

Lateral collateral ligament repair

Yves Tourné & Marco Peruzzi

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Introductory remarks

The aims of any surgical repair or reconstruction technique are to restore the capsuloligamentous structure and thus articular stability, while preserving the mobility of the talocrural and subtalar joints and avoiding secondary arthrosis [22, 24]. More than 80 ligament repair procedures to restore ankle stability including in the subtalar joint have been described. All show good short-term impact on stability [9, 13]. Techniques can be categorized as anatomic, repair (with or without augmentation) or reconstruction of the residual ligament bundles, e.g. anterior tibiofibular (ATFL), calcaneofibular (CFL) and cervical ligaments or non-anatomic reconstructions with tenodesis effect [24]. A conventional open approach is most widely used but arthroscopic techniques have started being reported [9, 23].

Yves Tourné¹ · Marco Peruzzi²

¹ Foot and Ankle Institute of Grenoble, Centre Ostéo Artculaire des Cèdres, Echirolles, France

² Largo Agostino Gemelli, Facoltà di Medicina e Chirurgia, Istituto di Ortopedia e Traumatologia, Università cattolica del Sacro Cuore, Roma, Italy

Lateral collateral ligament repair

Anatomical ligament reinsertion with augmentation using inferior extensor retinaculum flaps

Anatomical background

— More accurate descriptions of the different bundles of the lateral collateral ligaments (LCL) complex of the ankle were recently performed, due to the development of arthroscopic techniques [2, 14]. The ATFL is composed of two groups of fibers: the superior one is linked to the anterosuperior part of the capsule and provides attachment to the anterior aspect of the lateral malleolus, very close to the inferior insertion of the antero inferior tibiofibular ligament (AITFL) of the syndesmotic complex. The inferior one is attached on the fibular obscure tubercle as described by Matsui et al. [14]. The CFL insertion on the lateral malleolus is slightly posterior to the fibular obscure tubercle, independent from the ATFL or on the fibular obscure tubercle, by a conjoint ligament with the distal bundle of the ATFL. These different foot prints and landmarks

of the ATFL and CFL insertions onto the anterior aspect of the lateral malleolus must be considered before reinsertion (■ Fig. 1).

— The inferior extensor retinaculum (IER) is an aponeurotic structure in continuation with the sural fascia. It could be a Y-shaped or X-shaped structure with strong correlations to the intermediate dorsal cutaneous nerve (superficial peroneal nerve; ■ Fig. 2). To pay attention to those dorsal neurological structures is mandatory before using the IER. Furthermore, the X-shaped structure means the superolateral band can be very thin and therefore, not powerful enough to increase the strength of the reinsertion of the remnant ligaments. These anatomical findings could advise against the use of the Gould augmentation [4, 5].

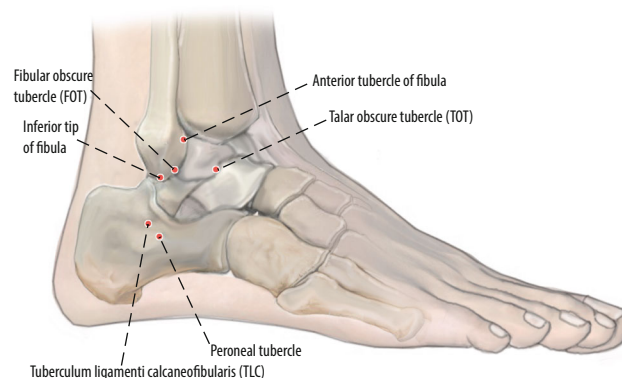


Fig. 1 ◀ Diagram of the right foot showing the normal anatomic relationship of the tubercles

Surgical Techniques

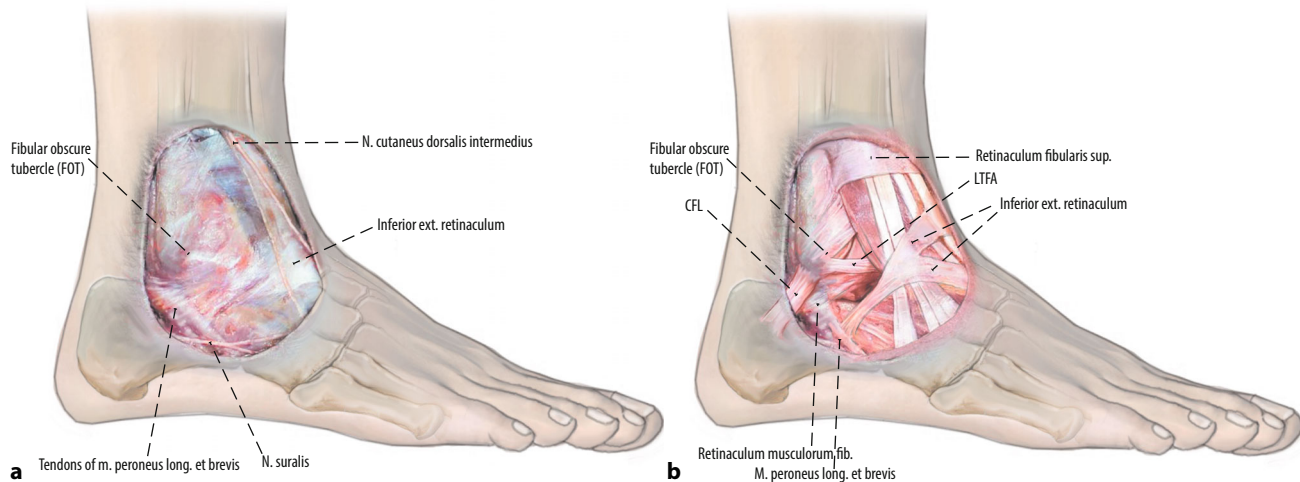


Fig. 2 ▲ Anatomical structures on the dorsal aspect of the midfoot showing the situation before (a) and after (b) removal of the fascia, with the inferior extensor retinaculum (IER), extensor digitorum longus tendons and superficial peroneal nerve branch

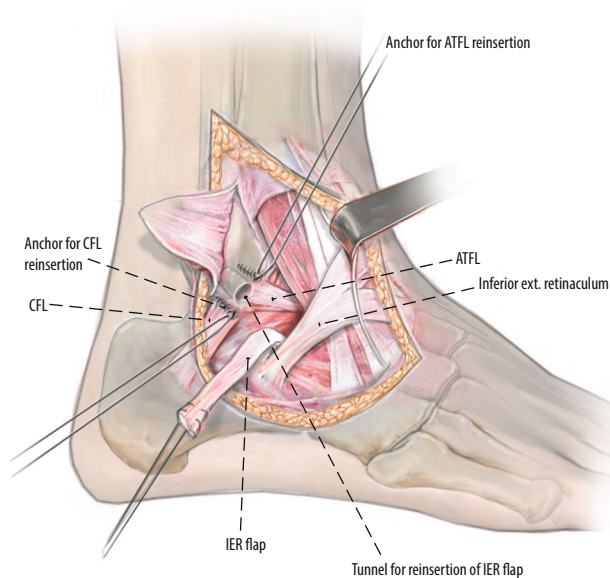


Fig. 3 ▲ Anterior tibiofibular ligament (ATFL) and calcaneofibular ligament (CFL) ready for reinsertion and flap harvested from the inferior extensor retinaculum (IER) before its reinsertion. The flap remains attached on the lateral aspect of the calcaneus

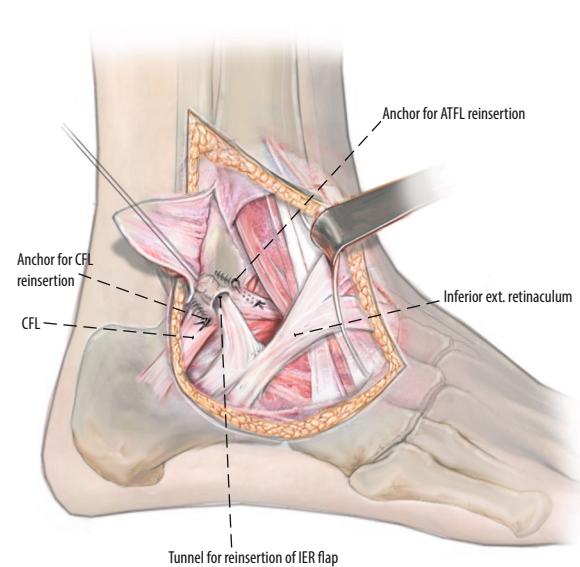


Fig. 4 ▲ Overall reinsertion, using anchors for anterior tibiofibular ligament (ATFL) and calcaneofibular ligament (CFL) and a tunnel with an interference screw for the flap

Surgical principle and objective

The surgical technique described combines retensioning of the incompetent lateral collateral ligaments (ATFL and CFL) with reinforcement by a neoligament harvested from the extensor retinaculum. Whilst the retensioning of the capsuloligamentous structures resembles the techniques described

by Broström [3] and Duquenois et al. [7], the reinforcement using the extensor retinaculum described by Saragaglia et al. [18] and modified by Tourné and Mabit [24] and reported in their work, is different to that reported by Blanchet [1] or Gould et al. [8] (Figs. 3 and 4). The retinaculum flap works as an actual neoligament, providing not only reinforcement and collagen in-

put but also peripheral stabilization of the subtalar joint by its calcaneal insertion, reinforcing the CFL.

Advantages

- Anatomical repair of the LCL of the ankle with reinsertion of the ATFL and CFL
- With augmentation using the most consensual collagenous tissue for

Abstract · Zusammenfassung

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Y. Tourné · M. Peruzzi

Lateral collateral ligament repair. Anatomical ligament reinsertion with augmentation using inferior extensor retinaculum flaps

Abstract

Objective. For chronic lateral ankle instability an anatomical repair procedure of the lateral collateral ligaments (LCL) of the ankle with augmentation by an inferior extensor retinaculum (IER) flap is proposed.

Indications. To treat the mechanical parts of an instable ankle involving both LCL and subtalar joint ligament damage.

Contraindications. This technique is not suitable when the anterior talofibular ligament (ATFL) and calcaneofibular ligament (CFL) are in a poor anatomical condition (exhaustive preoperative lesion mapping mandatory).

Surgical technique. This technique combines the reinsertion of the remnants of the lateral ligaments of the ankle, the ATFL and the CFL using anchors, with augmentation using an inferior extensor retinaculum flap fixed in

a tunnel by an interference screw. This flap works as an actual neoligament, providing not only reinforcement and collagen input but also peripheral stabilization of the subtalar joint by its calcaneal insertion and reinforcing the CFL stabilizing effect.

Postoperative management. Following immediate immobilization in an ankle-foot orthosis, proprioceptive physiotherapy exercises are initiated with a return to sports depending on the type of sport.

Results. The postoperative outcomes and long-term follow-up results of this technique are discussed.

Keywords

Ankle instability · Lateral collateral ligament laxity · Ligament reconstruction · Extensor retinaculum flap · Subtalar joint

- augmentation of the LCL: the inferior extensor retinaculum
- But with a flap harvested from the strongest part of the IER
- Stabilizes the subtalar joint in the mean time
- Bulkier construct than Gould's modification of the Broström procedure
- Preservation of the peroneus tendon as an augmentation tissue
- Very good results at long-term follow-up regarding stability and osteoarthritis
- Can be combined in the same surgical event with repair of peroneal tendons tears, repair of other ligaments, osteochondral lesions of the talar dome treatment

Disadvantages

- Not yet performed as a minimally invasive procedure
- But work in progress to develop a minimally invasive procedure to pick up the IER flap

Indications

- To treat the mechanical part of the instable ankle
 - Due to LCL damages
 - But also when lesions involve the subtalar joint
 - Guided by an exhaustive preoperative lesion mapping
- After failure of the conservative treatment that associated physiotherapy and rehabilitation program
- When ATFL and CFL remnant ligaments are considered suitable for reinsertion

Contraindications

- Surgical technique not suitable when ATFL and CFL in a very poor anatomic condition
- In this case anatomical reconstruction to recreate the course of injured ligament bundles is indicated
- Not to be used isolated, when varus of the hindfoot is well-established: high risk of failure of ligamentoplasty

Rekonstruktion des lateralen Kollateralbandapparats am oberen Sprunggelenk. Anatomische Reinsertion des Ligaments durch Augmentation mittels Retinaculum-extensorum-inferius-Flap

Zusammenfassung

Operationsziel. In diesem Beitrag wird ein Verfahren zur anatomischen Rekonstruktion des lateralen Kollateralbandapparats („lateral collateral ligaments“, LCL) des Sprunggelenks mittels Augmentation unter Verwendung eines Retinaculum-extensorum-inferius (IER)-Flaps zur Behandlung einer chronischen lateralen Sprunggelenkinstabilität vorgeschlagen.

Indikationen. Indikation ist die Behandlung eines mechanisch instabilen Sprunggelenks mit Beteiligung sowohl des LCL als auch einer Bandverletzung des Subtalgelenks.

Kontraindikationen. Diese Technik ist nicht geeignet, wenn sich das Lig. talofibulare anterius (ATFL) sowie das Lig. calcaneofibulare (CFL) massiv substanzgemindert sind (ein Mapping ist präoperativ unbedingt erforderlich).

Operationstechnik. Diese Technik kombiniert die Reinsertion der Residuen der Kollateralbänder des Sprunggelenks, des ATFL und des CFL mittels Anker durch Augmentation unter

Verwendung eines Retinaculum-extensorum-inferius-Flaps, der in einem Tunnel mittels einer Interferenzschraube fixiert wird. Dieser Retinakulumstreifen fungiert als eigentliches Neoligament, welches nicht nur eine substantielle Verstärkung bietet, sondern auch als periphere Stabilisierung des Subtalgelenks dient.

Weiterbehandlung. Nach unmittelbar postoperativer Immobilisation in einer Sprunggelenk-Fuß-Orthese wird mit propriozeptiven physiotherapeutischen Übungen begonnen. Die Rückkehr zum Sport hängt von der Sportart ab.

Ergebnisse. Die postoperativen und die Langzeit-Follow-up-Ergebnisse dieser Technik werden diskutiert.

Schlüsselwörter

Instabilität des Sprunggelenks · Laxität des inneren und äußeren Seitenbands · Bandrekonstruktion · Retinaculum-extensorum-Flap · Subtalgelenk

Surgical Techniques



Fig. 5 ◀ The patient is secured in a supine position, with a thigh-level pneumatic tourniquet and the lower limb maintained in internal rotation by a buttress under the ipsilateral buttock

Patient information

- Open procedure
- A preoperative antibiotic single injection to prevent the unusual risk of postoperative infection
- Implants as anchors and biotenodesis screw will be inserted even invisible on the postoperative X-rays
- Nerve injury risk despite an high surgical level training
- Below-knee cast or equivalent for 4–6 weeks with variable weight-bearing depending on associated procedures
- Prophylaxis of thromboembolic diseases mandatory for the same period
- Very good results at long-term follow-up in term of stability and osteoarthritis occurrence
- Time to return to field is depending on the category and level of sport practice (earlier for cycling than playing football or basketball)

Preoperative work up

In chronic ankle instability an exhaustive preoperative work-up is mandatory to determine:

- Tibio-fibulo-talo-calcaneal system ligament lesions to correctly fix the lesions
- Instability risk factors, such as malalignment of the hindfoot (especially the varus)
- Associated and/or laxity-related lesions: intra-articular impingement (usually anterolateral), peroneal tendon lesions, osteochondral lesions, or incipient osteoarthritis

First-line is the clinical assessment with an accurate patient history about instability (first sprain, subsequent instability-related accidents, treatment), symptoms reported as feeling of insecurity at the ankle, giving way, pains and blockage, and impact on occupational or sport activities. Clinical examination should be thorough and comparative, focused on foot morphotype (hindfoot varus which is a factor for instability even in the absence of laxity), joint range of motion (lack of ankle dorsiflexion, subtalar

joint stiffness), pain points, hanging legs, in the various lateral and medial ligament bundles, sinus tarsi, joint lines and tendon courses (especially retromalleolar and submalleolar peroneal tendons). Peroneal tendon dislocation under active and/or passive tension in eversion should also be screened for. Ligament testing is a key step, assessing laxity on the LCL (varus, talar anterior drawer), the medial ligament (Hintermann test) or the syndesmotic complex (squeeze test, external rotation in forced dorsiflexion of the ankle).

Clinical examination may or may not be sufficient to demonstrate laxity and often fails to diagnose lesion location. It should be supplemented by complete, targeted imaging assessment. Simple comparative anteroposterior (AP) and lateral weight-bearing ankle X-ray is routinely used to screen for and analyze bony avulsion of ligament insertions, associated lesions (osteochondral talar dome lesion, tibiofibular diastasis and tarsal synostosis), neglected fracture (non-union of the lateral talar apophysis or 5th metatarsal styloid process), and signs of osteoarthritis. Méary or Djian hindfoot view with cerclage, Saltzman view or long axial view [16] specify hindfoot morphotype, often varus or valgus. Radiographs in forced position in the talocrural joint, even controversial, may help to confirm and quantify laxity and lesion location (auto-varus, manual testing or Telos device). Other imaging examinations, e.g. ultrasound, computed tomography (CT) arthrography, the various forms of magnetic resonance imaging (MRI): gadolinium-enhanced and MRI arthrography, can confirm the presence of ligament lesions and sometimes determine their type (distension, tear, avulsion, etc.) and the number of bundles involved and analyze adjacent tendons (peroneal in particular) and cartilage.

Arthroscopy could help as an additional way to assess both the quality of the remnant ligaments and other intra-articular joint disorders. It could be considered if the procedure to repair would be arthroscopically assisted, as arthroscopy is more a surgical procedure than a tool for assessment [9, 23]. Therefore, only a comprehensive clinical

and radiographic assessment will yield the best possible outcome [21].

Instruments and implants

- Surgical knives (blades 23 and 15)
- Scissors, Metzenbaum, Mayo
- Bone levers (small Hohman retractors)
- Medium and small wound retractors
- Raspatory
- Hammer
- Kocher-Ochsner and mosquito clamps
- Power drill
- Cannulated drills 4–6 mm in diameter
- K-wires 2.0 mm and 2.5 mm
- Nitinol suture passing wire
- A 2-0 non-absorbable looped suture
- Two 3 × 14 mm anchors
- An interference screw (mostly 4.75 mm)
- Regular size staples for skin to close the wound

Anesthesia and positioning

In the Foot and Ankle Institute of Grenoble the preferred technique for patients is general or epidural anesthesia to avoid pain due to the upper leg tourniquet. A peripheral single shot nerve block, mostly popliteal, is performed additionally in terms of postoperative pain relief and patient comfort. In some selected cases, a double peripheral single shot nerve block, popliteal (for the procedure) and femoral (for the tourniquet), is performed. The patient is secured in a supine position with a thigh-level pneumatic tourniquet and the lower limb maintained in internal rotation by a buttress under the ipsilateral buttock (■ Fig. 5). In this way both the lateral and medial aspects of the ankle can be approached (medial ligaments repair, calcaneus osteotomy). A purely lateral decubitus positioning is recommended when any medial approach is planned as the calcaneus osteotomy to fix a varus of the hindfoot will be easier to perform.

Surgical technique

(■ Figs. 6, 7, 8, 9, 10, 11, 12, 13).

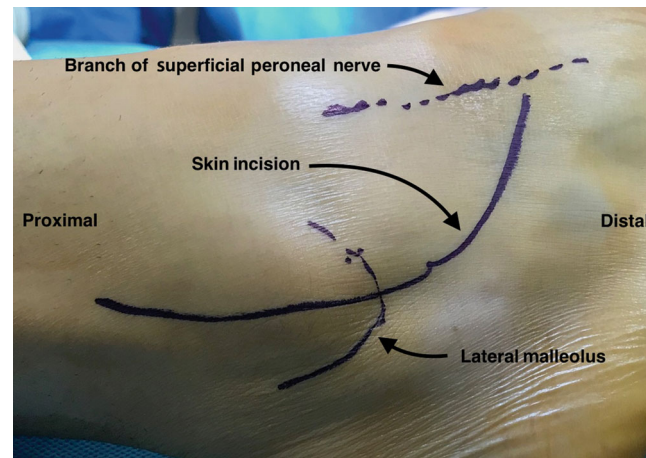


Fig. 6 ◀ Approach. The skin incision is anterolateral, curvilinear and centered on the lateral malleolus. It runs over the sinus tarsi to the dorsal aspect of midfoot

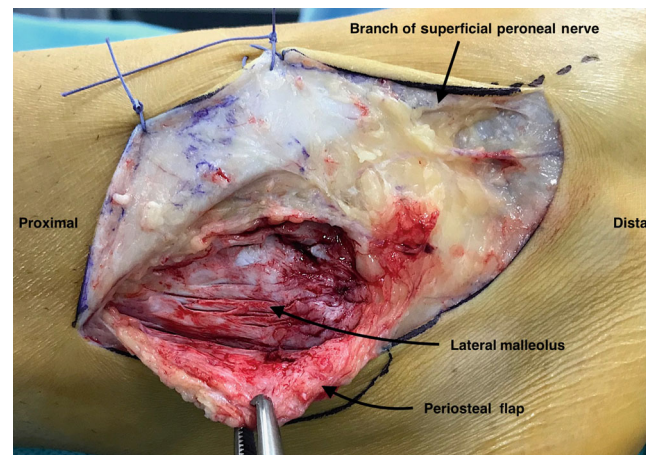


Fig. 7 ◀ Periosteal flap. A periosteal flap is developed posteriorly towards the sulcus for the peroneal tendons. It will reinforce the capsular shift at the end stage of the procedure

Surgical Techniques

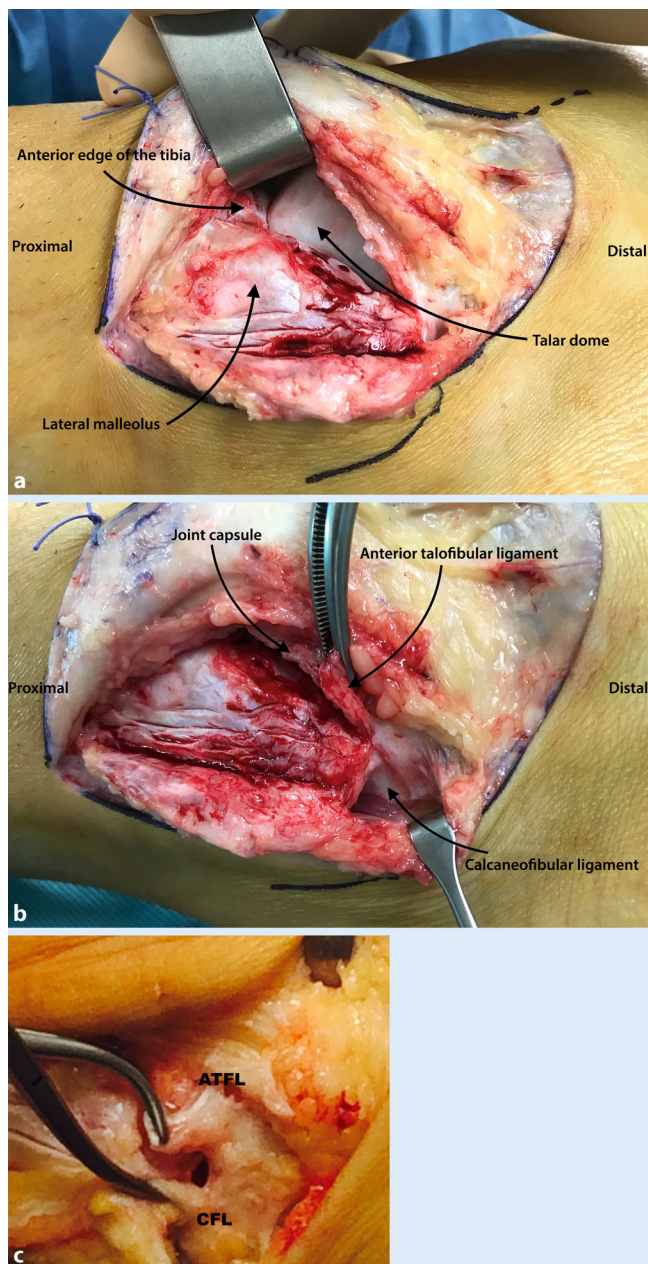


Fig. 8 ▲ Ankle arthrotomy. **a** An L-shaped arthrotomy is then performed along the course of the peroneus tertius, creating a residual capsuloligamentous flap, attached to the neck of the talus (capsule + ATFL). This arthrotomy allows the talar dome cartilage, mainly on the lateral side, the anterior edge of the tibia and talar neck to be checked. Synovial, bone and osteochondral procedures may be carried out as necessary, depending on the preoperative lesion assessment. **b** The fibular tendon sheet is opened at the anterior aspect of the tip of the fibular malleolus. The condition of the CFL is assessed (status, tension) and also the peroneal tendons. Peroneal tendons tears are fixed in the meantime on request. **c** The residual anterior tibiofibular (ATFL, with its 2 components) and calcaneofibular ligaments (CFL) are located and the possibility of reinsertion is assessed

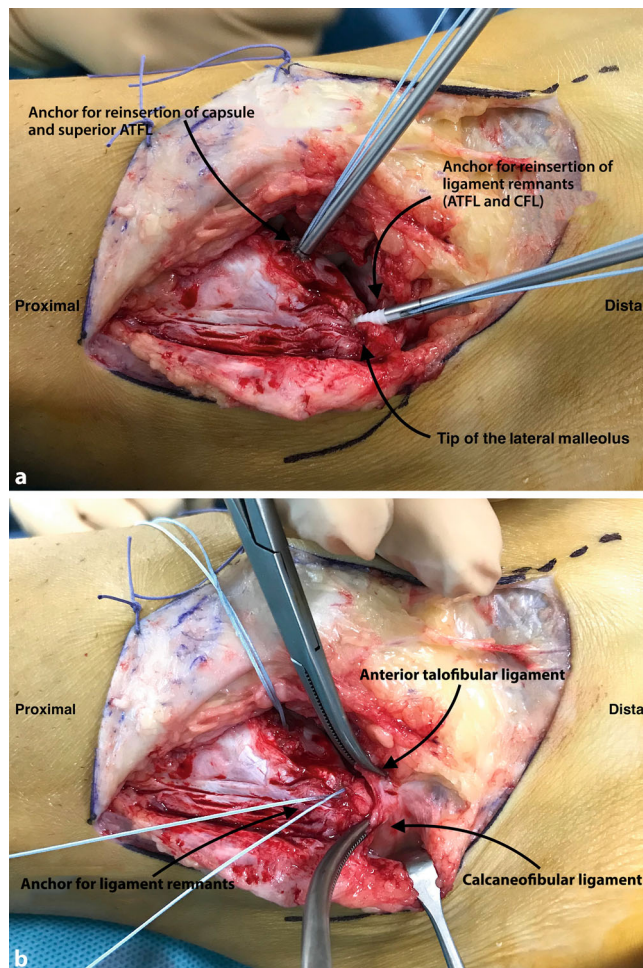


Fig. 9 ▲ Anchor fixation. **a** Fixation of two 3 × 14 mm anchors is performed for the reinsertion at a later stage of the procedure: one for the capsule and the superior branch of the anterior talofibular ligament (ATFL) at the upper anterior part of the fibular malleolus and one at the fibular obscure tubercle of the fibular malleolus for the inferior branch of the ATFL and calcaneofibular ligaments (1 needle per ligament) (**b**)

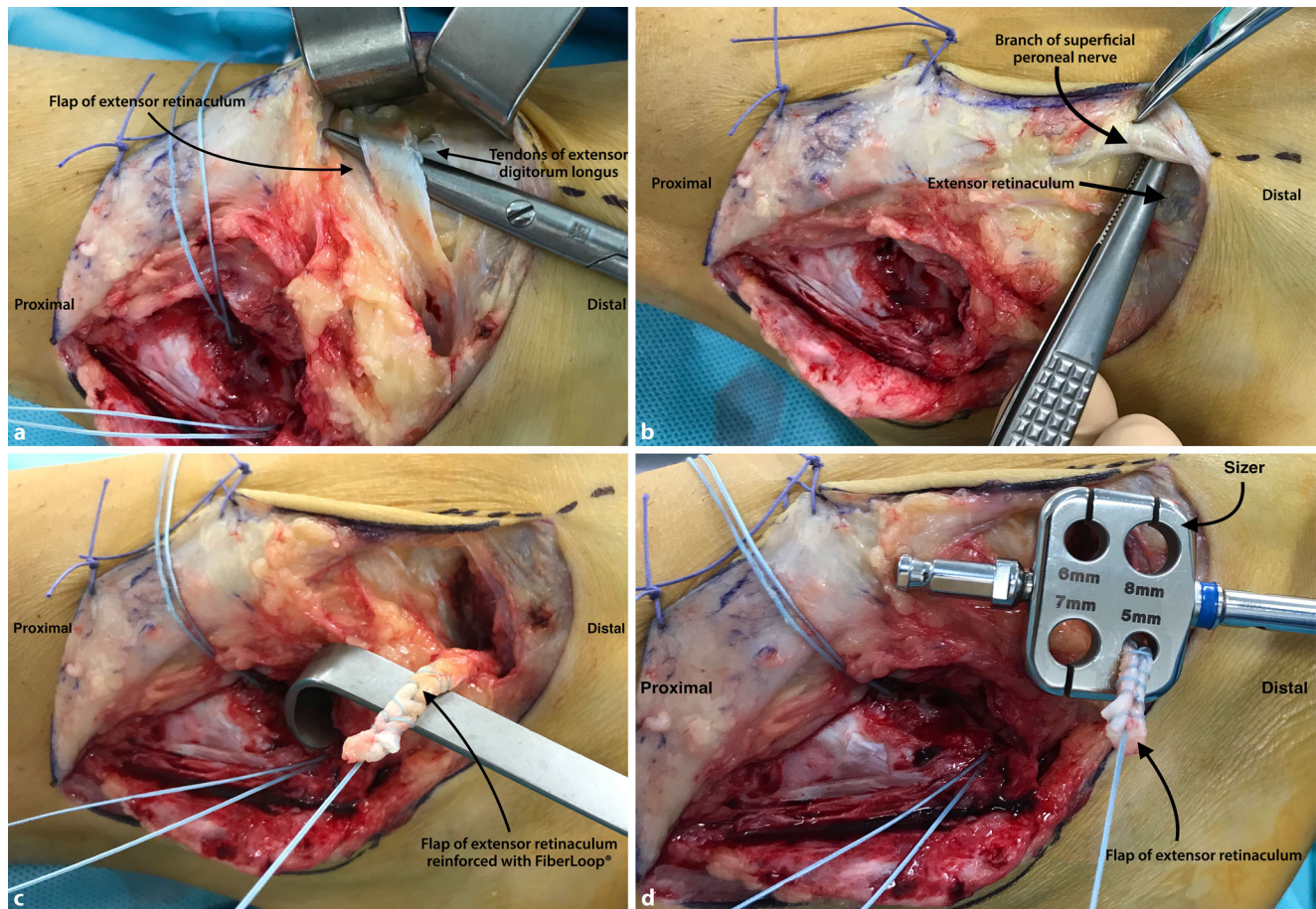


Fig. 10 ▲ Inferior extensor retinaculum flap (IERF) elevation and preparation. **a** Subcutaneous release isolates the IER, from which a rectangular flap 1 cm in width and 3–4 cm in length is harvested. Depending on the shape of the IER (X or Y, sometimes H), the bulkier part, the stem of frondiform ligament is used. **b** It is mandatory to pay attention to the superficial branches of the peroneal and sural nerves. **c** The flap remains inserted on the calcaneus at the entry to the sinus tarsi. The neoligament is reinforced using a 2-0 non-absorbable looped suture: FiberLoop®. **d** Its size is checked with a gauge and because it remains attached to the calcaneus, this flap stabilizes the subtalar joint at the end of procedure

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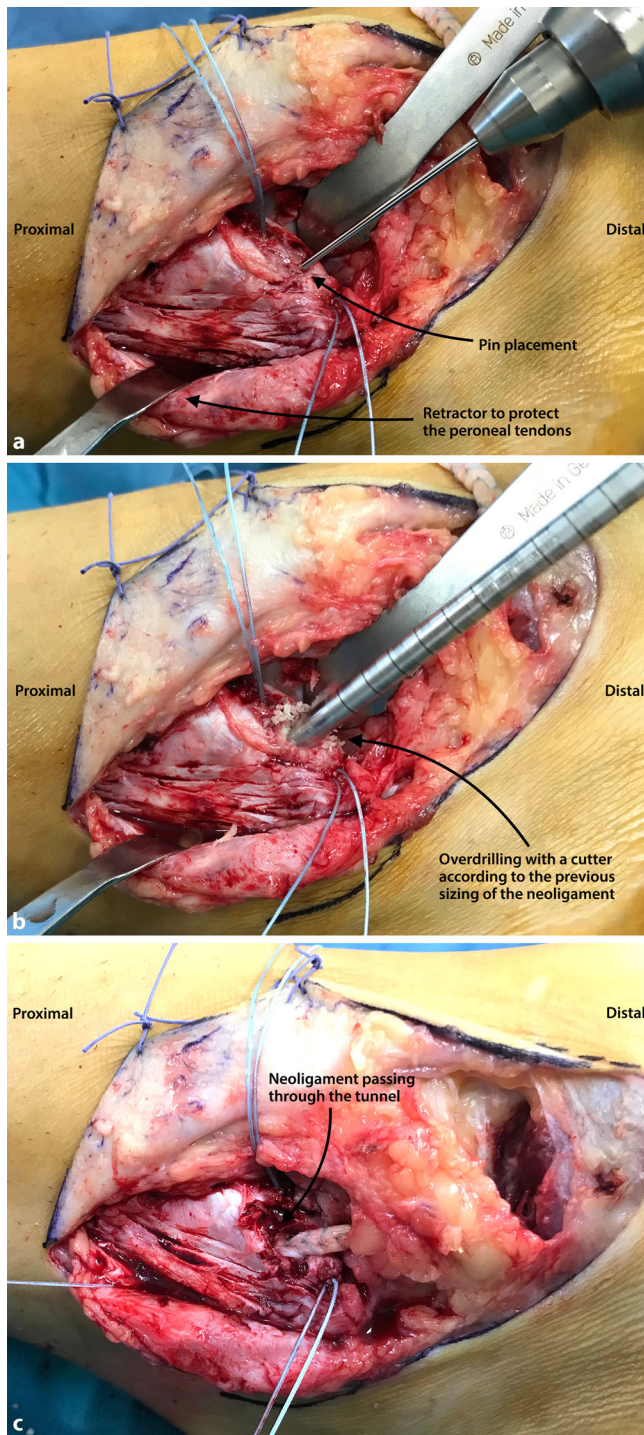


Fig. 11 ▲ Inferior extensor retinaculum flap (IEFR) reinsertion. **a** A 2.5-mm pin is inserted between the 2 anchors, from the anterior margin of the lateral malleolus to its posterior aspect. A retractor protects the fibular tendons. The orientation is 45° to the plantar aspect of the foot. **b** The pin is overdrilled according to the previous sizing of the neoligament (diameter between 4.5 mm and 5.0 mm). **c** The flap is passed through a short gap into the capsule and then into the tunnel, using a nitinol suture passing wire. The unhindered sliding of this flap is checked prior to the final fixation

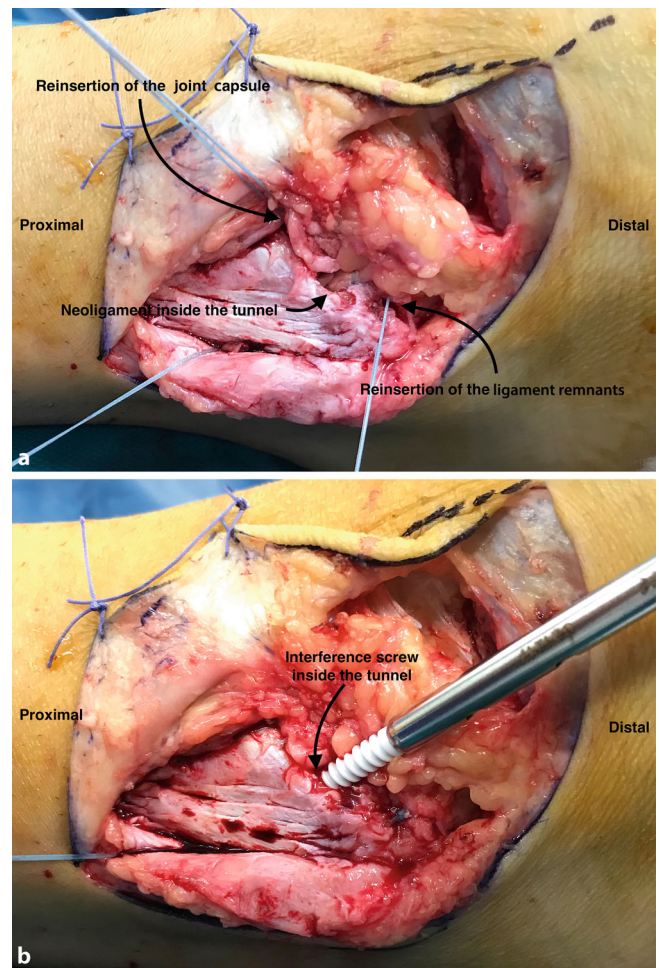


Fig. 12 ▲ Overall fixation. **a** The calcaneofibular ligament (CFL) first, then the anterior talofibular ligament (ATFL) and finally the capsule are secured to the previously placed anchors and so reinserted onto the anterior part of the lateral malleolus. The sutures are tied the ankle in neutral position. **b** The inferior extensor retinaculum flap is fixed by a 4.75-mm interference screw. Its tension is checked

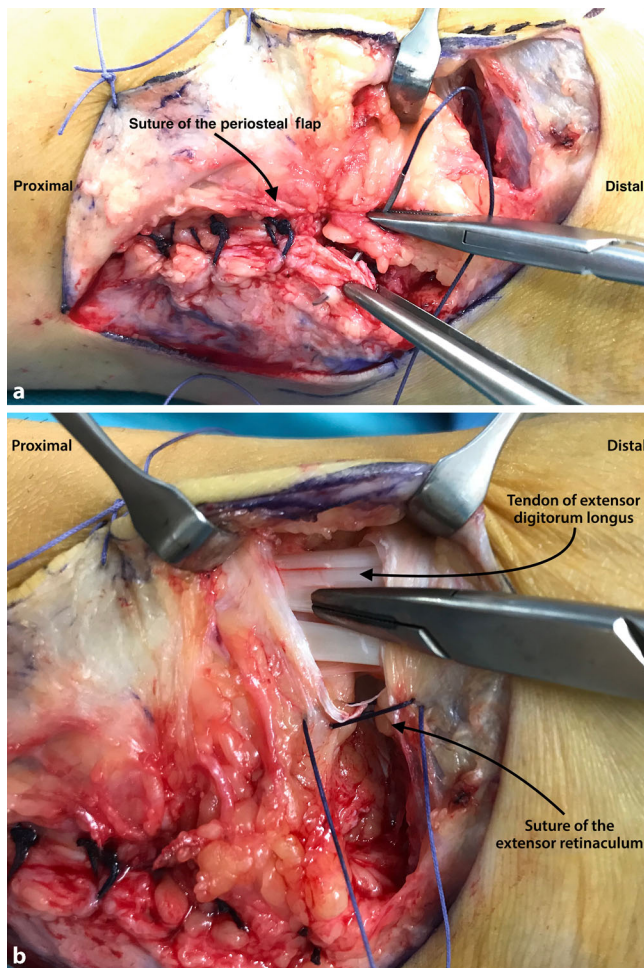


Fig. 13 ◀ End stage. **a** The periosteal flap is repositioned on the lateral side of the fibular malleolus, reinforcing the reconstruction. **b** Further sutures, placed over the extensor digitorum brevis muscle, completely close the sinus tarsi entry, and reinforce the subtalar joint ligaments. Subcutaneous and skin closures are performed

Special surgical considerations

1. The first step of this technique consists on an anatomical repair, such as the Broström procedure, by repairing ATFL and CFL on request. The preoperative assessment [21] and intraoperative findings will validate the anatomic conditions of the ligament remnants suitable for re-nsertion. Nevertheless, this first step is rarely performed as a stand-alone procedure, due to recurrence of laxity at long-term follow-up results, especially for high laxities. [13].
2. Augmentation is mandatory using anatomical structures close to the LCL, such as peroneus brevis, perios-teum and the extensor retinaculum [22, 24].
3. Furthermore the literature recommend avoiding the use of the peroneus entirely, as it is a powerful protective evertor muscle of the

ankle, whose recovery is essential for proprioception. It leads to worse long-term results, with stiffness, lack of proprioception and osteoarthritis at the ankle and the subtalar joints [10–12, 21, 26]. Even partially, its use remains debated with poor results also at long-term follow-up [19]. Therefore the use of the extensor retinaculum seems to be world wild consensual [9].

4. The Gould technique [8], which consists of a proximal advancement of the extensor retinaculum, provides an enhanced proprioceptive environment, more than a mechanical support. This is correlated to the poor anatomical structure of the very proximal retinaculum [5]. Furthermore, restriction of plantar flexion at the ankle has been reported [15, 21].
5. Thus, to construct a flap from the extensor retinaculum seems the best option. It remains independent from

the extensor retinaculum but vascularized because it is fixed on the lateral aspect of the calcaneus. Its reinsertion into the lateral malleolus is close to the ATFL and CFL foot-prints, at the anterior aspect of the distal end of the fibula. It works as a new ligament but stabilizes both the ankle and the subtalar joint. This is a very accurate key point because literature reports over 65% of cervical ligament rupture combined with an ATFL one [2, 12]. No restriction of the plantar flexion was reported at the ankle joint [22, 25].

6. Since the first report by Blanchet [1], some modifications were pointed out by Saragaglia et al. [18]. The IER flap (IERF) technique recently reported emphasizes some important anatomical, biomechanical and technical key points never described for this procedure:

- The retention of the ligament remnants clearly identify the two components of the ATFL and the CFL.
 - The bundles are reinserted using anchors that improve the biomechanical stability of the reattachment and avoid any knots in the pr-malleolar subcutaneous tissues.
 - The IERF is positioned in a tunnel corresponding to the bisector or bisectrix between the CFL and the inferior bundle of the ATFL. It is secured by an interference screw that avoids any knots in the lateral aspect of the fibula malleolar and improves the strength of the construct.
 - Furthermore, an implementation of this open technique to an arthroscopically-assisted one is in progress.
7. According to the preoperative work-up of lesions, complex ankle instability combining lateral to medial syndesmotic ligament lesions, peroneal tendon tears, osteochondral lesions of the talar dome and hindfoot malalignment (mainly in varus) will require combined procedures, such as medial, spring or syndesmotic complex reconstruction, peroneal tendon

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repair, talar dome debridement with microdrilling or mosaicplasty or calcaneus osteotomy. Depending on the surgeon's experience and the patient's decision, all these procedures can be performed in the same operative session.

Postoperative management

- Immobilization is initiated for 3 weeks in a non-weight-bearing below-knee cast followed for 3 weeks by a removable weight-bearing plastic boot to allow early rehabilitation
- Prophylaxis of thromboembolic disease using daily low molecular weight heparin (LMWH) is started the day following the procedure
- Proprioceptive physiotherapy is routinely prescribed and completed [17] and four fundamental elements of recovery will be developed [6, 17, 20]:
 - Dorsiflexion amplitude
 - Evertor muscle force
 - Proprioception
 - Neuromuscular reprogramming with evertor muscle preactivation [26]

New tools for postoperative rehabilitation are replacing those derived from the Freeman method (1965) [6, 20].

- Return to sport depends on the type of sport: cycling and swimming at 3 months, flat running at 4 months, cross-country running and racket sports at 5 months and pivoting/contact sports (soccer, rugby, handball, etc.) at 6 months.

Errors, hazards and complications

- To prevent wound healing problems, extensive subcutaneous release is to be avoided and the inframalleolar fat pad should be conserved
- The intermediate dorsal cutaneous nerve must be checked during the harvesting process of the flap to avoid any neurologic discomfort or painful neuroma
- Attention must be paid during the elevation of the flap at the dorsal

aspect of the mid-foot, to avoid any extensor tendon damage

- Similarly, caution should be exercised during the dissection between the calcaneus part of the flap and the fibers of the cervical ligament of the subtalar joint and also at the end of this process to avoid complete detachment of the flap from its calcaneus insertion. If so, reinsertion into the calcaneus using a 3.0-mm anchor will be helpful

Results

A preliminary report by Saragaglia et al. [18] or a very recent one by Trichine et al. [25] demonstrated very good results at short-term follow-up that could enable promising long-term results; however, the effectiveness of such a procedure was well-established by Tourné et al. [22], with the revision of 150 cases with a long-term follow-up (mean 11 years). The series reported that patients were satisfied in 93% of cases. According to the American orthopedic foot and ankle score (AOFAS) and Karlsson score combined with stress views (radiographs in forced position), 95.2% of ankles were considered to be stable. According to VanDijk staging [15, 27], osteoarthritis (G1 or G2 and no G3) occurred in 3% of ankles only. No subtalar joint stiffness was reported.

Conclusion

The technique to repair the collateral ligament bundles using an extensor retinaculum flap as an augmentation is the best option when the ligament remnants (ATFL, CFL) are suitable for reinsertion. The technique reported with very satisfactory results at long-term follow-up is an open one. Arthroscopic or minimally invasive developments must be considered in the very near future.

Corresponding address

Yves Tourné

Foot and Ankle Institute of Grenoble, Centre Ostéo Artculaire des Cèdres
5 rue des Tropiques, Parc Sud Galaxie,
38130 Echirolles, France
ytme@me.com

Compliance with ethical guidelines

Conflict of interest Y. Tourné is consultant for Arthrex, Stryker and In2Bones. M. Peruzzi declares that he has no competing interests.

For this article no studies with human participants or animals were performed by any of the authors. All studies performed were in accordance with the ethical standards indicated in each case. Additional written informed consent was obtained from the patient or the legal representative for whom identifying information is included in this article.

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