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ANKLE

Anatomy of the inferior extensor retinaculum and its role in lateral ankle ligament reconstruction: a pictorial essay

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Abstract The inferior extensor retinaculum (IER) is an aponeurotic structure, which is in continuation with the anterior part of the sural fascia. The IER has often been used to augment the reconstruction of the lateral ankle ligaments, for instance in the Broström–Gould procedure, with good outcomes reported. However, its anatomy has not been described in detail and only a few studies are available on this structure. The presence of a non-constant oblique supero-lateral band appears to be important. This structure defines whether the augmentation of the lateral ankle ligaments reconstruction is performed using true IER or only the anterior part of the sural fascia. It is concluded that the use of this structure will have an impact on the resulting ankle stability.

Anatomy · Inferior extensor retinaculum · Ankle ligaments · Broström-Gould · Ankle ligaments repair · Pictorial essay

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The inferior extensor retinaculum (IER) is a retaining aponeurotic structure located on the anterior aspect of the ankle and tarsus that is continuous with the sural fascia. It is a Y- or X-shaped structure that prevents the tendons of the tibialis anterior, extensor hallucis longus, extensor digitorum longus and peroneus tertius from bowstringing or subluxation [16]. It is a complex structure with three or four bands, which also plays an important role in subtalar joint stabilisation.

Anatomical and biomechanical studies have indicated that an attachment of the IER to the fibular periosteum can function in a role similar to that of the calcaneofibular ligament (CFL) in stabilising the subtalar joint [4, 5, 11, 21]. The incorporation of the IER in a traditional Broström procedure has been used for more than 30 years, and the results of this modification to the anatomical repair have been well reported [3, 6, 7, 9, 12, 14, 17, 19]. However, the use of the IER in all cases of lateral ankle stability surgery may not be indicated; as the IER crosses the subtalar joint, overtightening this structure may cause stiffness in the posterior subtalar joint, which may cause a functional impairment, especially in the athlete [15]. Long-term outcomes in terms of degenerative changes in the subtalar joint have not, however, been shown in anatomical repair using the IER.

The decision to include the IER in lateral ankle ligament repair is therefore best made at the time of surgery. In

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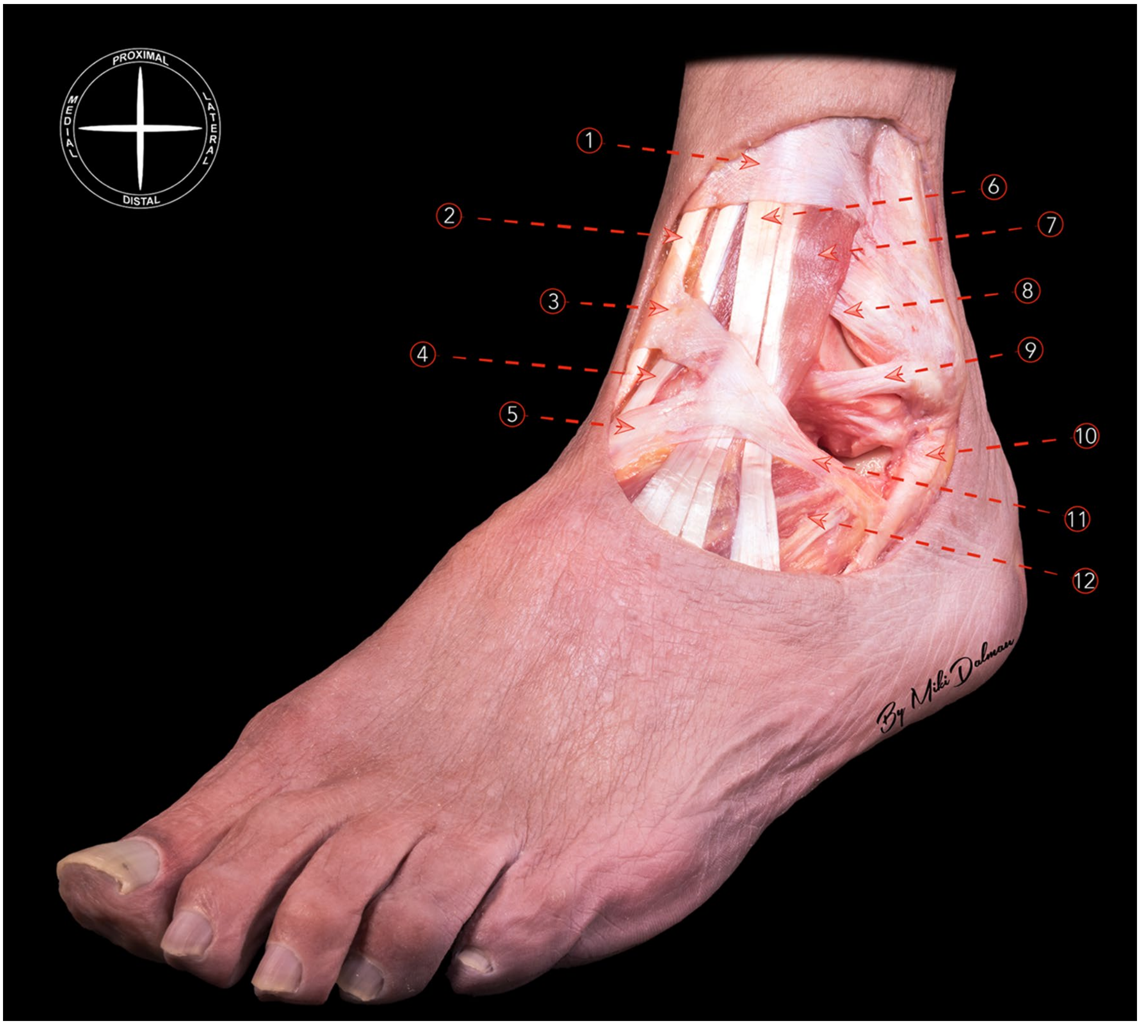

Fig. 1 Anterolateral view of a dissection of a left ankle showing the morphology of the inferior extensor retinaculum and its relation with the anterior talofibular ligament. *1* Superior extensor retinaculum, *2* tibialis anterior tendon, *3* oblique superomedial band of the inferior extensor retinaculum, *4* extensor hallucis longus tendon, *5* oblique inferomedial band of the inferior extensor retinaculum, *6* extensor digitorum longus tendon, *7* peroneus tertius muscle, *8* distal fascicle of the anterior tibiofibular ligament (partially covered by peroneus tertius muscle), *9* anterior talofibular ligament, *10* peroneus brevis tendon, *11* stem or frondiform ligament (lateral part of the inferior extensor retinaculum), *12* extensor digitorum brevis muscle

those cases where a small remnant of the anterior talofibular ligament (ATFL) remains or where the CFL is torn, IER imbrication may be used. In arthroscopic lateral ligament repair, the IER is included in several techniques described with good outcomes [2, 10, 14, 20]. Other arthroscopic lateral ligament repair procedures spare the IER by using a lasso-type technique [18], and comparisons between procedures using the IER and those not using it in arthroscopic repair have revealed no difference in terms of short-term outcomes [9].

Recent biomechanical testing has also questioned the role of the IER in direct anatomical repair using a time zero cadaveric model. Behrens et al. [1] found that the incorporation of the IER in the traditional Broström repair had no mechanical advantage when compared with the mechanical testing of those specimens in which the IER was not employed. In clinical studies of open lateral ligament reconstruction, Jeong et al. [8] reported no difference in those patients treated with and without IER augmentation in a traditional Broström technique in a group of 41 patients. Karlsson et al. [9] performed a prospective randomised study to compare the clinical outcomes following anatomical direct repair with and without IER augmentation for chronic lateral ankle instability and found more than 80 % successful short-term outcomes for both repair methods.

The incorporation of the IER therefore appears to offer neither mechanical nor clinical advantages using either an

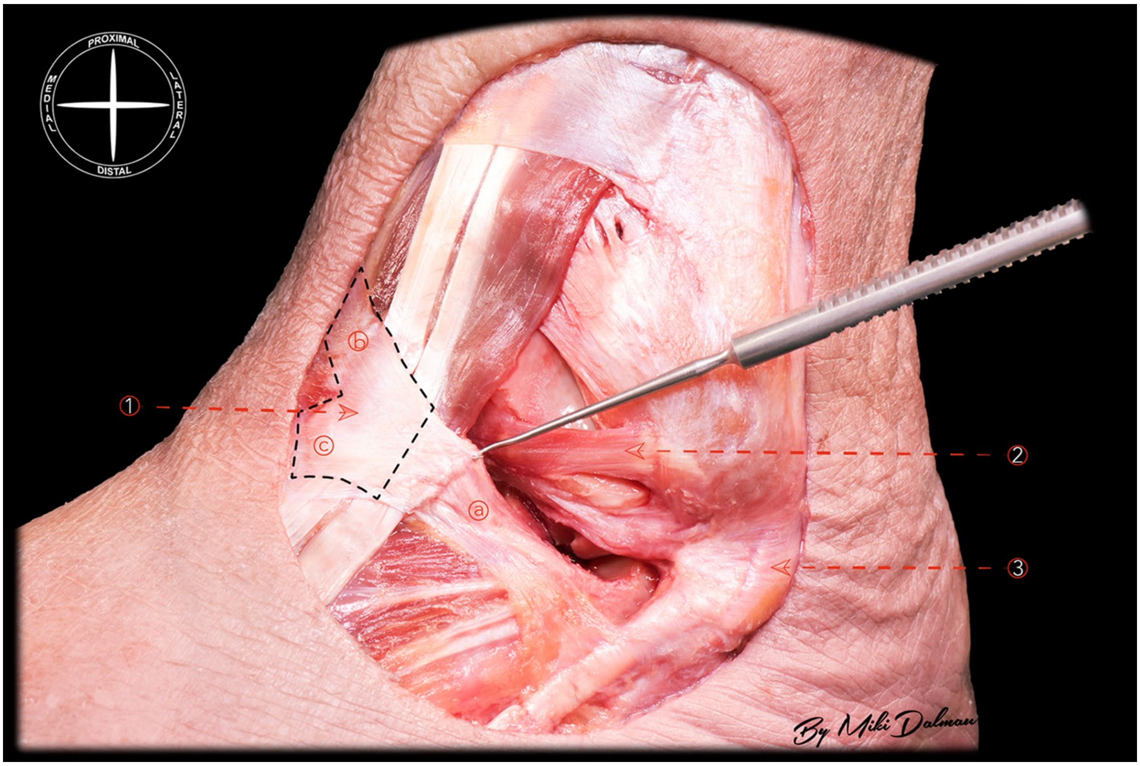

Fig. 2 Anterolateral view of a dissected ankle showing a surgical instrument trying to retract the stem of frondiform ligament towards the anterior talofibular ligament. The stem of frondiform ligament is a tense band of aponeurotic tissue that resists a proximal mobilisation. *1* Area of division of the stem or frondiform ligament (*a*) into the oblique superomedial band (*b*) and oblique inferomedial band (*c*). *2* Anterior talofibular ligament, *3* superior peroneal retinaculum

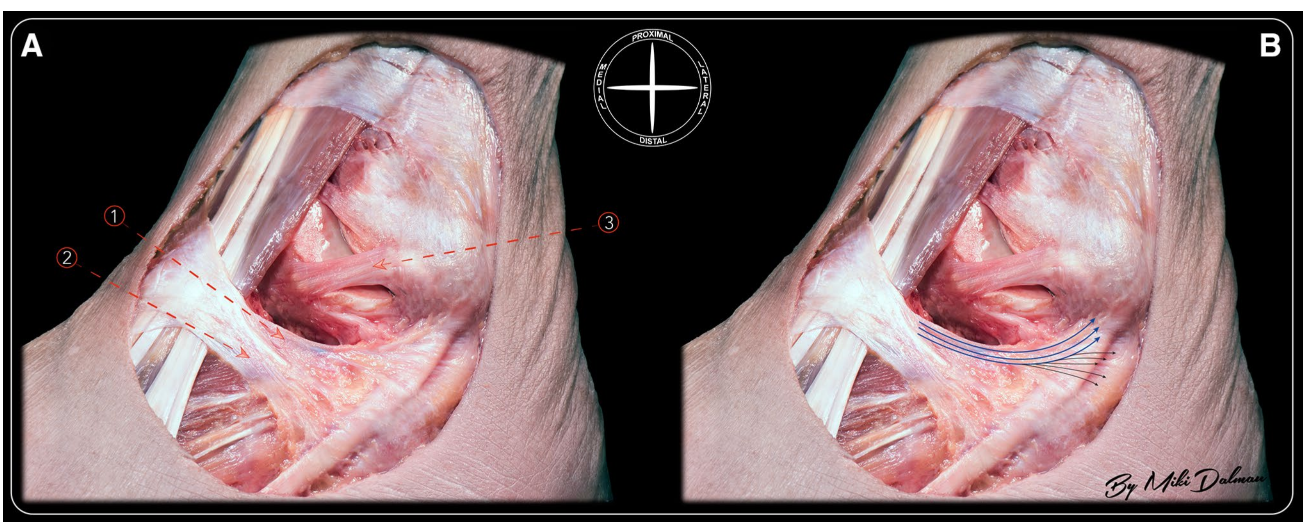

Fig. 3 Anterolateral view of a dissected ankle showing an inferior extensor retinaculum with an oblique superolateral band. **a** *1* Oblique superolateral band, *2* stem of frondiform ligament, *3* anterior talofibular ligament. **b** Oblique superolateral band has been highlighted. Its fibres are directed towards the anterior part of the lateral malleolus (*blue arrows*), and some of its fibres are continuous with the superior peroneal retinaculum (*black arrows*)

open or an arthroscopic procedure when combined with a traditional ATFL repair. In the absence of suitable tissue to repair, however, the IER provides an excellent source of tissue to facilitate lateral ligament repair. Excellent clinical outcomes have been reported when using the IER in lateral ankle ligament repair; Lee et al. [12] reported that the mean

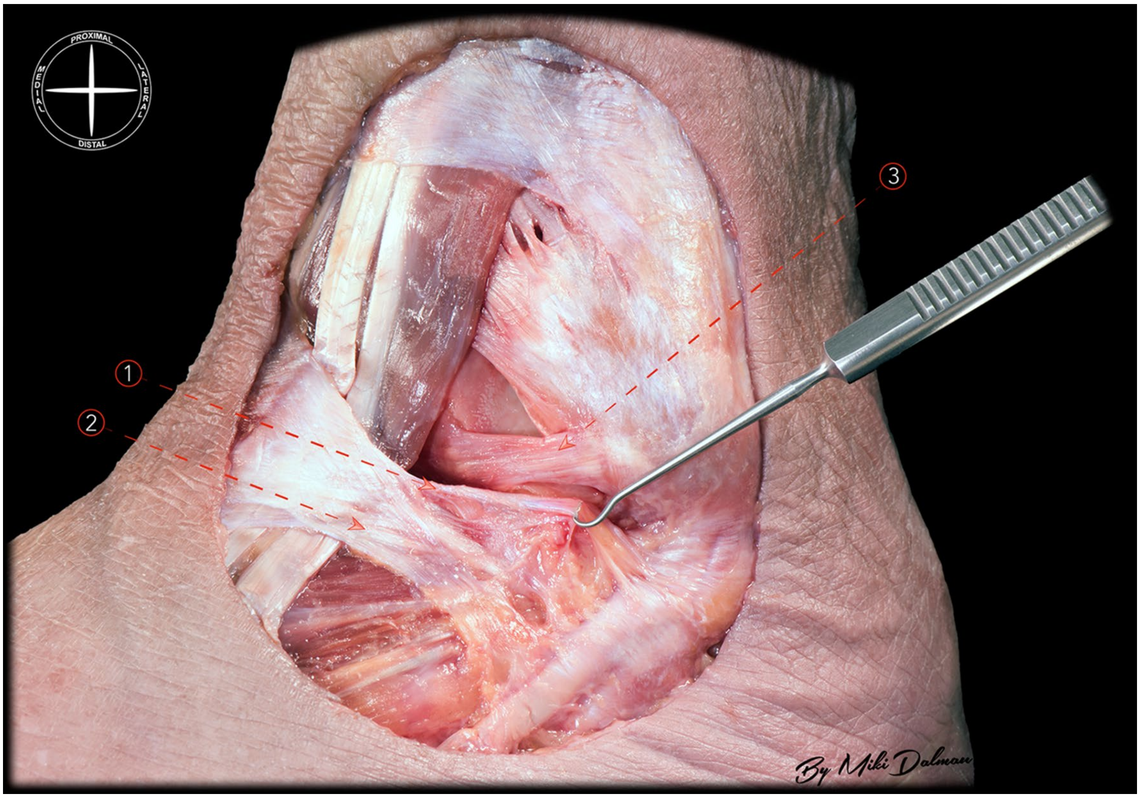

Fig. 4 Anterolateral view of a dissected ankle in ankle dorsiflexion, showing how the oblique superolateral band of the inferior extensor retinaculum is mobilised towards the fibular attachment of the anterior talofibular ligament. *1* Oblique superolateral band, *2* stem or frondiform ligament, *3* anterior talofibular ligament

AOFAS score was 90.8 points and that 93.3 % of patients had good or excellent outcomes, with no poor outcomes, in the 30 patients at a mean follow-up of 10.6 years. Similarly, Tourne et al. [19] found that 93 % of patients were satisfied with the results in a retrospective review of 150 cases, at a mean follow-up of 11 years. The role of the IER in ankle stability is therefore significant.

Whenever the IER is used as an ATFL augment, there is some confusion within the literature as to the part of the IER that is incorporated in the repair. In a practical setting, often through a limited small incision, it is often difficult to differentiate the anterior part of the sural fascia from the IER. Typically, the IER is a Y-shaped structure composed of the stem or frondiform ligament, an oblique superomedial band and an oblique inferomedial band (Fig. 1). The stem or frondiform ligament has three roots that arise from the sinus tarsi and divide into the oblique superomedial band, which inserts on the anterior aspect of the tibial malleolus, and into the oblique inferomedial band, which splits to insert on the abductor hallucis muscle and on the navicular and medial cuneiform. As the level of division into the oblique superomedial and oblique inferomedial bands is located on the medial side of the foot, the only part of the IER that could be used in the augmentation of the ATFL reconstruction is the stem or frondiform ligament; however, this structure neither crosses the ATFL ligament nor it is near enough to it to be used in its reconstruction. It is also a tense aponeurotic band that resists its proximal mobilisation towards the ATFL fibular attachment (Fig. 2).

Nevertheless, in approximately 25 % of the cases, an additional oblique superolateral band is found [13]. This band, which varies considerably in size, gives a X-shaped morphology to the IER (Fig. 3). When present, it crosses the ATFL and inserts on the lateral surface of the lateral malleolus; some of its fibres are continuous with the superior extensor retinaculum and the superior peroneal retinaculum. It is probably only in these circumstances that true IER is used in the augmentation of the ATFL repair (Fig. 4). While this contention is based on a single anatomical study demonstrating the low incidence of the oblique superolateral band of the IER [13], it is also our impression that, when using this technique, the structure used to reinforce the ATFL reconstruction in most cases is not the IER, but the sural fascia. It has to be remembered that the IER is an aponeurotic tissue continuous with the sural fascia and its limits are not always clear, leading to a subjective surgical assessment of the structure. In addition, important morphological variations between patients are possible (Fig. 5).

Fig. 5 Anterolateral view of a dissection showing a different morphology of the inferior extensor retinaculum, with a long stem or frondiform ligament. **a** Dissection showing the continuity of the sural fascia and the extensor retinaculum. *1* Superior extensor retinaculum, *2* superficial peroneal nerve (and branches), *3* inferior extensor retinaculum, *4* sural nerve. **b** Dissection showing delimitation of the extensor retinaculum, *5* superior extensor retinaculum, *6* stem or frondiform ligament of the inferior extensor retinaculum, *7* anterior talofibular ligament (fibrotic), *8* superficial peroneal nerve (cut)

We believe that new anatomical studies of the IER are needed in order to ascertain the incidence and morphological characteristics of the oblique superolateral band. This will clearly help the surgeon to make better decisions in the operating room, as is to be expected that a true IER reconstruction will provide more consistent tissue and consequently greater ankle stability than a reconstruction that uses only the sural fascia.

References

1. Behrens SB, Drakos M, Lee BJ, Paller D, Hoffman E, Koruprolu S, DiGiovanni CW (2013) Biomechanical analysis of Broström versus Broström-Gould lateral ankle instability repairs. Foot Ankle Int 34(4):587–592
2. Corte-Real NM, Moreira RM (2009) Arthroscopic repair of chronic lateral ankle instability. Foot Ankle Int 30:213–217
3. Cox JS (1985) Surgical and nonsurgical treatment of acute ankle sprains. Clin Orthop Relat Res 198:118–126
4. Golanó P, Vega J, de Leeuw PA, Malagelada F, Manzanares MC, Götzens V, van Dijk CN (2010) Anatomy of the ankle ligaments: a pictorial essay. Knee Surg Sports Traumatol Arthrosc 18(5):557–569
5. Golanó P, Vega J, Pérez-Carro L, Götzens V (2006) Ankle anatomy for the arthroscopist. Part II: role of the ankle ligaments in soft tissue impingement. Foot Ankle Clin 11(2):275–296 **(v–vi. Review)**
6. Gould N, Seligson D, Gassman J (1980) Early and late repair of lateral ligament of the ankle. Foot Ankle 1:84–89
7. Hamilton WG, Thompson FM, Snow SW (1993) The modified Broström procedure for lateral ankle instability. Foot Ankle 14(1):1–7
8. Jeong BO, Kim MS, Song WJ, SooHoo NF (2014) Feasibility and outcome of inferior extensor retinaculum reinforcement in modified Broström procedures. Foot Ankle Int 35(11):1137–1142
9. Karlsson J, Bergsten T, Lansinger O, Peterson L (1988) Reconstruction of the lateral ligaments of the ankle for chronic lateral instability. J Bone Joint Surg Am 70(4):581–588
10. Kim ES, Lee KT, Park JS, Lee YK (2011) Arthroscopic anterior talofibular ligament repair for chronic ankle instability with a suture anchor technique. Orthopedics 34(4):273
11. Lee KT, Lee JI, Sung KS, Kim JY, Kim ES, Lee SH, Wang JH (2008) Biomechanical evaluation against calcaneofibular ligament repair in the Broström procedure: a cadaveric study. Knee Surg Sports Traumatol Arthrosc 16(8):781–786
12. Lee KT, Park YU, Kim JS, Kim JB, Kim KC, Kang SK (2011) Long-term results after modified Broström procedure without calcaneofibular ligament reconstruction. Foot Ankle Int 32(2):153–157
13. Meyer P (1955) La morphologie du ligament annulaire anterieur du cou-de-pied chez l'homme. Comptes-Rendus Assoc Anat 84:286

14. Nery C, Raduan F, Del Buono A, Asaumi ID, Cohen M, Maffulli N (2011) Arthroscopic-assisted Broström-Gould for chronic ankle instability: a long-term follow-up. Am J Sports Med 39(11):2381–2388
15. Prisk VR, Imhauser CW, O'Loughlin PF, Kennedy JG (2010) Lateral ligament repair and reconstruction restore neither contact mechanics of the ankle joint nor motion patterns of the hindfoot. J Bone Joint Surg Am 92(14):2375–2386
16. Sarrafian SK (1983) Chapter 3: retaining systems and compartments. In: Sarrafian SK (ed) Anatomy of the foot and ankle. Descriptive, topographic, functional, 1st edn. J.B. Lippincott Co, Philadelphia
17. Scranton PE Jr, McDermott JE, Rogers JV (2000) The relationship between chronic ankle instability and variations in mortise anatomy and impingement spurs. Foot Ankle Int 21(8):657–664
18. Takao M, Matsui K, Stone JW, Glazebrook MA, Kennedy JG, Guillo S, Calder JD, Karlsson J; Ankle Instability Group (2015) Arthroscopic anterior talofibular ligament repair for lateral instability of the ankle. Knee Surg Sports Traumatol Arthrosc [**epub ahead of print**]
19. Tourné Y, Mabit C, Moroney PJ, Chaussard C, Saragaglia D (2012) Long-term follow-up of lateral reconstruction with extensor retinaculum flap for chronic ankle instability. Foot Ankle Int 33(12):1079–1086
20. Vega J, Golanó P, Pellegrino A, Rabat E, Peña F (2013) All-inside arthroscopic lateral collateral ligament repair for ankle instability with a knotless suture anchor technique. Foot Ankle Int 34(12):1701–1709
21. Weindel S, Schmidt R, Rammelt S, Claes L, v Campe A, Rein S (2010) Subtalar instability: a biomechanical cadaver study. Arch Orthop Trauma Surg 130(3):313–319