Review article

Lateral ligament reconstruction procedures for the ankle

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ARTICLE INFO

Article history:
Received 12 January 2016
Accepted 10 June 2016

Keywords:
Ankle
Instability
Lateral ligament reconstruction

ABSTRACT

Capsule/ligament lesions of the lateral compartment of the ankle lead to lateral laxity, which is a prime contributor to chronic ankle instability. Lateral ligament reconstruction stabilizes the joint. Exhaustive preoperative clinical and paraclinical work-up is essential. The present article classifies, presents and criticizes the main techniques in terms of long-term stabilization and reduction of osteoarthritis risk. Anatomic ligament repair with reinforcement (mainly extensor retinaculum) or anatomic ligament reconstruction are the two recommended options. Non-anatomic reconstructions using the peroneus brevis should be abandoned. Arthroscopy is increasingly being developed, but results need assessment on longer follow-up than presently available. Postoperative neuromuscular reprogramming is fundamental to optimal recovery. Finally, the concept of complex ankle instability is discussed from the diagnostic and therapeutic points of view. The various forms of ligament reconstruction failure and corresponding treatments are reported.

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1. Introduction

Chronic ankle instability includes two main, often related, entities: mechanical instability due to ligament and/or bone trauma, and functional instability due to postural or proprioceptive defect [1]. Both show intrinsic risk factors, basically morphologic or postural, and extrinsic (environmental) factors, basically concerning sport or occupation, which are modifiable.

Lateral compartment capsule-ligament lesions (anterior tibiofibular or calcaneofibular ligament) induce lateral laxity, which is a determining and predominant factor in chronic mechanical instability. The mechanism is usually varus and equinus (anterior tibiofibular and cervical ligaments), or sometimes varus and dorsiflexion (calcaneofibular and interosseous talocalcaneal ligaments). In forced rotation trauma, there may be associated ligament lesions of the ankle complex (medial and tibiofibular syndesmosis). These lesions are largely dependent on the specific mechanism and intensity, and lead to a concept of complex ankle laxity over and above simple lateral laxity [2,3].

Risk factors for chronic instability, such as congenital hindfoot varus or proprioceptive deficit, as well as laxity-related osteochondral talar dome lesions, peroneal tendon dislocation and/or fissure or anterior or posterior impingement, should be treated at the same time as lateral laxity.

When rehabilitation (neuromuscular reprogramming, evertor reinforcement and muscular pre-activation) associated to orthotic correction of any morphostatic disorder proves insufficient, surgery is indicated.

Lateral ligament reconstruction is fundamental, providing long-term joint stability and reduced risk of osteoarthritis [4,5].

Complete preoperative clinical and paraclinical work-up is fundamental, to determine ligament lesions and the possible multifactor etiology of instability. This “lesion mapping” guides treatment strategy for satisfactory functional outcome.

2. Preoperative lesion work-up

In chronic ankle instability, work-up should determine:

- tibio-fibulo-talo-calcaneal system ligament lesions;
- instability risk factors;
- and associated and/or laxity-related lesions: intra-articular impingement (usually anterolateral), peroneal tendon lesions, osteochondral lesions or incipient osteoarthritis.
Peroneal tendon dislocation under active and/or passive tension in eversion should also be screened for.

Ligament testing is a key step, assessing laxity:

- varus laxity is screened for with the patient prone; assessment can be global or focus more specifically on talocrural laxity by blocking the subtalar joint manually;
- talar anterior drawer is screened for with the knee in flexion, limbs pendant, classically in medial rotation to test the anterior talofibular ligament, but should also be assessed in lateral rotation, as suggested by Hintermann, in which case there is often an associated anteromedial pain point.

2.2. Imaging [6,7]

Clinical examination may or may not be sufficient to demonstrate laxity and often fails to diagnose lesion location. It should be supplemented by complete, directed imaging assessment.

2.2.1. Simple comparative AP and lateral weight-bearing ankle X-ray

Simple comparative AP and lateral weight-bearing ankle X-ray are systematic to screen for and analyze bone avulsion of ligament insertions, associated lesions (osteochondral talar dome lesion, tibiotalar diastasis and tarsal synostosis), neglected fracture (non-union of the lateral talar apophysis or 5th metatarsal styloid process) and signs of osteoarthritis (arthritic remodeling, asymmetric joint impingement with talar tilt of varying degree, often lateral varus or more rarely medial valgus).

Méary or Djan hindfoot view with cerclage, Salzman view or long axial view [6,7] specify hindfoot morphotype, often varus or valgus (Fig. 2).

2.2.2. Stress X-rays

Stress X-rays confirm and quantify laxity and lesion location:

- in the talocrural joint (Fig. 3) radiography may be manual or use the Telos device (at 150 N), or use active varus, measuring anterior drawer and varus laxity. However, methods vary between reports [6,7] and a meta-analysis [6] found a wide variety of techniques, with results that are difficult to apply. These radiographs are thus poorly reproducible. They are, however, useful for assessing results, comparing the healthy and affected sides and pre- versus postoperative status. Above all, tilting induced by...
forced positioning is a specific sign of laxity, but with low sensitivity: it has diagnostic value only if positive; • subtalar laxity is hard to demonstrate. Many radiological techniques have been suggested, but are difficult to apply in clinical practice.

2.2.3. Other imaging examinations

Other imaging examinations (ultrasound, CT arthrography, the various forms of MRI: gadolinium-enhanced, 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.

The main interest of ultrasound is for dynamic analysis of the lateral collateral ligament, peroneal tendons and possible anterolateral impingement.

CT arthrography (Fig. 4) can show the different types of anterior talofibular ligament injury, calcaneofibular ligament tear (indirectly, by an aspect of opaque peroneal sheath), anterolateral capsule-synovial plicae, subtalar ligament lesions and sinus tarsi fibrosis. Above all, it diagnoses or describes bone or cartilage lesions that may be poorly if at all visible on plain X-ray. It is the optimal examination to detail the extent, location and open or closed status of talar osteochondral lesions.

MRI makes a major contribution to the analysis of the sinus tarsi ligament complex and associated lesions, notably of the peroneal tendons. Gadolinium-enhanced MRI (Fig. 5) is more effective than simple MRI. MRI arthrography (Fig. 6) allows easier interpretation of ligament tear and is more effective than gadolinium-enhanced MRI for cartilage analysis but less effective for ligament distension or synovial impingement. The future may belong to dynamic MRI, but for the moment this remains a purely research tool.

Ankle arthroscopy was recommended by Hintermann [8] in particular, but seems to us to make no contribution to normal laxity work-up. Some authors [8] see it as a diagnostic tool for assessing residual ligament bundle tissue quality and guiding strategy for surgery, which can then be performed arthroscopically [8].

Surgical planning should take account of the various lesions involved in ankle instability, which requires precise lesion assessment to optimize results and avoid iterative surgery:

- to quantify laxity, clinical examination and radiography in forced position (when positive) are the most effective; the hindfoot axis is well analyzed on clinical examination and Méary view;
Fig. 4. Ankle CT arthrography. A. Total anterior tibiofibular ligament tear and lateral capsule-synovial plicae. B. Calcaneofibular ligament tear. C. Medial talar osteochondral lesion.

- to analyze ligament lesions and lateral synovitis, ultrasound, gadolinium-enhanced MRI and MRI arthrography are used;
- peroneal tendons are assessed on gadolinium-enhanced MRI;
- cartilage is assessed on weight-bearing radiographs, MRI arthrography and, above all, CT arthrography.

3. Surgical techniques for lateral ligament reconstruction [6,9]

More than 80 ligament repair procedures have been described, to restore ankle stability, including in the subtalar joint. All show good short-term impact on stability [6]. We shall describe below the most widely used and their long-term results, for stability and above all for the prevention of osteoarthritis, which is the main challenge in ligament reconstruction.

Techniques can be categorized as anatomic, repairing or reconstructing the residual ligament bundles (anterior tibiofibular, calcaneofibular and cervical ligaments) or non-anatomic reconstructions with tenodesis effect.

A conventional open approach is most widely used, but arthroscopic techniques are also beginning to be reported [9].

Fig. 5. Gadolinium-enhanced ankle MRI. A. Anterolateral impingement and Bassett’s ligament. B. Grade 4 peroneus brevis fissure. C. Posteromedial impingement. D. Pathologic plantar calcaneonavicular ligament.
3.1. General technical considerations

Patient positioning and surgical approach differ little between techniques. The patient is positioned supine, with a support holding the limb in internal rotation. The approach is centered with respect to the lateral malleolus, curving forward then upward to a greater or lesser degree depending on the technique.

The associated risks are:

- cutaneous, which is why extensive subcutaneous release is to be avoided and the inframalleolar fat pad should be conserved;
- and neurologic: superficial sural cutaneous (or lateral dorsal cutaneous) terminal sensory branch and superficial peroneal nerve lesions.

3.2. Isolated anatomic ligament repair

This consists in simple capsule-ligament retensioning.

In 1964, Broström [10] described anterior tibiofibular and calcaneofibular ligament suture or transosseous reinsertion.

Karlsson [6] recommended shortening the ligament bundles, which are more often distended than torn and reinserting them transosseously onto the fibular malleolus.

Duquennoy popularized the technique in France, and in 1980 reported his own technique of transosseous tensioning of the anterior capsule-ligament flap (anterior tibiofibular ligament and anterior capsule) (Fig. 7) [11].


Reinsertion may use anchors and be performed arthroscopically, either partially (with associated minimal approach) or entirely (arthroscopic Broström procedure) [12].

Reinsertion conserves joint freedom, but is insufficient in case of severe preoperative laxity on X-ray and/or when the subtalar ligament complex itself is involved, as we shall see below.

3.3. Reinforced anatomic ligament repair

3.3.1. Extensor retinaculum

Gould et al. [13] recommended this procedure to reinforce Broström reinsertion [10]. The superior distal extensor retinaculum bundle is fixed transosseously or by anchors to the anterior part of the fibular malleolus, thereby reinforcing the anterior capsule and anterior tibiofibular ligament. The technique can be performed arthroscopically (arthroscopic Broström-Gould procedure) [12].

However, first Blanchet [6] then and above all, Saragagalia et al. [14] went on to use the retinaculum as an actual neoligament, providing not only reinforcement and collagen input, but also peripheral stabilization of the subtalar joint by its calcaneal insertion, reinforcing the cervical ligament (Fig. 8).

Subcutaneous release isolates the lateral capsule-ligament structure and distal extensor retinaculum, from which a rectangular flap, about 1 cm by 3–4 cm, is harvested from the superior bundle, which remains inserted on the calcaneus at the entry to the sinus tarsi. The neoligament is laced using large-diameter absorbable suture.

The subtalar ligament structures (cervical and interosseous ligaments) are checked.

A periosteal flap is then harvested and folded back toward the peroneal tendon groove, remaining pediculated on the fibular malleolar crest, to reinforce anterior capsule reinsertion at end of surgery.

L-shaped tibiofibulotalar arthrotomy enables inspection of the joint cavity.

The residual anterior tibiofibular and calcaneofibular ligaments are located and the possibility of reinsertion is assessed. The
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 osteoechondral procedures may be associated as necessary, depending on the preoperative lesion assessment.

The residual capsule-ligament complex and its extensor retinaculum reinforcement are reinserted onto the anterior part of the fibular malleolus, with 1 anchor for the capsule, 1 at the tip of the fibular malleolus for the anterior tibiofibular and calcaneofibular ligaments (1 needle per ligament) and the extensor retinaculum flap is fixed by interference screw between the two in an adapted tunnel. The sutures are tied, with the foot in neutral position (90◦ flexion without varus or valgus). The periosteal flap is repositioned on the lateral side of the fibular malleolus, reinforcing the reconstruction. Further sutures, lying on the extensor digitorum brevis muscle, completely close the sinus tarsi entry.

3.3.2. Periosteum

Kuner [15], followed in France by Roy-Camille [6] (Fig. 9), suggested associating capsule-ligament complex retensioning to periosteal reconstruction; the pediculated periosteal flap, harvested from the lateral malleolus, is used as required to reconstruct the anterior tibiofibular and calcaneofibular ligaments. It can be used to reinforce the residual ligament bundles or as an actual ligament reconstruction, for 1 (anterior tibiofibular) or 2 (anterior tibiofibular + calcaneofibular) bundles, according to the lesion assessment findings. The whole fibro-periosteal covering of the lateral malleolus (8–10 cm long) is harvested, conserving the distal fibular attachment. The flap insertion base is reinforced by non-absorbable sutures to avoid avulsion during tensioning. An anterior talar tunnel and a posterior calcaneal tunnel (requiring further skin incision) are needed for fixation. The capsule-ligament structure is sutured as cover at end of surgery.

The fibular malleolar periosteum, however, is not always very resistant, and in some cases does not even exist.

This reconstruction may be associated to reconstruction by extensor retinaculum.

3.3.3. Synthetic reinforcement

Synthetic reinforcement is not a matter of prosthetic ligament, long since abandoned, but a synthetic material, providing augmentation, increasing the mechanical resistance of the anatomic repair and thus enabling early rehabilitation [16]. Outcome is not known.

3.4. Anatomic ligament reconstruction

Anatomic ligament reconstruction is intended to overcome the absence or insufficiency of the residual anterior tibiofibular and calcaneofibular ligaments. It uses various tendons, which should reproduce the course of the anterior tibiofibular and/or calcaneo-fibular ligaments as anatomically as possible.

3.4.1. Tendons

Niethard (Fig. 10B) [6], followed by Anderson (Fig. 10C) [17], used the plantar tendon for true anatomic anterior and medial bundle reconstruction, without, in their original designs, stabilizing the subtalar joint.


Fig. 9. Anatomic repair with periosteum reinforcement/anatomic ligament reconstruction with extensor retinaculum (Roy-Camille technique). Arnaud Bamaud. La cheville instable. Y. Tourné, C. Mabit. Elsevier Masson, 2015.
The plantar tendon is harvested via incisions along the calcaneal tendon. Pediculated on the calcaneus, it is used to reconstruct the calcaneofibular then fibulotalar bundles of the lateral collateral ligament, from posterior to anterior with 3 tunnels (c calcaneal, fibular and talar).

Storen (Fig. 10A) [18] described anatomic reconstruction of the anterior bundle and cervical ligament, using the Achilles tendon, but with non-anatomic, purely functional reconstruction of the medial bundle.

In 1996, Mabit et al. [19] described a true ligament reconstruction using the peroneus tertius, if present and thick enough to reconstruct the anterior talofibular and possibly cervical talocalcaneal ligaments (Fig. 11). Fixation is via bone tunnels in the fibular malleolus and talar neck. The length of the transplant allows subtalar stabilization if necessary, via a third tunnel in the calcaneus, which may be completed by reconstruction using the extensor retinaculum.

Some authors reported using free tendon (gracilis or plantaris) to replace defective ligament bundles using conventional techniques, anatomically reproducing the original ligament course [20]. This reconstruction can be performed arthroscopically [21].
Other authors used tendon-bank homograft (frozen peroneal or gracilis tendon or fascia lata), thus avoiding tendon sacrifice and a second surgical approach [22].

3.4.2. Peroneus brevis tendon [6]

The tendon is sectioned as proximally as possible, either fully (with the muscle body sutured to the peroneus longus tendon) or partially, conserving the distal insertion onto the 5th metatarsal styloid process.

In 1952, Watson-Jones [6] reported anterior tibiofibular liga-
ment reconstruction using the whole peroneus brevis, through 2 horizontal tunnels in the fibular malleolus and 1 in the talar neck (Fig. 12). The reconstruction corrected anterior drawer effectively, but the lateral talocrural opening less effectively, and restricted subtalar motion.

In 1969, Snook et al. [23] reported variants, followed by Vidal (1974) [6] and Colville (1994) [6], using half the peroneus brevis to reconstruct the anterior tibiofibular and calcaneofibular ligaments, with lateral ankle framing. Anterior drawer and lateral talocrural opening, but subtalar motion is systematically restricted. Subcutaneous release is considerable, tunnels numerous and the sural nerve is very close.

3.5. Non-anatomic ligament reconstruction [6,9]

Non-anatomic ligament reconstruction also uses the peroneus brevis, in its entirety (Evans [1953] or Castaing [1961] techniques) or partially (“hemi-Castaing”, Moyen [1978] [6]). Castaing’s technique used to be the gold standard in France but is no longer, as was shown in a professional survey [24].

Reconstruction follows an entirely non-anatomic course, reproducing the bisector of the angle between the anterior tibiofibular and calcaneofibular ligaments. In plantar flexion, the plasty is verticalized, thereby stabilizing the talocrural and subtalar joints, but completely locking the latter (Fig. 13).

A tunnel is drilled in the fibular malleolus and the tendon (whole or partial) is passed through it from the back and sutured to itself near its insertion on the 5th metatarsal base. Closure of the tendon triangle by more or less proximal sutures creates and adjusts transplant tension.

Certain technical imperatives have to be respected due to the harvesting of the peroneus brevis, which is the main active stabilizer in eversion:

- opt for partial harvesting;
- avoid undue tightening in valgus, which risks inducing subtalar ankylosis which would be difficult to correct surgically;
- position the transmalleolar tunnel exactly, following the criteria of obliqueness and height described above for the apex of the fibular malleolus.

3.6. Subtalar joint ligament reconstruction

Our own biomechanical and anatomic studies showed that the cervical ligament and sometimes the lateral part of the interosseous talocalcaneal ligament are indissociable from the lateral collateral ligament [2].

Certain surgical techniques used to compensate the lateral collateral ligament can also, depending on their course, stabilize the subtalar joint peripherally [9,25].

As mentioned above, reconstruction using the extensor retinaculum or Mabit’s peroneus tertius can play this role. Some authors described specific techniques for the subtalar joint, using peroneus brevis; however, these techniques are more invasive [6,25].

3.7. Postoperative course

Mean immobilization time is 6 weeks, with weight-bearing at 2 weeks; immobilization is strict for the first 3 weeks, after which a removable orthosis is used for a further 3 weeks, day and night except for physiotherapy.

Rehabilitation then begins, developing 4 fundamental elements of recovery [26]:

- dorsiflexion amplitude;

![Fig. 13: Non-anatomic reconstruction using peroneus brevis (Castaing technique). A. Harvesting. B. Reconstruction with tenodesis effect.](image-url)
• evertor force;
• proprioception;
• neuromuscular reprogramming, with evertor pre-activation [26].

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

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

4. Results of ligament reconstruction

Stability and long-term control of progression towards osteoarthritis are the two main criteria referred to in the literature, and should guide the choice of reconstruction technique [6, 12] (Table 1).

4.1. Simple anatomic repair

Simple anatomic repair (Broström, Duquennoy) is insufficient in case of severe laxity, exceeding 20°, on preoperative X-ray [6] or when the subtalar ligaments are involved [27]. Moreover, residual ligament bundle quality is often bad, requiring reinforcement [6]. Results from arthroscopic series are no better in the long-term and concern only anterior tibiofibular ligament reinsertion [12, 21].

4.2. Anatomic repair with reinforcement

Results on the Broström technique as modified by Gould are similar whether the peroneus tertius or periotemus is used, with 82 to 85% good and very good results [9, 28, 29].

Arthroscopy series presently lack sufficient follow-up [12].

Long-term (mean 11 year) follow-up of neoligament reconstruction by extensor retinaculum reported 93% of patients satisfied or very satisfied, 4.8% with residual instability and only 2% with osteoarthritic ankle [30].

4.3. Anatomic reconstruction

Reconstruction using plantar tendon [6, 17]: the results in the 2 published series diverge strongly, with 67 and 100% good and very good results.

Reconstruction using a hemi-peroneal following Chrisman-Snook or Coleville: results for long-term stability are excellent in 90 to 100% of cases [9, 23], but with unacceptable skin and neurologic complications due to subcutaneous detachment and the size of the surgical approach.

Reconstruction using the peroneus tertius provides 85% good and very good long-term results [18].

reports for tendon allograft reconstruction are nearly comparable, with 80 to 90% good and very good results, but with less than 5 years’ follow-up [22].

4.4. Non-anatomic reconstruction

The Watson-Jones technique, with 50 to 70% good and very good results, and even more that of Evans, show stability loss and osteoarthritis in the long term [6, 27, 28, 29]. Results are poorer than for anatomic repair with reinforcement [28, 29].

Long-term results with the Castaing technique vary between 71 (37) and 80% [27] good and very good results.

Reconstruction with the whole peroneal tendon [6, 27] gives poorer long-term results than reconstruction using a hemi-tendon but, even using a hemi-tendon, reconstruction with the peroneal tendon gives poorer results than other techniques [31].

5. Does the management of mechanical instability consist in lateral ligament repair?

Ankle instability used to be attributed simply to tibio-fibulo-talar joint lateral collateral ligament lesions. However, better knowledge of the patho-physiological mechanisms involved [2], more effective examination techniques and reports of failure of well-conducted surgery [8] revealed early or late associations of ligamentous, muscular, proprioceptive and postural lesions, brought together under the term of complex ankle instability, with elevated risk of osteoarthritis.

5.1. At early stages

Complex instability associates ligament lesions and mechanical malalignment at various levels, mainly infra-malleolar.

Multiple ligament lesions accompanying the lateral lesions are due to rotational lesions affecting the medial collateral ligament and syndesmosis ligaments.

Medial plane lesions require medial soft-tissue reconstruction, ranging from medial collateral or plantar calcaneonavicular “spring” ligament suture to reinforcement of the posterior tibial tendon [32]. For syndesmosis lesions with less than 6 months’ progression, syndesmosis by screw, k-wire or tight rope between the tibia and fibula allows healing; beyond 6 months, reconstruction using the plantaris tendon is needed.

In case of inframalleolar valgus, whether pre-existing or secondary to medial complex (deltoid and spring ligaments, posterior tibial tendon), calcaneal varizing osteotomy resolves the varus and protects the repaired medial soft-tissue [32].

Conversely, primary hindfoot varus, systematically suspected in lateral laxity, being a prime cause of failure in lateral ligament reconstruction, should be corrected by calcaneal valgization osteotomy (Dwyer procedure, lateral translation of the greater tuberosity, or Z osteotomy) [33].

5.2. At late stages

Mechanical, ligamentous and alignment disorders have impact in 3 dimensions, leading to complex talar malalignment in the mortise. Osteoarthritis risk is high and joint salvage should be considered.

Varizing or valgizing osteoarthritis requires supramalleolar tibiofibular opening or closing osteotomy with multidirectional (lateral, medial and syndesmosis) ligament balancing or inframalleolar osteotomy [33].

Finally, associated lesions due to longstanding ligament lesions may contribute to complex instability. In case of talar dome osteochondral lesion or anterior soft-tissue or bone impingement, ankle arthroscopy, and in some cases conventional reconstruction, is recommended [12], while peroneal tenosynovitis requires tenoscopy or direct repair of tendon fissures [34].

6. Treatment following failure of lateral ligament reconstruction

There are 4 types of failure of lateral ligament reconstruction, corresponding to very different clinical, paraclinical and surgical situations.
Table 1
Results on various lateral ankle ligament reconstruction techniques.

<table>
<thead>
<tr>
<th></th>
<th>References</th>
<th>Follow-up</th>
<th>Good/very good</th>
<th>Residual instability</th>
<th>Osteoarthritis</th>
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<tbody>
<tr>
<td>Anatomic repair</td>
<td>[6,27]</td>
<td>&gt; 10 years</td>
<td>86/91%</td>
<td>15/23%</td>
<td>4%</td>
</tr>
<tr>
<td>Repair + reinforcement</td>
<td>[6,8,9,29]</td>
<td>&gt; 10 years</td>
<td>82/85%</td>
<td>17.5/21%</td>
<td>4%</td>
</tr>
<tr>
<td>Extensor retinaculum</td>
<td>[6,30]</td>
<td>11/13 years</td>
<td>93%</td>
<td>4.8%</td>
<td>2%</td>
</tr>
<tr>
<td>Anatomic reconstruction</td>
<td></td>
<td></td>
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<tr>
<td>Plantar</td>
<td>[6,17]</td>
<td>&gt; 10 years</td>
<td>67/100%</td>
<td>32%</td>
<td>4%</td>
</tr>
<tr>
<td>Hemi-peroneus (Chrisman-Snook)</td>
<td>[9,23]</td>
<td>&gt; 10 years</td>
<td>90/100%</td>
<td>9%</td>
<td>5%</td>
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<tr>
<td>Peroneus tertius</td>
<td>[18]</td>
<td>&gt; 10 years</td>
<td>85%</td>
<td>18%</td>
<td>4%</td>
</tr>
<tr>
<td>Allograft</td>
<td>[22]</td>
<td>&lt; 5 years</td>
<td>80/90%</td>
<td>Unknown</td>
<td>Unknown</td>
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<td></td>
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<tr>
<td>Watson Jones/Evans</td>
<td>[6,27,28,29]</td>
<td>&gt; 10 years</td>
<td>50/70%</td>
<td>15/44%</td>
<td>20/40%</td>
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<td>Castang</td>
<td>[6,27]</td>
<td>&gt; 10 years</td>
<td>71 to 80%</td>
<td>32%</td>
<td>Unknown</td>
</tr>
<tr>
<td>Hemi-Castaing</td>
<td>[31]</td>
<td>&gt; 10 years</td>
<td>91/92%</td>
<td>4/20%</td>
<td>4%</td>
</tr>
</tbody>
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6.1. Severe late repeat trauma on stabilized ankle

Surgical repair does not prevent new traumatic lesions. In repeat trauma, in the form of sprain of varying severity, the diagnostic and therapeutic procedure is the same as above and may involve surgery.

6.2. Early postoperative instability or failure to recover stability by rehabilitation, without evident trauma

Proprioceptive deficits require innovative rehabilitation with muscular pre-activation [26].

Gastrocnemius stiffness, undetected on prior Silfverskjöld test is managed by stretching or surgical recession, from the distal aspect of the gastrocnemius, as Strayer, or the proximal aspect, focused on the medial gastrocnemius tendon.

The ligament stabilization technique was unsuited to the initial lesions, which had probably been misassessed.

Revision of simple anatomic repair for severe primary laxity consists in retensioning and reinforcement using the extensor retinaculum, peristome, peroneus tertius, etc.

Persistent subtalar instability is managed by reinforcement bridging the subtalar joint, using extensor retinaculum, peroneus tertius, etc.

Poor residual ligament quality despite reinforcement is managed by anatomic reconstruction, using gracilis or plantar tendon or allograft.

6.3. Medium-term instability without evident trauma

Medium-term instability without evident trauma is often due to initial underestimation of associated instability factors.

In axial disorder and notably hindfoot varus, calcaneal valgization osteotomy can, if necessary, be associated to M1-raising (dorsiflexion) osteotomy and gastrocnemius recession (Fig. 14A and B).

Associated medial and/or syndesmosis ligament lesions are treated by adapted ligament reconstruction.

Tibiotaral or subtalar stiffness may be due to unduly tight reconstruction by peroneus brevis, resulting in extreme cases in locked hindfoot valgus and induces proprioceptive impairment. The initial reconstruction has to be undone then redone, anatomically. Depending on local conditions, retensioning with extensor retinaculum, peristome or peroneus tertius reinforcement or reconstruction by gracilis or plantaris tendon is performed.

6.4. Residual pain

Residual pain may be of preoperative origin, overlooked in inadequate preoperative work-up (talar dome osteochondral lesion, osteoarthritis, anterior or posterior impingement, or peroneal tendon tears), or postoperative (neuroma, anterior synovitis, local regional pain syndrome, or impingement by reinsertion sutures or anchors) and treatment should be adapted to the case.

Fig. 14. Hindfoot varus: failure of reconstruction using peroneus brevis due to failure to correct hindfoot axis.
7. Conclusion

Knowing the various ligament reconstruction techniques enables surgery to be adapted to the preoperative lesion assessment with intraoperative adaptation according to "qualitative tissue assessment". An approach centered on the lateral malleolus gives access to the various structures that can be used for tissue reinforcement or ligament replacement, although perhaps requiring proximal extension toward the fibular shaft or distal extension toward the 5th metatarsal styloid process.

The surgical technique can then be chosen:

- anatomic repair, usually with reinforcement to ensure good long-term joint stability; the extensor retinaculum is the most accessible structure;
- or anatomic reconstruction, to recreate the course of injured ligament bundles that cannot be reinserted even with reinforcement; fibular periosteum, peroneus tertius (if present and thick enough, which is true in 60% of cases), gracilis or plantar tendon (if present), or allograft (with the problem of availability) may be used.

In the vast majority of cases, these various techniques enable anatomic reconstruction adapted to the tissue lesions, sparing the peroneus longus (if the latter has to be used, a semi-tendon should be harvested).

Non-anatomic reconstruction using peroneus brevis has been abandoned.

Arthroscopic techniques are currently under assessment.

Chronic ankle laxity, especially when lateral, is now the main cause of ankle osteoarthritis, which argues for early surgical repair of the lateral ligamentous structures.

Disclosure of interest

The authors declare that they have no competing interest.

References

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