injury, with a sensitivity of 96% and a specificity of 84%.[21,22]

On the other hand, the presence of "high ankle pain and tenderness," more proximally, is suggestive of a more significant injury.[23] In fact, it has been shown that there is a significant correlation between how far this tenderness radiates proximally in the leg and the severity of the injury and consequently, the time to return to sports.[23] Patients with high ankle sprains, may complain of the inability to bear weight, swelling, pain during the push off phase of gait and pain anteriorly between distal tibia and fibula, as well as posteromedially at the level of the ankle joint.[15] Ankle ROM will often be limited, with pain felt more at terminal dorsiflexion.[24] Numerous special tests are used to detect syndesmotic injury. However, a recent systematic review on 8 different tests reported a low diagnostic accuracy of these tests.[25] The squeeze test was the only test with a clinical significance.[25]

In the diagnosis of ankle sprains, the Ottawa ankle rules are very useful to rule out fractures, with a sensitivity of almost 100%.[26] Conversely, stress radiographs are usually not suggested for the routine diagnosis of lateral ligament injury, as they are difficult to perform and will not alter the management. Both ultrasonography and MRI can be valuable in diagnosing any concomitant chondral or tendon injury. Recently a study compared ultrasonography in the emergency room with MR images for injuries of the ATFL and found no differences in diagnostic accuracy.[27] The sensitivity and specificity of MRI in diagnosing ATFL injuries are 92%-100% and 100%, respectively.[28,29]

"High" Ankle Sprain

In the diagnosis of syndesmotic injuries—if there is a clinical suspicion of a Maisonneuve fracture—full length radiographs of the lower leg are indicated. Several radiographic parameters have been developed to help identify syndesmotic injuries: the tibiofibular clear space which represents the distance between the medial border of the fibula and the lateral border of the posterior tibia, providing the most reliable indicator of a syndesmotic injury.[30] Computed tomography (CT) is useful in detecting small avulsion fractures and is considerably more accurate than radiographs in revealing subtle diastasis.[31] Recently, bilateral standing CT is developing as an alternative diagnostic stress view, although prospective comparatively controlled data is still currently lacking.[32] MRI has been considered the investigation of choice for suspected syndesmotic ligament injury.[33] It demonstrated a sensitivity of 100% and a specificity of 93% for AITFL injuries and sensitivity and specificity of 100% for PITFL tears.[34] In a retrospective MRI study, a high prevalence of associated injuries was found, comprising osteochondral lesions (28%), bone contusions (24%), and osteoarthritis (10%).[35] There are still no reports that have correlated the extent of these lesions on imaging and the recovery time or clinical outcome. Although dynamic ultrasonographic examination showed a 100% sensitivity and specificity,[36] unfortunately it has the drawback that it lacks the ability to detect associated injuries and is investigator dependent.[33]

Therapeutic Options

"Low" Ankle Sprain

The definitive management of ankle sprains shall depend to a large extent upon the classification of the injury.[37] In "low" ankle sprains this classification combines actual ligament damage with patient's symptoms and is of more significance with a delayed physical examination. Grade I (mild) injuries are a stretch of the ligament without macroscopic rupture. There is minimal swelling and tenderness, and no increased laxity. *Grade II (moderate) injuries include partial tear of the ligaments, with moderate pain, swelling and tenderness. There is a mild to moderate increase in laxity, some loss of motion, and moderate functional disability*. In grade III (severe) injuries (Fig. 2A and B), a complete rupture of the ligaments is present with severe pain, swelling, and bruising. There is increased laxity and a major loss of function. The patient is also usually unable to bear weight.

Generally, most Grade I-III acute lateral ligament injuries can be treated conservatively. Yet despite a propensity of research regarding ankle sprains some controversy still exists as regarding the optimum treatment of grade III injuries in athletes.[38]

The initial treatment of lateral ankle ligament sprains usually involves the RICE-principle (rest, ice (cryotherapy), compression, and elevation), for the first 4-5 days; although a recent systematic review found no conclusive value for the application of that principle.[39] Manual mobilization of the ankle was found to add limited value and therefore is discouraged.[40] Additionally, no benefit was found for the usage of laser therapy, ultrasound therapy, or electrotherapy.[40] Functional treatment was proven to be more beneficial than long periods of immobilization and the use of NSAIDS, taping or orthosis is valuable in the initial phase.[38,41] However, for severe (Grade III) lateral ligamentous injuries, a short period of immobilization (max 10 days) in a below knee cast or a removable boot could be advantageous.[38,42] Controlled stresses on an injured ligament promotes more proper collagen fiber orientation, and consequently, the use of an external ankle support is encouraged. To this effect, a recent study found no differences in outcome between tape, semi-rigid brace and a lace-up brace 6 months after treatment,[43] however, most studies report superior results for protection with a brace.[38,44] Physical exercise therapy combined with progressive weight bearing is a fundamental component of the functional treatment of acute lateral ligamentous injury.[45] Rehabilitation programs for acute lateral ligamentous injuries, based on current best evidence, have been described.[46–48] Generally, early active range of motion (ROM) exercises is followed by strengthening exercises, proprioception, and functional exercises. Most re-injuries are probably related to inadequate neuromuscular training during the rehabilitation phase.[45]

Treatment of grade III lateral ligament injury especially in athletes remains controversial. Reviews comparing surgery vs conservative treatment have failed to demonstrate a clearly superior method.[38,44] Thus, functional treatment might be preferred over surgery in most cases.[38,44] However, surgical treatment may be beneficial in certain professional athletes on an individual basis.[49] The advantage of surgical repair is significantly less objective instability when compared to non-operative treatment[45] and this factor has been found to be predictive for future ankle sprains.[50] A recently described rehabilitation regimen for lateral ligament injuries after direct anatomic reconstruction included 1 or 2 weeks in below knee cast, then 2-4 weeks in a walking boot. This was then followed by an active rehabilitation protocol with the use of an ankle support.[51]

"High" Ankle Sprain

The classification of syndesmotic injury is divided into 3 grades: grade I is a minor sprain to the AITFL without instability; grade II represents a tear of the AITFL and a partial

Figure 2 (A) Clinical presentation of a grade 3 "low" ankle sprain. (B) Axial T2 MRI image of a grade 3 "low" ankle sprain.

tear of the IOL with some instability; and grade III involves complete rupture of all syndesmotic ligaments.[33]

Grade I injuries are usually treated with non-surgically.[52] A 3-phase approach has been advocated[23,53]: an acute phase, a subacute phase, and an advanced training phase, delivered over a period of 2-3 weeks. Treatment of grade II injuries depends on syndesmotic stability.[33] A recent study in athletes with a stable syndesmosis, found that a positive squeeze test and injury to the ATFL and MLC are important factors in differentiating stable (type IIa) from dynamically unstable grade II injuries (type IIb).[54] Recreational individuals without diastasis can be treated non-operatively with good results.[55] Compared to a lateral ankle sprain, the recovery time of a conservatively treated grade IIa syndesmotic injury is more prolonged. In higher level professional athletes, with a grade II injury and clinical or radiological suspicion of dynamic instability (type IIb) an examination under anesthesia and arthroscopic visualization of the syndesmosis is recommended.[55,56] Dynamic diastasis of 2 mm or more merits fixation.[52] The conservative treatment for "high" ankle sprains consists of similar rehabilitation strategies as the "low" ankle sprains (proprioception, stability, taping/orthosis, and NSAIDS) like with the exception that no preventative strategies are available and that the time to return to play is over 5 weeks minimum.

Grade III injuries (Fig. 3) will generally require operative fixation to maintain anatomic reduction of the ankle mortise.

Screws or suture-buttons can both be used to stabilize the syndesmosis, with similar outcomes; but suture-button devices might provide the added value of a quicker return to play and a lower rate of implant removal.[57,58] Arthroscopic visualization can identify and address any additional intra-articular pathology. Furthermore, it can be used to confirm anatomic reduction of the syndesmosis.[34] Recent literature indicates that the routine removal of the screw is no longer advocated.[58]

Syndesmotic ruptures are commonly associated with ankle fractures. After reduction and fixation of the associated fracture, intraoperative testing of syndesmotic stability should be performed. The Hook or Cotton test are considered as the

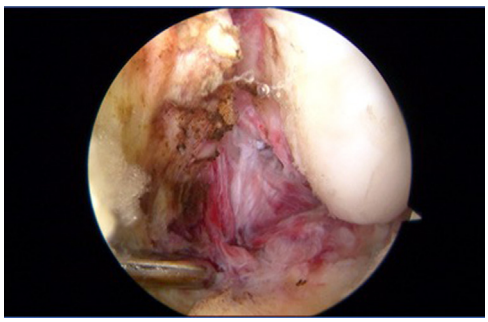

Figure 3 Arthroscopic view of a grade 3 syndesmotic injury.

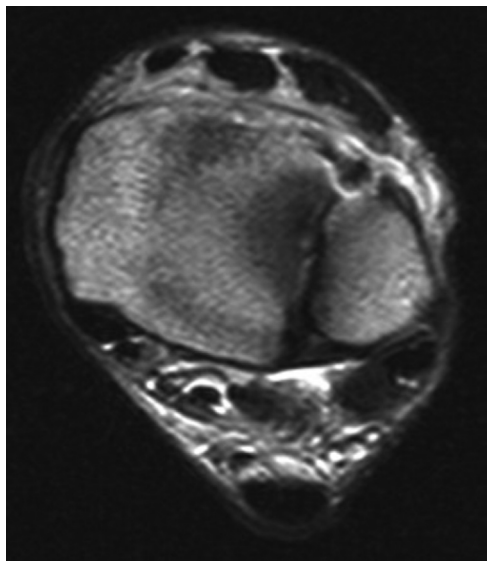

Figure 4 Axial MRI image of an AITFL rupture in an elite football player.

most reliable intraoperative stress tests.[59] A force of 100 N has been stated as sufficient, and tibiofibular clear space widening exceeding 5 mm in the case of an unstable syndesmosis will require stabilization.[59] Whenever in doubt about syndesmotic instability (Fig. 4), stabilization should be performed because of the long-term complications caused by chronic syndesmotic instability.[59]

Return to Play and Prevention

"Low" Ankle Sprain

It is difficult to determine when an athlete can return to play (RTP) following an ankle sprain. Residual disability of ankle sprains is often caused by inadequate proprioceptive rehabilitation and a potentially overly hurried RTP.[47] Self-reported ankle scoring systems (eg, FAOS[60]) are not validated for RTP decisions, but can be useful to evaluate the effectiveness of the rehabilitation protocol. Use of functional performance tests to assess an athlete's ability to perform sport-specific skills is considered helpful.[46] Tests can progress from the single-legged balance test[61] to more complex tests, such as the Star Excursion Balance Test,[62] the Y-balance test,[63] and the agility *t*-test.[64] The rehabilitation process should never abruptly be stopped, and continuing sport-specific rehabilitation will help to minimize the risk of deficits or re-injuries. The time needed to RTP in lateral ligamentous injury will depend upon several factors, including severity of the initial injury, the patient's ability and the rehabilitation facilities available and ranges from 10 days to 6 weeks.

The most important risk factor for developing a chronic ankle sprain is a previous ankle sprain. This is probably due to reduced proprioceptive function and deficient mechanical stability. There is academic evidence that neuromuscular training, especially balance and proprioceptive training, is effective for the prevention of recurrent ankle sprains. This form of therapy can also be effectively performed at home.[65]

"High" Ankle Sprain

Athletes who sustain a syndesmotic ankle sprain typically should go through much longer recovery periods than those who sustain a lateral ankle sprain.[13]

RTP in grade I injuries is usually at 6-8 weeks' post-injury, but is variable. Professional athletes with stable isolated grade II syndesmotic injuries are reported to RTP at a mean of 45 days, compared with 64 days for those with unstable grade II injuries.[54] Also, athletes with injury to both the AITFL and deltoid ligament took longer to RTP than those with an AITFL injury alone, and IOL injury on MRI and PITFL injury on MRI were both independently associated with a delay in RTP.[54]

In the case of surgically treated grade III injuries, the expected time frame to RTP is between 10 and 14 weeks,[13,55] although RTP as early as 6 weeks has been described in case series.[66]

RTP in syndesmotic injury is permitted when able to single-leg hop for 30 seconds without significant pain.[59] To our knowledge, there are no specific studies on prevention of syndesmotic re-injury. Although it might be assumed that neuromuscular bracing and bracing or taping is beneficial, injury mechanisms differ and further investigation is required to increase our understanding of syndesmotic injuries and improve treatment and prevention of this significant injury.[13]

Conclusion

"Low" and "high" ankle sprains in athletes are very different entities in the mechanism of injury, clinical features, diagnostic setup, management, and prevention. The aim of this review is to document the specific characteristics of both and present the best evidence-based literature data along. If proper management can be started after early detection, excellent results can be obtained in both types of ankle sprains. This is not the case for the evolution to chronic instabilities and combined injuries in both and this needs to be avoided at all times. Therefore, further research is needed to fine tune the preventative strategies and treatment in both types of athlete ankle sprains.

"Low" Ankle Sprain Factbox

- *Physical examination for the detection and classification of lateral ankle ligaments is best delayed for (4-5 days) after initial trauma to give better results, knowing that the Ottawa rules remain valuable in the acute setting.*
- *Most acute lateral ligament injuries can be treated conservatively with adequate rehabilitation.*
- *Surgery might be considered in professional athletes with acute grade III injuries, as it may provide lower incidence of chronic ankle instability than conservative treatment.*
- *RTP should include functional performance tests.*

"High Ankle Sprain" Factbox

- *Syndesmotic injury generally occurs in association with other injuries, especially fractures.*
- *Stable syndesmotic injuries (types I and IIa) should be treated conservatively, whereas unstable injuries (types IIb and III) require surgical fixation.*
- *RTP is generally prolonged in syndesmotic injury and allowed when able to single-leg hop for 30 seconds.*

References

1. DiGiovanni CW, Brodsky A: Current concepts: Lateral ankle instability. Foot Ankle Int 27:854-866, 2006
2. Waterman BR, Owens BD, Davey S, et al: The epidemiology of ankle sprains in the United States. J Bone Joint Surg Am 92:2279-2284, 2010
3. Fernandez WG, Yard EE, Comstock RD: Epidemiology of lower extremity injuries among US high school athletes. Acad Emerg Med 14:641-645, 2007
4. Cooke MW, Marsh JL, Clark M, et al: Treatment of severe ankle sprain: a pragmatic randomized controlled trial comparing the clinical effectiveness and cost-effectiveness of three types of mechanical ankle support with tubular bandage. The CAST trial. Health Technol Assess 13:1-121, 2009
5. Kofotolis ND, Kellis E, Vlachopoulos SP: Ankle sprain injuries and risk factors in amateur soccer players during a 2-year period. Am J Sports Med 35:458-466, 2007

6. Khor YP, Tan KJ: The anatomic pattern of injuries in acute inversion ankle sprains: A magnetic resonance imaging study. Orthop J Sports Med 1: 2013. eCollection 2013: 2325967113517078
7. Van Rijn RM, Van Os AG, Bernsen RM, et al: What is the clinical course of acute ankle sprains? A systematic literature review. Am J Med 121:324-331, 2008
8. Corte-Real MN, Moreira RMM: Arthroscopic repair of chronic lateral ankle instability. Foot Ankle Int 5:213-217, 2009
9. Ferran NA, Maffulli N: Epidemiology of sprains of the lateral ankle ligament complex. Foot Ankle Clin 11:659-662, 2006
10. Woods C, Hawkins R, Hulse M, et al: The Football Association Medical Research Programme: An audit of injuries in professional football: An analysis of ankle sprains. Br J Sports Med 37:233-2388, 2003
11. Roemer FW, Jomaah N, Niu J, et al: Ligamentous injuries and the risk of associated tissue damage in acute ankle sprains in athletes: A cross-sectional MRI study. Am J Sports Med 42:1549-1557, 2014
12. Waterman BR, Belmont Jr PJ, Cameron KL, et al: Risk factors for syndesmotic and medial ankle sprain: Role of sex, sport, and level of competition. Am J Sports Med 39:992-998, 2011
13. Williams GN, Jones MH, Amendola A: Syndesmotic ankle sprains in athletes. Am J Sports Med 35:1197-1207, 2007
14. Purvis GD: Displaced, unstable ankle fractures: Classification, incidence, and management of a consecutive series. Clin Orthop Relat Res 91-98, 1982
15. Hopkinson St WJ, Pierre P, Ryan JB, et al: Syndesmosis sprains of the ankle. Foot Ankle 10:325-330, 1990
16. 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 77:847-856, 1995
17. Beumer A, Valstar ER, Garling EH, et al: Effects of ligament sectioning on the kinematics of the distal tibiofibular syndesmosis. Acta Orthop 77:531-540, 2006
18. Zalavras C, Thordarson D: Ankle syndesmosis injury. J Am Acad Orthop Surg 15:330-339, 2007
19. van den Bekerom MP, Kerkhoffs GM, McCollum GA, et al: Management of acute lateral ankle ligament injury in the athlete. Knee Surg Sports Traumatol Arthrosc 21:1390-1395, 2013
20. Jonckheer P, Willems T, De Ridder R, et al: Evaluating fracture risk in acute ankle sprains: Any news since the Ottawa Ankle Rules? A systematic review. Eur J Gen Pract 1:31-41, 2016
21. Van Dijk CN, Lim LS, Bossuyt PM, et al: Physical examination is sufficient for the diagnosis of sprained ankles. J Bone Joint Surg Br 78:958-962, 1996
22. Van Dijk CN, Mol BW, Lim LS, et al: 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 67:566-570, 1996
23. Nussbaum ED, Hosea TM, Sieler SD, et al: Prospective evaluation of syndesmotic ankle sprains without diastasis. Am J Sports Med 29:31-35, 2001
24. Mulligan EP: Evaluation and management of ankle syndesmosis injuries. Phys Ther Sport 12:57-69, 2011
25. Sman AD, Hiller CE, Refshauge KM: Diagnostic accuracy of clinical tests for diagnosis of ankle syndesmosis injury: A systematic review. Br J Sports Med 47:620-628, 2013
26. Bachmann LM, Kolb E, Koller MT, et al: Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: Systematic review. Br Med J 326:417, 2003
27. Gün C, Unlüer EE, Vandenberk N, et al: Bedside ultrasonography by emergency physicians for anterior talofibular ligament injury. J Emerg Trauma Shock 6:195-198, 2013
28. Joshy S, Abdulkadir U, Chaganti S, et al: Accuracy of MRI scan in the diagnosis of ligamentous and chondral pathology in the ankle. Foot Ankle Surg 16:78-80, 2010
29. Oae K, Takao M, Uchio Y, et al: Evaluation of anterior talofibular ligament injury with stress radiography, ultrasonography and MR imaging. Skeletal Radiol 39:41-47, 2010
30. Harper MC: An anatomic and radiographic investigation of the tibiofibular clear space. Foot Ankle 14:455-458, 1993
31. Ebraheim NA, Lu J, Yang H, et al: Radiographic and CT evaluation of tibiofibular syndesmotic diastasis: A cadaver study. Foot Ankle Int 18:693-698, 1997
32. Vopat ML, Vopat BG, Lubberts B, et al: Current trends in the diagnosis and management of syndesmotic injury. Curr Rev Musculoskelet Med 10:94-103, 2017
33. van Dijk CN, Longo UG, Loppini M, et al: Classification and diagnosis of acute isolated syndesmotic injuries: ESSKA-AFAS consensus and guidelines. Knee Surg Sports Traumatol Arthrosc 24:1200-1216, 2016
34. 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 85:324-329, 2003
35. Brown KW, Morrison WB, Schweitzer ME, et al: MRI findings associated with distal tibiofibular syndesmosis injury. Am J Roentgenol 182: 131-136, 2004
36. Mei-Dan O, Kots E, Barchilon V, et al: A dynamic ultrasound examination for the diagnosis of ankle syndesmotic injury in professional athletes: A preliminary study. Am J Sports Med 37:1009-1016, 2009
37. Kaikkonen A, Kannus P, Järvinen M: A performance test protocol and scoring scale for the evaluation of ankle injuries. Am J Sports Med 22:462-469, 1994
38. Petersen W, Rembitzki IV, Koppenburg AG, et al: Treatment of acute ankle ligament injuries: A systematic review. Arch Orthop Trauma Surg 133:1129-1141, 2013
39. van den Bekerom MP, Struijs PA, Blankevoort L, et al: What is the evidence for rest, ice, compression, and elevation therapy in the treatment of ankle sprains in adults? J Athletic Training 47:435-443, 2012
40. Kerkhoffs GM, van den Bekerom M, Elders LA, et al: Diagnosis, treatment and prevention of ankle sprains: An evidence-based clinical guideline. Br J Sports Med 46:854-860, 2012
41. Kerkhoffs GM, Rowe BH, Assendelft WJ, et al: Immobilisation and functional treatment for acute lateral ankle ligament injuries in adults. Cochrane Database Syst Rev 2002. CD003762
42. Lamb SE, Marsh JL, Hutton JL, et al: Mechanical supports for acute, severe ankle sprain: A pragmatic, multicentre, randomised controlled trial. Lancet 373:575-581, 2009
43. van den Bekerom MP, van Kimmenade R, Sierevelt IN, et al: Randomized comparison of tape versus semi-rigid and versus lace-up ankle support in the treatment of acute lateral ankle ligament injury. Knee Surg Sports Traumatol Arthrosc 24:978-984, 2016
44. Kemler E, van de Port I, Backx F, et al: A systematic review on the treatment of acute ankle sprain: Brace versus other functional treatment types. Sports Med 41:185-197, 2011
45. Kerkhoffs GM, Handoll HH, de Bie R, et al: Surgical versus conservative treatment for acute injuries of the lateral ligament complex of the ankle in adults. Cochrane Database Syst Rev 2007. CD000380
46. Kaminski TW, Hertel J, Amendola N, et al: National Athletic Trainers' Association position statement: Conservative management and prevention of ankle sprains in athletes. J Athl Train 48:528-545, 2013
47. Renström PA, Konradsen L: Ankle ligament injuries. Br J Sports Med 31:11-20, 1997
48. Zöch C, Fialka-Moser V, Quittan M: Rehabilitation of ligamentous ankle injuries: A review of recent studies. Br J Sports Med 37:291-295, 2003
49. Kerkhoffs GM, Tol JL: A twist on the athlete's ankle twist: Some ankles are more equal than others. Br J Sports Med 46:835-836, 2012
50. Verhagen EA, Van der Beek AJ, Bouter LM, et al: A one season prospective cohort study of volleyball injuries. Br J Sports Med 38:477-481, 2004
51. Pearce CJ, Tourné Y, Zellers J, et al: Rehabilitation after anatomical ankle ligament repair or reconstruction. Knee Surg Sports Traumatol Arthrosc 24:1130-1139, 2016
52. McCollum GA, van den Bekerom MP, Kerkhoffs GM, et al: Syndesmosis and deltoid ligament injuries in the athlete. Knee Surg Sports Traumatol Arthrosc 21:1328-1337, 2013
53. Williams GN, Allen EJ: Rehabilitation of syndesmotic (high) ankle sprains. Sports Health:460-470, 2010
54. Calder JD, Bamford R, Petrie A, et al: Stable versus unstable grade ii high ankle sprains: A prospective study predicting the need for surgical stabilization and time to return to sports. Arthroscopy 32:634-642, 2016

55. Hunt KJ, Phisitkul P, Pirolo J, et al: High ankle sprains and syndesmotic injuries in athletes. J Am Acad Orthop Surg 23:661-673, 2015
56. Kerkhoffs GM, de Leeuw PAJ, Tennant JN, et al: Ankle ligament lesions, The Ankle in Football. Paris, Springer-Verlag, 81-96, 2014
57. Schepers T: Acute distal tibiofibular syndesmosis injury: A systematic review of suture-button versus syndesmotic screw repair. Int Orthop 36:1199-1206, 2012
58. van Dijk CN, Longo UG, Loppini M, et al: Conservative and surgical management of acute isolated syndesmotic injuries: ESSKA-AFAS consensus and guidelines. Knee Surg Sports Traumatol Arthrosc 24: 1217-1227, 2016
59. van den Bekerom MP: Diagnosing syndesmotic instability in ankle fractures. World J Orthop 2:51-56, 2011
60. Roos EM, Brandsson S, Karlsson J: Validation of the Foot and Ankle Outcome Score for ankle ligament reconstruction. Foot Ankle Int 22:788-794, 2001
61. Freeman MA, Dean MR, Hanham IW: The etiology and prevention of functional instability of the foot. J Bone Joint Surg Br 47:678-685, 1965
62. Hertel J, Miller SJ, Denegar CR: Intratester and intertester reliability during the star excursion balance test. J Sport Rehabil 9:104-116, 2009
63. Plisky PJ, Gorman PP, Butler RJ, et al: The reliability of an instrumented device for measuring components of the star excursion balance test. N Am J Sports Phys Ther 4:92-99, 2009
64. Pauole K, Madole K, Garhammer J, et al: Reliability and validity of the *t*-test as a measure of agility, leg power, and leg speed in college aged men and women. J Strength Cond Res 14:443-450, 2000
65. Hupperets MD, Verhagen EA, van Mechelen W: Effect of unsupervised home based proprioceptive training on recurrences of ankle sprain: randomised controlled trial. BMJ 339:b2684, 2009
66. Taylor DC, Tenuta JJ, Uhorchak JM, et al: Aggressive surgical treatment and early return to sports in athletes with grade III syndesmosis sprains. Am J Sports Med 35:1833-1838, 2007