Subtalar Joint Instability

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7.1 Anatomy

The subtalar joint (STJ), also known as the talocalcaneal joint, is an important and complex joint in the hindfoot that allows articulation of the talus and calcaneus. It consists of three articular facets between the inferior surface of the talus and the dorsal surface of the calcaneus (Fig. 7.1). STJ is formed by two articular components: the anterior talocalcaneal articulation and the posterior talocalcaneal articulation [1].

The anterior talocalcaneal articulation is formed by the anterior and middle facets of anterior one-third of the calcaneum that articulate with the head of the talus and the proximal navicular surface. The joints are connected by a fibrous capsule, the talonavicular ligament (a fibrous band which connects the neck of the talus to the dorsal surface of the navicular), the plantar calcaneo-navicular ligament (a broad thick band which connects the anterior margin of the sustentaculum tali of the calcaneus to the plantar surface of the navicular, also called "spring ligament"), and the calcaneo-navicular portion of the bifurcated ligament (also called "Y shaped" ligament, a strong band which originates from the anterior surface of the calcaneus and splits anteriorly into the calcaneo-cuboid portion, which lies in the horizontal plane and attaches to the dorsal aspect of the cuboid, and the calcaneo-navicular portion, which lies in the vertical plane and attaches to the lateral aspect of the navicular) [2].

The posterior talocalcaneal articulation is formed by the posterior calcaneal facet on the inferior surface of the talus and the posterior facet on the superior surface of the calcaneus and makes up the largest articulation between the talus and calcaneus. The joint is surrounded by a fibrous capsule and synovial membrane that attach at the edges of the articular surface. However orthopedic surgeons consider the talocalcaneal joint and the talocalcaneonavicular joint to be one functional unit [2].

The subtalar joint essentially is a uniaxial joint at which the calcaneus rotates from dorsolateral to medioplantar. The axis of motion passes obliquely from a posterior, plantar, and lateral position to an anterior, dorsal, and medial position. STJ range of motion (ROM) is approximately from 25 to 30° of inversion/supination to 5 to 10° eversion/pronation [3–5]. However the

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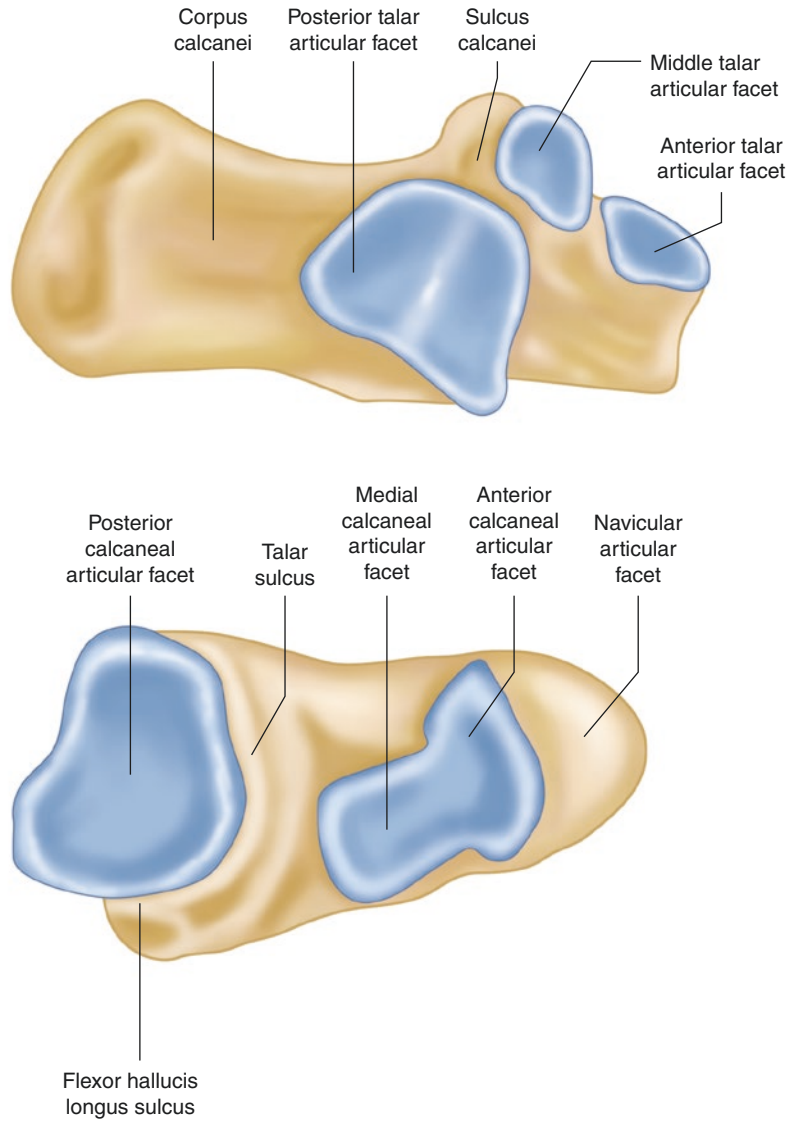

Fig. 7.1 Dorsal surface of the calcaneus and Inferior surface of the talus

STJ motions are linked to the ankle joint motions and to the midtarsal joint motions. Subtalar ligaments can be divided into intrinsic ligaments (interosseous talocalcaneal ligament—ITCL, cervical ligament—CL, lateral, posterior, and medial talocalcaneal ligament) and extrinsic ligaments (calcaneo-fibular ligament—CFL and the tibio-calcaneal fascicle of the deltoid ligament).

The ITCL is a dense, broad, and flat bilaminar bundle that descends obliquely and laterally from the sulcus tali to the calcaneal sulcus and runs through the sinus tarsi. The posterior band of ITCL lies posterior to the anterior band. ITCL attaches to the sinus tarsi anterior to the superior posterior articular facet of the calcaneus and inserts into the sinus tali just anterior to the posterior inferior articular facet of the talus [2]. It is the primary restraint of the subtalar joint and can be classified according to its shape in band type, fan type, and multiple type [6]. The ITCL can be compared with the cruciate ligaments of the knee for its stabilizing and proprioceptive function [7].

The CL is located along the antero-lateral portion of the STJ and is the strongest ligament con-

necting the talus and the calcaneus [8]. It is attached to the upper surface of the calcaneus and passes superiorly and medially to a tubercle on the inferior and lateral aspect of the neck of the talus [2]. The primary function of the CL is to resist excessive STJ supination whereas the ITCL remains taut during pronation.

The lateral talocalcaneal ligament arises from the lateral tubercle of the talus, runs obliquely inferiorly and posteriorly, and attaches to the lateral surface of the calcaneus [2].

The posterior talocalcaneal ligament arises from the lateral tubercle of the talus and inserts on the proximal and medial portion of the calcaneus [2].

The medial talocalcaneal ligament connects the medial tubercle of the talus with the posterior and medial aspect of the calcaneus [2].

The calcaneo-fibular ligament is a narrow, rounded cord, running from the tip of the lateral malleolus of the fibula downward and slightly backward to a tubercle on the lateral surface of the calcaneus. It restricts the hyperinversion of the subtalar joint.

The tibio-calcaneal fascicle of the deltoid ligament arises from the medial malleolus, descends almost perpendicularly, and inserts into the whole length of the sustentaculum tali of the calcaneus.

The extensor retinaculum significantly contributes to stability of the ankle and subtalar joint. Weindel et al. demonstrated in a biomechanical cadaver study that dissection of the inferior extensor retinaculum results in a significant increase in eversion and inversion [9].

7.2 Pathophysiology

Subtalar instability (STI) is a chronic functional talocalcaneal instability characterized by a combination of anterior movement, medialization, and varus tilt of the calcaneus [10].

Subtalar instability is a problem because it can lead to severe flatfoot with growing pain and quick fatigue while walking and running. It can lead to many orthopedic problems affecting ankle, knee, hip joint, and lower back and result in clinical presentations like anterior or posterior tibial tendinopathy, plantar fasciitis, and forefoot pain [11].

STI could be a consequence of acute subtalar injury or dislocation; however chronic tear or insufficiency of interosseous talocalcaneal ligament (ITCL), cervical ligament (CL), and calcaneofibular ligament (CFL) have been reported as the most frequent etiologies of STI [12].

Acute injury of ST joint is common in basketball and volleyball players and it is seen when the player comes to an abrupt stop [13].

Acute subtalar dislocation is a relatively uncommon injury that occurs frequently in the third decade of life in male patients after motor vehicle accidents [14, 15]. Frequently the subtalar dislocation is closed; however, between 10 and 40% of all cases, high-energy injuries may lead to open subtalar dislocation. Medial dislocations are the most common, followed by lateral and posterior.

Acute subtalar dislocation is caused by forced inversion combined with the ankle in dorsiflexion or the neutral sagittal position. The CFL is the first to be damaged, followed by the lateral talocalcaneal ligament, the cervical ligament, and finally the ITCL. Dislocation of subtalar joint is often associated with fractures of the fifth metatarsal, the talus, or the malleoli. However isolated subtalar dislocation is common in patients with aplasia of the ankle ligaments or the calcaneus facets, hypoplasia of the malleolus, recurrent ankle sprains, post-traumatic ligamentous insufficiency, and atrophy of the peroneal muscles [16]. Broca distinguished three types of subtalar dislocation: (1) the medial dislocation; (2) the lateral dislocation; and (3) the posterior dislocation. Direction of the rest foot in relation to the talus was the determinant element to classify dislocation as medial, lateral, or posterior [17]. Malaigne and Burger described an additional type of subtalar dislocation, the anterior dislocation [17]. After an acute dislocation, conservative treatment with closed reduction under general anesthesia and an ankle brace for 3–6 weeks, followed by physical therapy, is recommended. However the interposition of posterior tibialis tendon after the rupture of the flexor retinaculum or the interposition of the extensor retinaculum makes the dislocation not reducible. In this case an operative treatment is required [4].

Chronic tear or insufficiency of ligaments could be a consequence of recurrent ankle sprains [18].

Subtalar instability is frequently accompanied by ankle instability. On the other hand, lateral ankle instability may be combined with subtalar joint involvement in up to 25% of the cases [10].

7.3 Diagnosis

Clinical symptoms of ankle and subtalar instability are very similar and therefore a correct diagnosis is not easy. A feeling of uncertainty during walk on uneven ground is a common finding. Other symptoms include recurrent swelling, painful stiffness of the subtalar joint, and diffuse pain in the hindfoot and onto the sinus tarsi.

In the acute phase lateral ecchymoses, swelling, and tenderness in the area of the sinus tarsi can be found. In contrast to chronic ankle instability female patients with STJ instability may prefer high-top shoes [18].

The instability of the subtalar joint has been assessed clinically by a manual inversion stress test. An increased amount of inversion is revealed stressing the hindfoot. However, after acute injury it may be problematic to recognize an increased amount of calcaneal inversion compared with the intact side due to pain-induced limitations [19].

Radiographic examination of STJ instability involves stress Broden views [20]. To perform the stress Broden view, the examiner internally rotates the foot, the beam is centered on the talonavicular joint, and the tube is angled from 30° cephalad. This positioning allows the surgeon to view different portions of the posterior facet of the STJ. Separation of the posterior facet of the calcaneus and talus greater than 7 mm may indicate chronic subtalar instability [20].

CT scan may be helpful. Some investigators have recommended its use because of the inaccuracies of stress radiographs [21, 22]. CT allows an accurate analysis of any type of osseous deformity or osteoarthritis.

MR imaging has been shown to have significant role in the detection of injured structures [22]. Moreover, MRI can be useful in evaluating the joint surfaces for osteochondral defects and identifying peroneal tendon injury. With MRI, a partial or complete tear of components of the ligaments contributing to subtalar stability may be diagnosed as well as an acute involvement of the subtalar joint by bone marrow edema in T2-weighted sequence.

Arthrography of the ankle and STJ can also be used for the evaluation of ruptured ligaments and associated pathologic condition. Sugimoto et al [23] attributed to arthrography a sensitivity of 92% and a specificity of 87% for the diagnosis of CFL rupture in patients with recurrent ankle instability.

7.4 Treatment

The treatment of acute STJ injury consists of wearing an ankle–foot orthosis within the shoe for 5–6 weeks [24]. In chronic injury nonoperative treatment is essential and involves physical therapy directed at the soft tissue envelope and dynamic stabilizers, taping, proprioceptive training, stretching of the Achilles tendon, and lateral wedging of the shoe or insole up to 0.5 mm for 12–16 week [18]. If conservative treatment is unsuccessful, operative treatment may be an option to restore stability and function to the joint. However, normal subtalar joint kinematics are not restored by tenodesis ligament reconstruction [25, 26]. Techniques for surgical reconstruction generally are divided into anatomical and nonanatomical reconstruction, such us tendon transfer procedures.

Broström first introduced a direct anatomic repair of the ruptured ATFL and CFL, with good long-term results and functional recovery (Fig. 7.2) [27]. The Gould modification of the Brostrom procedure associated the direct repair of the lateral ligaments with extensor retinaculum reinforcement (Fig. 7.3) [27]. Brostrom Evans procedure adds to Brostrom repair the transfer of the anterior third of the peroneus brevis tendon to provide supplemental lateral static restraint [28], but it increased stiffness and had poor long-term patient satisfaction [29]. Moreover it has been suggested that the

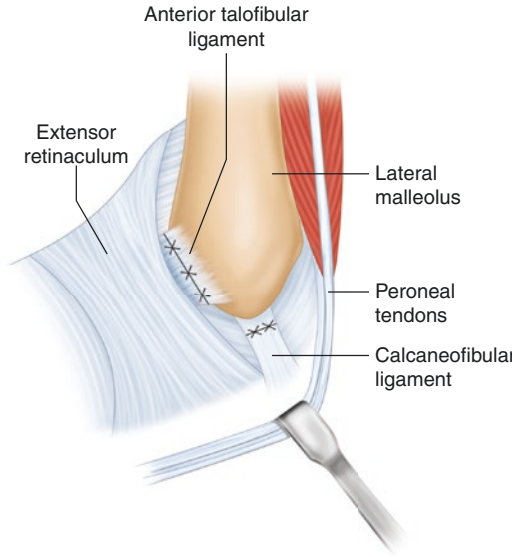

Fig. 7.2 Brostrom procedure

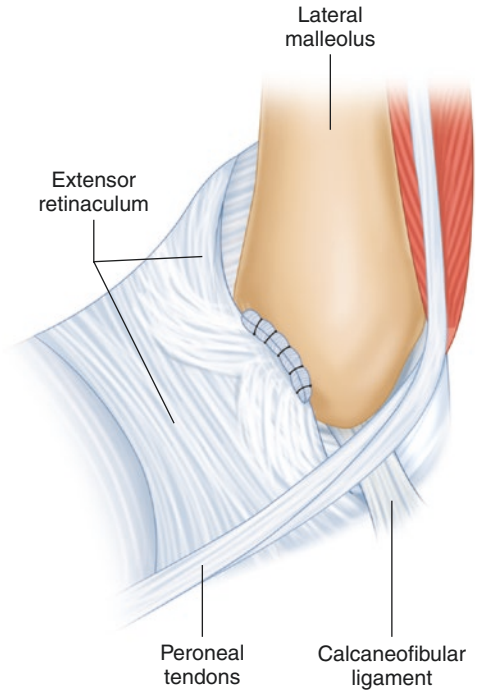

Fig. 7.3 Gould modification of the Brostrom procedure

Evans procedure is ineffective for SJI [30]. However, especially for STJ instability, tenodesing procedures may be considered advantageous because of the reduction of hindfoot motion. For this reason Chrisman-Snook procedure has become the procedure of choice for patients with isolated STJ instability [24]. The Chrisman-Snook tenodesis consists in the use of a split peroneus brevis tendon: the proximal part of the tendon is passed through the fibula in an anterior to posterior direction and finally the tendon is fixed to the calcaneus near the original insertion of the CFL. Other procedures addressed in the literature include ITCL reconstruction, ligamentous reconstruction using the entire peroneus brevis tendon to recreate the ATFL and CFL, and triligamentous reconstruction procedures to address the ruptured ATFL, CFL, ITCL, and cervical ligament [31]. Kato performed an ITCL reconstruction with a partial Achilles tendon graft with good functional results and a very low rate of postoperative complications [32]. Pisani used the anterior half of the peroneus brevis tendon for reconstruction of ITCL with an open surgical technique [33]. Liu described an arthroscopic approach with a gracilis tendon from the ipsilateral knee as a graft with controversial results [34].

Surgery is a successful solution for patients with STJ instability; however, hindfoot malalignment can contribute to subtalar joint instability and dysfunction and can be a cause of surgery's failure [35].

7.5 Surgical Technique of Brostrom-Gould Procedure

Brostrom procedure is performed with the patient placed in the lateral decubitus position. The borders of the fibular malleolus and the location of the anterior talo-fibular and calcaneo-fibular ligaments are identified. The skin incision is inferiorly to the tip of the fibula ending just posterior to the lateral malleolus and extends across the body of the ATFL and CFL. Careful dissection is critical to avoid damage to dorsal cutaneous and sural nerves.

After the identification of the intra-capsular ATFL, the ligament is incised and the midportion removed. Dissection is then directed toward the distal portion of the fibula. The peroneal sheath is incised, peroneal tendons are retracted, and CFL is identified. The lax portion of the ligament is removed and the remaining portions sutured with a nonabsorbable suture. The foot is dorsiflexed and everted and the ATFL ligament is sutured. Finally the extensor retinaculum is identified and its lateral border is brought superficial to the ATFL repair and sutured to the fibular periosteum. The subcutaneous tissue and skin are then closed. The patient is maintained in a non-weight-bearing orthosis. After about 1 month the ankle is protected with an air stirrup brace, and range of motion exercises are begun [36, 37].

7.6 Surgical Technique of Chrisman-Snook Procedure

The procedure is performed with the patient placed in the lateral decubitus position. The skin incision is made from the mid-calf laterally along the course of the peroneal tendons beneath the lateral malleolus and turning down to the base of the fifth metatarsal, reminding a single "hockey stick"; however some authors prefer a three incisional approach incision. In this case the first incision is placed over the peroneal tendons, posterior to the distal fibula. The second over the sinus tarsi. The third laterally, over the posterior tubercle of the calcaneus. The peroneal brevis tendon is identified and split. Once the tendon is split, half of it is transected proximally, so the distal half may be pulled into the anterior incision. The tendon graft is passed subcutaneously from the base of the fifth metatarsal to superiorly to the sinus tarsi region, and after through the distal fibular using a tendon passer. The foot is placed in an ankle-neutral STJ-everted position and the peroneal brevis tendon is sutured to the anterior fibular periosteum. A second subcutaneous tunnel is made from the lateral malleolus to the lateral wall of the calcaneus and the tendon is inserted into the calcaneus using an anchoring device [37].

7.7 Conclusion

Subtalar joint pain and instability are a common problem. The estimated number of unknown cases with chronic subtalar instability might be substantially higher than the number of patients where we actually recognize this diagnosis. A high degree of suspicion is necessary for the correct diagnosis. Moreover weight-bearing X-rays including Broden views, CT scan, MR imaging, and arthrography could be helpful. The treatment of acute injuries is conservative and has good outcomes. The situation is less clear for operative approaches although tenodesing procedures had showed good clinical outcomes. There is a definitive need for prospective and controlled studies to get a more reliable answer regarding subtalar joint pathology.

References

1. Sarrafian SK. Biomechanics of the subtalar joint complex. Clin Orthop Relat Res. 1993;(290):17–26.
2. Rockar PA Jr. The subtalar joint: anatomy and joint motion. J Orthop Sports Phys Ther. 1995;21(6):361–72.
3. Goto A, Moritomo H, Itohara T, Watanabe T, Sugamoto K. Three-dimensional in vivo kinematics of the subtalar joint during dorsi-plantarflexion and inversion-eversion. Foot Ankle Int. 2009;30(5):432–8.
4. van Dijk CN, Longo UG, Loppini M, Florio P, Maltese L, Ciuffreda M, et al. Conservative and surgical management of acute isolated syndesmotic injuries: ESSKA-AFAS consensus and guidelines. Knee Surg Sports Traumatol Arthrosc. 2016;24(4):1217–27.
5. Lubberts B, Vopat BG, Wolf JC, Longo UG, DiGiovanni CW, Guss D. Arthroscopically measured syndesmotic stability after screw vs. suture button fixation in a cadaveric model. Injury. 2017;48(11):2433–7.
6. Jotoku T, Kinoshita M, Okuda R, Abe M. Anatomy of ligamentous structures in the tarsal sinus and canal. Foot Ankle Int. 2006;27(7):533–8.
7. Pisani G. Chronic laxity of the subtalar joint. Orthopedics. 1996;19(5):431–7.
8. Heilman AE, Braly WG, Bishop JO, Noble PC, Tullos HS. An anatomic study of subtalar instability. Foot Ankle. 1990;10(4):224–8.
9. Weindel S, Schmidt R, Rammelt S, Claes L, v Campe A, Rein S. Subtalar instability: a biomechanical cadaver study. Arch Orthop Trauma Surg. 2010;130(3):313–9.
10. Karlsson J, Eriksson BI, Renstrom PA. Subtalar ankle instability. A review. Sports Med. 1997;24(5):337–46.

11. Mullen JE, O'Malley MJ. Sprains--residual instability of subtalar, Lisfranc joints, and turf toe. Clin Sports Med. 2004;23(1):97–121.
12. Aynardi M, Pedowitz DI, Raikin SM. Subtalar instability. Foot Ankle Clin. 2015;20(2):243–52.
13. Longo UG, Ciuffreda M, Locher J, Maffulli N, Denaro V. Apophyseal injuries in children's and youth sports. Br Med Bull. 2016;120(1):139–59.
14. Choisne J, Ringleb SI, Samaan MA, Bawab SY, Naik D, Anderson CD. Influence of kinematic analysis methods on detecting ankle and subtalar joint instability. J Biomech. 2012;45(1):46–52.
15. Bonnel F, Toullec E, Mabit C, Tourne Y, Sofcot. Chronic ankle instability: biomechanics and pathomechanics of ligaments injury and associated lesions. Orthop Traumatol Surg Res. 2010;96(4):424–32.
16. Giannoulis D, Papadopoulos DV, Lykissas MG, Koulouvaris P, Gkiatas I, Mavrodontidis A. Subtalar dislocation without associated fractures: Case report and review of literature. World J Orthop. 2015;6(3):374–9.
17. Zimmer TJ, Johnson KA. Subtalar dislocations. Clin Orthop Relat Res. 1989;238:190–4.
18. Barg A, Tochigi Y, Amendola A, Phisitkul P, Hintermann B, Saltzman CL. Subtalar instability: diagnosis and treatment. Foot Ankle Int. 2012;33(2):151–60.
19. Keefe DT, Haddad SL. Subtalar instability. Etiology, diagnosis, and management. Foot Ankle Clin. 2002;7(3):577–609.
20. Broden B. Roentgen examination of the subtaloid joint in fractures of the calcaneus. Acta Radiol. 1949;31(1):85–91.
21. Sijbrandij ES, van Gils AP, van Hellemondt FJ, Louwerens JW, de Lange EE. Assessing the subtalar joint: the Broden view revisited. Foot Ankle Int. 2001;22(4):329–34.
22. van Hellemondt FJ, Louwerens JW, Sijbrandij ES, van Gils AP. Stress radiography and stress examination of the talocrural and subtalar joint on helical computed tomography. Foot Ankle Int. 1997;18(8):482–8.
23. Sugimoto K, Takakura Y, Samoto N, Nakayama S, Tanaka Y. Subtalar arthrography in recurrent instability of the ankle. Clin Orthop Relat Res. 2002;394:169–76.
24. Thermann H, Zwipp H, Tscherne H. Treatment algorithm of chronic ankle and subtalar instability. Foot Ankle Int. 1997;18(3):163–9.
25. Hollis JM, Blasier RD, Flahiff CM, Hofmann OE. Biomechanical comparison of reconstruction techniques in simulated lateral ankle ligament injury. Am J Sports Med. 1995;23(6):678–82.
26. Karlsson J, Eriksson BI, Renstrom P. Subtalar instability of the foot. A review and results after surgical treatment. Scand J Med Sci Sports. 1998;8(4):191–7.
27. Gould N, Seligson D, Gassman J. Early and late repair of lateral ligament of the ankle. Foot Ankle. 1980;1(2):84–9.
28. Hsu AR, Ardoin GT, Davis WH, Anderson RB. Intermediate and long-term outcomes of the modified Brostrom-Evans procedure for lateral ankle ligament reconstruction. Foot Ankle Spec. 2016;9(2):131–9.
29. Evans DL. Recurrent instability of the ankle; a method of surgical treatment. Proc R Soc Med. 1953;46(5):343–4.
30. Nicholas JA. Ankle injuries in athletes. Orthop Clin North Am. 1974;5(1):153–75.
31. Zwipp H, Rammelt S, Grass R. Ligamentous injuries about the ankle and subtalar joints. Clin Podiatr Med Surg. 2002;19(2):195–229.
32. Kato T. The diagnosis and treatment of instability of the subtalar joint. J Bone Joint Surg. 1995;77(3):400–6.
33. Pisani G, Pisani PC, Parino E. Sinus tarsi syndrome and subtalar joint instability. Clin Podiatr Med Surg. 2005;22(1):63–77.. vii
34. Liu C, Jiao C, Hu Y, Guo QW, Wand C, Ao Y. Interosseous talocalcaneal ligament reconstruction with hamstring autograft under subtalar arthroscopy: case report. Foot Ankle Int. 2011;32(11):1089–94.
35. Knupp M, Stufkens SA, Bolliger L, Barg A, Hintermann B. Classification and treatment of supramalleolar deformities. Foot Ankle Int. 2011;32(11):1023–31.
36. Molloy AP, Ajis A, Kazi H. The modified Broström-Gould procedure—early results using a newly described surgical technique. Foot Ankle Surg. 2014;20(3):224–8.
37. Hentges MJ, Lee MS. Chronic ankle and subtalar joint instability in the athlete. Clin Podiatr Med Surg. 2011;28(1):87–104.