

Medial ankle instability

Instabilidade medial do tornozelo

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Abstract

While much is known about the anatomy and biomechanics of lateral ankle ligaments, the medial ankle ligaments are still poorly understood. Analogously, very little objective data is available regarding the clinical presentation of medial ankle instability. The focus of this article is to elucidate the anatomy and function of the medial ligaments, and to present our experience for diagnosis and treatment of incompetent deltoid ligament.

Keywords: Ankle joint/physiology; Ankle joint/surgery; Arthroscopy; Collateral ligaments/physiology; Collateral ligaments/surgery; Joint instability/etiology; Joint instability/physiology; Joint instability/surgery; Ligaments, articular/anatomy & histology

Resumo

Até quanto é conhecida a anatomia e a biomecânica do complexo ligamentar lateral, o ligamento medial continua mal compreendido. Analogamente, poucos relatos objetivos são direcionados ao quadro clínico da instabilidade medial. O objetivo deste artigo é elucidar a anatomia e a biomecânica do ligamento medial e mostrar a experiência no diagnóstico e na conduta da incompetência do ligamento deltóide.

Descritores: Articulação do tornozelo/fisiologia; Articulação do tornozelo/cirurgia; Artroscopia; Ligamentos colaterais/fisiologia; Ligamentos colaterais/cirurgia; Instabilidade articular/etiologia; Instabilidade articular/fisiologia; Instabilidade articular/cirurgia; Ligamentos articulares/anatomia & histologia

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INTRODUCTION

There is evidence, that the medial ankle ligaments are more often injured than generally believed⁽¹⁻³⁾. Typically, injuries to the medial ankle ligaments occur during running down the stairs, landing on uneven surface and dancing while the body simultaneously rotated in the opposite direction. A key feature of the patients' history is whether they have sustained a pronation (eversion) trauma, e.g., an outward rotation of the foot during simultaneous inward rotation of the tibia. Excessive lateral rotation may injure the tibiofibular and interosseous ligaments at the syndesmosis. The anterior fibers of the deltoid ligament may also be involved in extreme rotation injuries. In practice, however, this is not as easy as patients often report of having sustained one more multiple ankle sprains, but they are not able to clearly indicate the injury mechanism.

Complete deltoid ligament ruptures are sometimes seen in association with lateral malleolar fractures⁽⁴⁾, or in specific bimalleolar fractures⁽⁵⁾.

Chronic deltoid ligament insufficiency can be in a number of conditions including posterior tibial tendon disorder, trauma and sports related deltoid disruptions, as well as valgus talar tilting in those with previous triple arthrodesis or total ankle arthroplasty.

One concern may be by the question whether posterior tibial dysfunction and medial ankle instability are distinct conditions. Although possible, it is not clear yet if, or to which extent, a medial ankle instability may cause a secondary posterior tibial dysfunction over time, as the tendon may become elongated and/or ruptured⁽⁶⁾.

The focus of this article is to elucidate the anatomy and function of the medial ligaments, and to present our experience for diagnosis and treatment of incompetent deltoid ligament.

Anatomy of deltoid ligament

Wide variations have been noted in the anatomic description of the medial ligamentous complex of the ankle. It is a multibanded complex, nevertheless, it is generally agreed that it can be considered as having superficial and deep components. It may be wise to differentiate the superficial and deep portions of the deltoid complex, as proposed by Milner and Soames⁽⁷⁾, respecting the joints they are spanning; the superficial ligaments crossing two – the ankle and the subtalar joints - and the deep ligaments crossing one joint – only the ankle joint, although differentiation is not always absolutely clear. Milner and Soames⁽⁷⁾ observed in osteoligamentous preparation of 40 cadavers, six different component bands:

four superficial (tibiospring, tibionavicular, superficial posterior tibiotalar, and tibiocalcaneal ligaments), of which only the tibiospring and tibionavicular ligaments were constant, and two deep bands (deep posterior tibiotalar and deep anterior tibiotalar ligaments), of which only the deep posterior tibiotalar ligament was constant. Boss and co-workers⁽⁸⁾, in contrast, differentiated three superficial and more anterior bands (tibionavicular, tibiospring, and tibiocalcaneal ligaments), and three deep bands (anterior, intermediate, and posterior tibiotalar ligaments).

As the tibioligamentous portion of the superficial deltoid has a broad insertion on the “spring ligament”, this ligament complex may interplay with the deltoid ligament in the stabilization of the medial ankle joint, and thus functionally not be separated from it (Figure 1).

Function of deltoid ligament

Close⁽⁹⁾ found the deltoid ligament to be a strong restraint limiting talar abduction. With all lateral structures removed, he found that the intact deltoid ligament allows only 2 mm of between the talus and medial malleolus. When the deep deltoid ligament is released, the talus can be separated from the medial malleolus by a distance of 3.7 mm. Grath⁽¹⁰⁾ confirmed these findings in a similar experiment. Rasmussen et al.⁽¹¹⁻¹²⁾ investigated the function of various parts of the deltoid ligament and stated that the superficial layers of the deltoid ligament, specifically limit talar abduction or negative talar tilt.

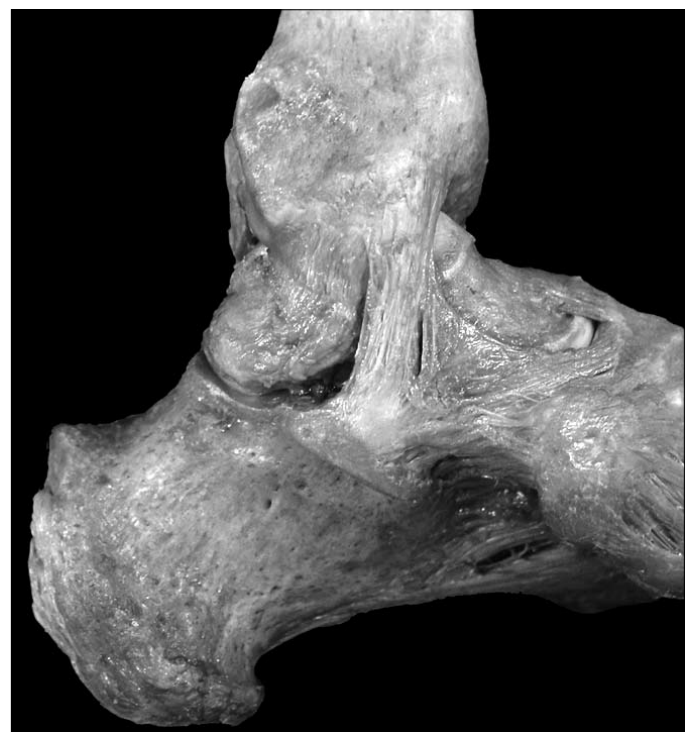


Figure 1- Medial view of ankle showing the deltoid ligament complex.

Whereas, the talocalcaneal ligament specifically limits talar pronation, while the deep layers of the deltoid ligament rupture in external rotation without the superficial portion being involved. Harper⁽¹³⁾ claimed the deltoid ligament to be the primary restraint against pronation of the talus, but with the superficial and deep components equally effective in this regard. Nigg et al.⁽¹⁴⁾ stated that the deltoid ligament appears to be sensitive to plantar flexion, external rotation, and pronation.

Clinical presentation of deltoid ligament incompetence

Acute injuries to the deltoid ligament must be suspected after an eversion and/or pronation trauma of the foot. Typically, the foot was on ground when an eversion force caused a valgus stress to the ankle, or an internal rotation force caused a pronation stress to the hindfoot. It can also occur in association with lateral ankle fracture. Chronic injuries to the deltoid ligament, typically, causes medial ankle instability, which must be suspected on the basis of patient's feeling of "giving-way", especially toward medially, when

walking on even ground, down-hill, or down-stairs, pain at the anteromedial aspect of the ankle, and sometimes pain on lateral ankle, especially during dorsiflexion of the foot⁽¹⁵⁾.

Clinical findings

Acute injuries may evidence tenderness and hematoma at the side of deltoid ligament. A key finding in chronic injuries of the deltoid ligament was a pain in the medial gutter, as typically provoked by palpation of the anterior border of medial malleolus^(1,15). With the patient bearing weight, asymmetrical planus and pronation deformity of the affected foot was found to indicate medial ankle instability^(1,6,15). Typically, the excessive valgus of the hindfoot and pronation of the foot (Figures 2-A, 2-C) disappeared while the patient was asked to correct the hindfoot pronation and thereby to activate the posterior tibial muscle (Figure 2-B). Analogously, the excessive valgus of the hindfoot and pronation of the foot disappeared while the patient was asked to go in tip-toe position (Figure 2-D). As there was no presence of a flattening of the medial longitudinal arch, a hindfoot valgus, and a forefoot ab-



Figure 2 - Twenty-five year old female volleyball player having sustained a pronation trauma 14 months ago; after primary conservative treatment, she complains about medial ankle pain and instability feeling. On clinical investigation, there is a pronation deformity with prominence of medial malleolus and slightly internally rotated leg when standing (A: anterior view; B: posterior view) that disappears incompletely while tip-toe standing (C: anterior view; D: posterior view).

duction that were not corrected by performing the single heel rise test, a posterior tibial dysfunction was excluded.

Clinical stress investigation was found to be most reliable when the patient was seated on table with hanging feet⁽¹⁵⁾. The heel is taken with one hand and the tibia with the other hand. First, a varus, and then a valgus tilt stress are applied to the heel, and the result with the contralateral side. Second, anterior drawer stress is applied, and again the result compared with the contralateral side.

Radiological findings

Plain standard films are used to exclude a fracture or bony pathologies. In chronic conditions, weight-bearing X-ray should be obtained to assess the extent of deformity if present. This is particularly true for a valgus deformity of the hindfoot as a result of a severe incompetence of medial ankle ligaments.

While stress X-rays were found to be helpful to discern an incompetence of deltoid ligament in treatment of acute ankle fractures⁽⁶⁾, it was not in chronic conditions⁽¹⁵⁾.

In the past, arthrography was found to be able to show an acute rupture of the deltoid ligament⁽¹⁶⁾. This method have been, however, mostly abundant in the last years.

Additional imaging methods

If a talocalcaneal coalition or bony fragmentation that involves the articular surfaces is suspected, additionally computed tomography (CT) may be initiated. Although magnetic resonance image (MRI) may evidence an injury to the deltoid ligament, particularly in acute conditions (Figure 3), there is no need for MRI investigation on a regular base.

The criteria for diagnosing medial ankle instability are therefore a feeling of giving-way, pain on the medial gutter of the ankle, and a valgus and pronation deformity of the foot that can typically be corrected by the posterior tibial muscle.

Arthroscopic assessment

Ankle arthroscopy was found to be a helpful diagnostic tool to confirm clinically suspected instability of the medial (Figure 4) and lateral ankle, and to detect additional structural changes such as cartilage lesions^(15,17). As evaluated for both, the lateral and medial side, the ankle joint is graded as stable when there is some translocation of the talus, but not enough to open the tibiotalar joint by more than 2 mm, as measured by the 2 mm-hook, and not enough to introduce the 5 mm-arthroscope into the tibiotalar space; as moderately unstable when the talus moved to some extent out of the ankle mortise, allowing to introduce the 5 mm-arthroscope

into the tibiotalar space, but not enough to open the tibiotalar joint by more than these 5 mm; as severely unstable when the talus moved easily out of the ankle mortise, typically allowing for free insight into the posterior aspect of the ankle joint without significant pulling stress on the heel⁽¹⁷⁾.

Most interestingly, 75% of patients with chronic medial ankle instability evidenced an associated avulsion of the an-

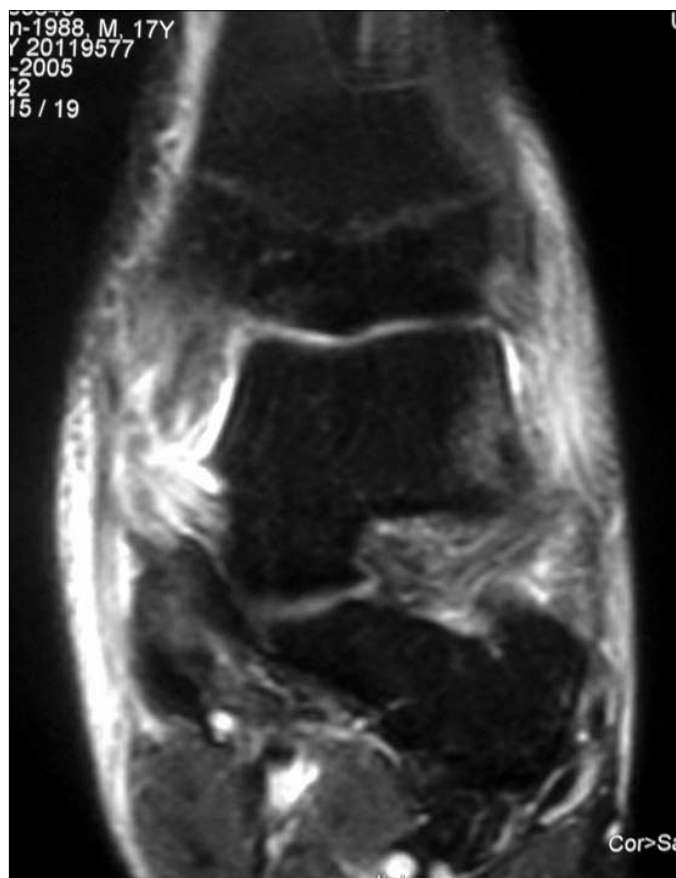


Figure 3 - Twenty-nine year old soccer player after acute eversion trauma. On MR imaging, evidence of a complete avulsion of deltoid ligament.



Figure 4 - Arthroscopic view from anteriorly to the medial malleolus showing a naked malleolus due to avulsion of the deltoid ligament.

terior talofibular ligament that resulted in a complex rotational instability of the talus within the ankle mortise⁽¹⁵⁾.

Surgical exploration of the ligaments

Surgical exploration of the medial ankle ligaments should be performed in all patients with symptomatic ankle instability in whom medial ankle instability has been suspected clinically and confirmed arthroscopically. If additional instability of the lateral ankle ligament is suspected, the lateral ankle ligaments should also be explored.

On the medial side, a gently curved incision of 4 to 8 cm is made, starting 1 to 2 cm cranially of the tip of the medial malleolus toward the medial aspect of the navicular bone. After dissection of the fascia, the anterior aspect of the deltoid ligament is exposed. Then, a longitudinal incision of the tendon sheath allows to explore the posterior tibial tendon and to identify the spring ligament. The tibionavicular ligament and the tibiospring ligament are then explored.

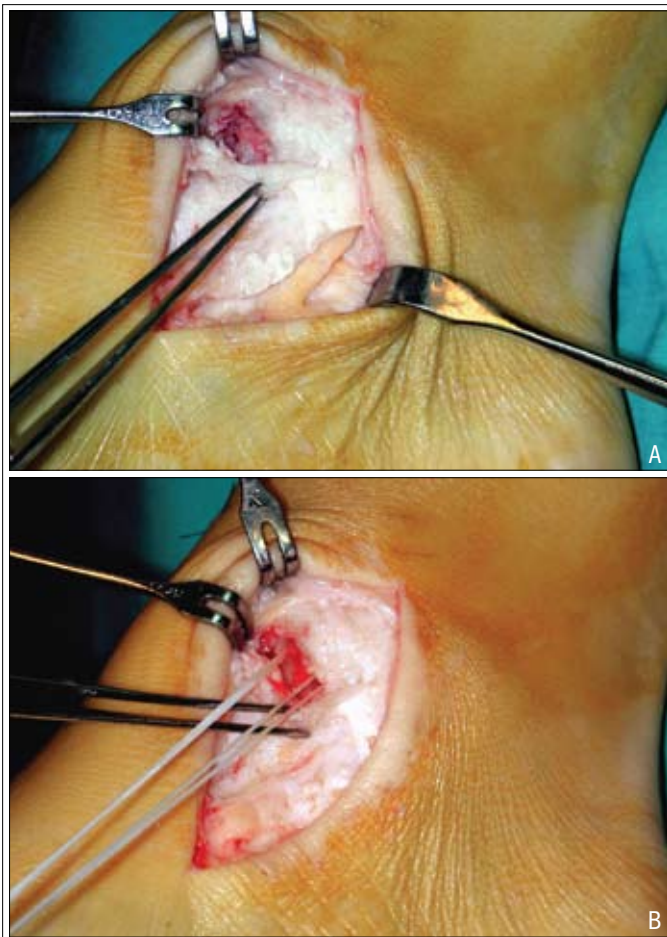


Figure 5 - Medial ligament reconstruction (same patient as figure 1): A) avulsion of tibionavicular and tibiospring ligaments with a tear of the interval to the tibiocalcaneal ligament; B) transosseous reattachment by using a bony anchor.

The lateral ankle ligaments are exposed through a 5 to 8 cm long skin incision. The sinus tarsi and the subtalar joint are exposed and opened first. The dissection continues in a proximal direction while preserving the remaining and often scarred ligaments. The state of the stumps of the anterior talofibular ligament, calcaneofibular ligament and lateral tibiocalcaneal ligament can now be assessed.

Classification of medial ankle instability

Medial ankle instability can result from an acute injury to the deltoid ligament and include a wide injury pattern from partial to complete tearing of the ligament structures. Chronic medial ankle instability can, however, result from various conditions: an ankle sprain that has left residual instability of the talus within the mortise (e.g. where the repetitive stress has worn-out the superficial anterior bundles of the deltoid ligament), an insufficiency of the posterior tibial muscle following tendon dysfunction (e.g. where an increased valgus and pronation movement of the hindfoot is initiated while loading the foot), or a chronic overload in fixed valgus and flatfoot deformity (e.g. where the acting valgus forces overpass the tensile forces of the deep tibiocalcaneal bundles of the deltoid ligament). Previously, Hintermann⁽¹⁻²⁾ has proposed to divide injuries to the anterior bundles of the deltoid ligament into three types: Type I-lesion, proximal tear/avulsion of the deltoid ligament; Type II-lesion, intermediate tear of the deltoid ligament; and Type III-lesion, distal tear/avulsion of the deltoid and spring ligaments.

Surgical techniques

Medial ankle ligaments

- Complete acute rupture: As the rupture is mostly situated proximally of the deltoid ligament, reattachment to the medial malleolus is achieved by interosseous sutures; a bony anchor can also be used for reattachment to the bone.
- Chronic rupture of superficial deltoid ligament, Type I-lesion: The anterior border of the medial malleolus is exposed by a short longitudinal incision between the tibionavicular and tibiospring ligaments, where usually a small fibrous septum without adherent connective fibers between the two ligaments is present (Figure 5-A). After roughening of the medial aspect of the medial malleolus, an anchor (Panalock[®]) is placed 6 mm above the tip of the malleolus (Figure 5-B) and serves for reattachment of the tibionavicular and tibiospring ligaments to the medial malleolus, and to shorten both, the tibionavicular and tibiospring ligaments. Additional 0 resorbable sutures are used to reattach the tibionavicular and tibiospring ligaments.

- Chronic rupture of superficial deltoid ligament, Type II-lesion: The scarred insufficient ligament is divided into two flaps: the deep flap remains reattached distally, whereas the superficial flap remains reattached to the medial malleolus⁽¹⁾. One anchor (Panalock[®]) is placed 6 mm above the tip of the malleolus and one anchor (Panalock[®]) is placed at the superior edge of the navicular tuberosity. The two anchors serve for refixation of the deep flap to the medial malleolus, and the superficial flap to the navicular tuberosity, thereby creating a strong and well-tightened ligament reconstruction. Additional 0 resorbable sutures are used to further stabilize the reconstructed tibionavicular and tibiospring ligaments.
- Chronic rupture of superficial deltoid ligament, Type III-lesion: If necessary, the tear is debrided⁽¹⁾. Then, two non-resorbable sutures are placed in the spring ligament, and, if the tibionavicular ligament is completely detached from its insertion, an anchor (Panalock[®]) is placed at the superior edge of the navicular tuberosity. After having tightened the sutures, additional 0 resorbable sutures are used to further stabilize the reconstructed tibionavicular and spring ligaments.
- Chronic rupture of deep deltoid ligament: As this condition includes in most instances an extended tear of the superficial anterior bundles of the deltoid ligament, any reconstruction surgery should attempt to address the whole deltoid ligament. The posterior tibial tendon can be used as a graft for augmentation of reconstructed deltoid ligament while passing it through a drill hole from the tip of medial malleolus to the medial aspect of the distal tibia. This technique was found to be somehow disappointing as it does not sufficiently reinforce the deep tibiotalar ligaments (Hintermann, unpublished data). Most recently, the use of a bone-tendon-bone transplant has been proposed for reconstruction of deltoid ligament⁽¹⁸⁾. In this *in vitro* study, two limbs were created on distal transplant of which one was fixed to the medial aspect of talus, and the other to the sustentaculum tali; whereas, the proximal end was fixed either to the distal tibia, medial malleolus, or lateral tibia. Less than 2.0 degrees of angulation was found while applying valgus stress of 5daN for all fixation methods. However, the authors advised against fixation the proximal limb in the medial malleolus.

Additional procedures

The posterior tibial tendon is meticulously inspected during surgery, especially in the case of a Type II- and Type III-lesion of anterior deltoid ligament. If there is some degeneration of the tendon, débridement of the tendon is performed. If there is an elongation of the tendon, shortening

of the tendon is considered. If there is an accessory bone (os tibiale externum), reattachment of the bone with the tendon insertion is considered; the posterior tibial tendon can additionally be tightened if the bone is reattached more distally to the navicular bone⁽¹⁹⁾. A tendon transfer might be considered in the case of a diseased or ruptured tendon.

Reconstruction of the lateral ankle ligaments is considered in the case of an additional lateral instability of the ankle (Figure 6-A). If the condition of the anterior talofibular ligament and calcaneofibular ligament allows an adequate primary repair, these ligaments are reconstructed by shortening and reinsertion (Figure 6-A). When no substantial ligamentous material is present, augmentation with a free plantaris tendon graft is performed.

A calcaneal lengthening osteotomy is considered in the case of a pre-existing valgus and pronation deformity of the foot (e.g., when a valgus and pronation deformity is also present on the contralateral, asymptomatic foot), and/or in the case of a severe attenuation or defect of the tibionavicular

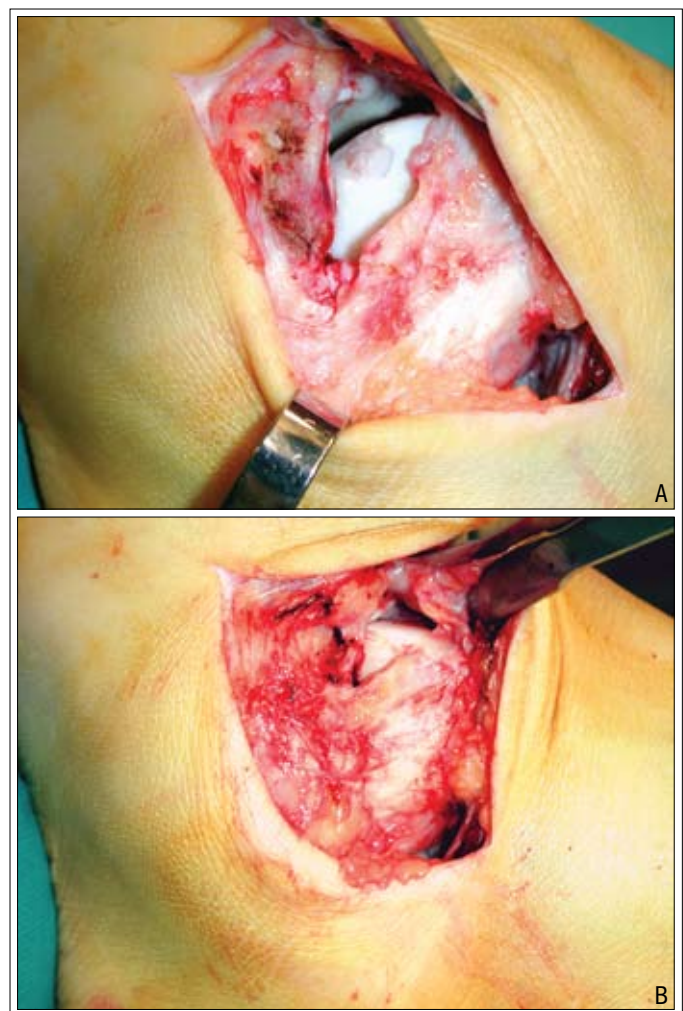


Figure 6 - Lateral ligament reconstruction (same patient as figure 1): A) avulsion of lateral ankle ligament from fibula; B) reattachment to the fibula by transosseous sutures.

lar, tibiospring and/or spring ligaments. Calcaneal osteotomy is performed along and parallel to the posterior facet of the subtalar joint, from lateral to medial, preserving the medial cortex intact^(4,20). As the osteotomy is widened, the pronation deformity of the foot is seen to disappear. A tricortical graft from the iliac crest is fashi to the length required and placed into the osteotomy site.

A triple arthrodesis is considered when the medial ankle instability is so excessive that a valgus tilt of talus within the mortise is seen on AP standard view of the ankle while the foot is loaded. Attention has to be paid to fully correct the whole deformity (e.g. valgus malalignment of the heel, and the peritalar dislocation of talus).

Postoperative management

The foot is protected by a plaster cast for six weeks and allowed for full weight-bearing as soon as pain free loading is possible, and the rehabilitation program starts afterwards. It includes passive and active mobilization of the ankle joint, training of the muscular strength and protection by a stabilizing shoe when walking. A walker or stabilizing shoe may be recommended to be used for four to six weeks after plaster removal, depending on regained muscular balance of the hindfoot. Afterwards, we still recommend the patient to use it for walks on uneven ground, for high risk sports activities, and for professional work outside. In the case of triple arthrodesis, initial plaster immobilization of eight weeks is recommended.

The author's experience

In an arthroscopic assessment of 288 acute ankle fractures, the deltoid ligament was found to be injured more frequently than expected, particularly in Weber Type B fractures⁽⁴⁾. Such injuries may be a source of persisting pain or pronation deformity, when not appropriately treated. Despite of the opinion others that surgical reconstruction of a ruptured deltoid ligament is not necessary⁽²¹⁾, we advise to go for careful reconstruction of medial ankle ligaments as long as restoration of full stability is not proven after internal fixation of the fracture and, if necessary, screw fixation of syndesmosis, or proper repositioning of talus within the ankle mortise can be achieved because of interposition of the disrupted ligament between medial malleolus and talus.

Complete acute rupture of the deltoid ligament can also be seen in athletes after a valgus trauma, without lateral side injury to the ankle, but it is rare⁽¹⁶⁾. As primary operative repair was found to get most satisfying results, we continue to consider surgical reconstruction in such acute injuries.

Chronic incompetence of the anterior superficial deltoid ligament was found to cause chronic disabling pain and subjective instability⁽¹⁵⁾. In this prospectively documented and consecutive series of 52 patients, a pain in the medial gutter was found in all ankles (100%), pain along the posterior tibial tendon in 14 ankles (27%), and pain along the anterior border of the lateral malleolus in 13 ankles (25%). A proximal rupture (Type I-lesion) of the deltoid ligament was noted in 37 cases (71%), an intermediate rupture (Type II-lesion) in five (10%), and a distal rupture (Type III-lesion) in 10 cases (19%). The posterior tibial tendon evidenced elongation in six cases (12%) and degeneration in five cases (10%), but neither attenuation nor a rupture in any case. Repair of the deltoid ligament was performed in all 52 cases, repair of the spring ligament in 13 cases (24%), repair of the lateral ligaments in 40 cases (77%), and an additional calcaneal lengthening osteotomy in 14 patients (27%). At follow-up (4.4 [2.0 – 6.6] years) the AOFAS-Hindfoot-score⁽²²⁾ was found to have improved from 42.9 preoperatively to 91.6 points. The clinical result was considered to be good/excellent in 46 cases (90%), fair in four cases (8%), and poor in one case (2%). Based on these favourable results, we have continued with this protocol. However, we consider additional calcaneal osteotomy (e.g. medial sliding osteotomy to correct heel valgus, or lateral column lengthening osteotomy to correct pronation deformity of the hindfoot) more frequently, particularly in those patients with pre-existing deformities.

The most conflicting problem remains a chronic incompetence of the deep deltoid ligament which results in valgus tilt of talus while loading the foot. As, despite of the use of tendon augmentation, most attempts of isolated ligament reconstruction have failed, the main step is probably a triple fusion in getting a stable and well aligned hindfoot. An alternative may be a tibio-calcaneal arthrodesis.

DISCUSSION

Recent work has brought more light into the injuries to the deltoid ligament. The mechanism of injury can vary from an acute eversion stress to a repetitive rotational movement of the unstable talus within the ankle mortise. Out of 52 patients, 22 patients (42%) indicated they had sustained primarily a supination trauma, but thereafter they sustained other sprains; whereas, 18 patients (35%) reported having sustained an eversion trauma, and the other 12 patients (23%) reported having sustained one or multiple ankle sprains, but they were not able to clearly indicate the injury mechanism⁽¹⁵⁾. While an increased pronation of the affected foot was found in 26 patients (50%), a similar deformity was also found on contra lateral unaffected foot in 11 patients

(19%). Therefore, an acute ankle sprain may involve the deltoid ligament, particularly in eversion trauma; whereas, recurrent ankle sprains after an initial inversion trauma can lead to incompetence of the anterior deltoid ligament which, in turn, increases sagittal plane movement of the medial talus within the ankle mortise. Further, there is evidence that a pronation deformity of the foot may dispose the deltoid ligament to wear-out and consequent incompetence.

The clinical manifestation of chronic medial ankle instability following injury to the deltoid ligament is a persisting valgus and/or pronation deformity of the hindfoot. Such an instability can be suspected on the basis of patient's feeling of "giving-way", especially toward medially, when walking on even ground, down-hill, or down-stairs, pain at the anteromedial aspect of the ankle, and sometimes pain on lateral ankle especially during dorsiflexion of the foot. Hallmark of the disorder is a pain on the medial gutter of the ankle, and a valgus and pronation deformity of the foot. The deformity can typically be actively corrected by the posterior tibial muscle. In contrast to stress X-ray, arthroscopy was shown to be a very helpful diagnostic tool in verifying medial instability;

especially, it proved that also the lateral ankle ligaments can be involved. MRI, in contrast, was not found to be helpful in assessing the condition of the deltoid ligament, but it may help to detect associated lesions of cartilage.

The treatment of an acute tear of deltoid ligament should be operatively as long as competence of the remaining ligament structures against valgus stress cannot be proven. In chronic injuries of the superficial deltoid ligament with symptomatic medial instability of the ankle, surgical reconstruction should include all involved ligaments at the medial, and, if necessary, also the lateral ankle. In the case of progressed foot deformity, and/or bilateral long-standing valgus and pronation deformity of the foot, an additional calcaneal lengthening osteotomy might be considered. If the chronic injury involves the deep deltoid ligament, isolated ligament reconstruction might be critical and will potentially fail, as long as proper alignment and stability of the hindfoot has not been achieved by osteotomies and/or triple fusion. In severe valgus deformity, tibiocalcaneal arthrodesis may be considered.

This treatment concept was shown to provide high patient's satisfaction and reliable clinical results.

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