On the surgical treatment of chronic anterolateral ankle instability

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Citation for published version (APA):
Chapter III

METHODS FOR ANATOMICAL RECONSTRUCTION OF THE LATERAL ANKLE LIGAMENTS IN CHRONIC ANTEROLATERAL ANKLE INSTABILITY

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Chronic Ankle Instability, 122-138, 2000

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Summary

Anatomical reconstruction for chronic anterolateral ankle instability is successful in approximately 85-95% of patients, both in the short- and long-term. When compared with the classic tenodesis procedures, anatomical reconstruction leads to superior functional results, mechanical laxity is more effectively restored and subsequently the risk for development of degenerative changes in the ankle joint is reduced. Therefore, anatomical reconstruction of the lateral ankle ligaments is nowadays considered to be the surgical treatment of choice. In some patients direct suturing of the anterior talo-fibular and calcaneo-fibular ligament is possible. But, in contrast with Broström’s findings, many authors do not find well preserved torn ligaments, which can be directly repaired. More frequently the original torn ligament ends are difficult to identify. In most patients with chronic ankle instability the ligaments are attenuated or elongated. For these cases, several modified anatomical reconstructive procedures based on Broström’s original concept have been developed. The ligaments can be shortened and reinserted and reinforcement with local tissue or structures, such as periosteum or inferior extensor retinaculum. These procedures lead to similar or superior functional results when compared with the original Broström procedure.

When the ligaments are absent a plantaris tendon plasty may be indicated. This is a tenodesis procedure in which the plantaris tendon is used as a free graft to restore the anatomy of the anterior talo-fibular ligament.

Several studies report better results after reconstruction of both the anterior talo-fibular and calcaneo-fibular ligaments than after reconstruction of the anterior talo-fibular ligament alone. The literature, however, does not provide a consensus about this question. The role of subtalar instability remains unclear, since it is difficult to objectify this type of instability. More experimental and clinical studies are necessary to determine the exact contribution of subtalar instability in patients chronic functional ankle instability.

Any open surgical procedure is correlated with the risk of infection, haematoma, nerve damage and postoperative dystrophy. With arthroscopy, as a minimal invasive procedure, these problems can be minimized. The role of procedures like arthroscopic stapling repair and thermal capsular shrinkage in the treatment of chronic ankle instability have yet to be established.
Introduction

The lateral ankle ligaments have been reported to be the most commonly involved anatomical structures in sports injuries. The anterior talo-fibular ligament is the main stabilizer of the lateral side of the ankle joint, and is the most frequently injured ankle ligament. Recurrent instability of the ankle is a frequent sequela following inversion injuries and has been estimated to occur in approximately 10 to 20% of patients with an acute lateral ankle ligament rupture regardless of the type of initial treatment. Loss of integrity of the lateral ankle ligaments, proprioceptive deficit, peroneal muscle weakness, tibio-fibular sprain and instability of the subtalar joint have all been speculated to contribute to the development of chronic ankle instability. If conservative treatment fails, a reconstructive procedure can be performed. Several surgical procedures have been described. Originally, the most widely used of these procedures has been some kind of a tenodesis, using augmentation of an autogenous graft. In the classic tenodesis, most often the peroneus brevis tendon, or a part of it, is used to establish a tenodesis between the distal fibula and the calcaneus, the talus, or the base of the fifth metatarsal. Other authors have recommended tendon transfer in which replacement of the lateral ankle ligaments is performed in a more anatomical fashion, for example, by using a split peroneus brevis tendon. This reduces the risk of losing eversion strength.

The main disadvantage of these non-anatomical procedures is the disruption of the local anatomy and the disturbance of normal joint kinematics. Experimental studies show that the procedure can result in a limited range of ankle motion and talar tilt and anterior talar translation are insufficiently prevented. The inability to restore mechanical laxity increases the risk for the development of degenerative changes, especially on the medial side of the ankle joint. This is probably the reason why long-term clinical follow-up studies show unsatisfactory functional results after tenodesis in a large number of patients.

More recently, there has been a trend towards anatomical reconstruction. In 1966, Broström observed that in patients with an old rupture of lateral ankle ligaments, the attenuated ends of the anterior talofibular and calcaneo-fibular ligaments could be easily identified. Broström concluded that these ligaments could be repaired as if it were a fresh injury. Other authors, however, have experienced that it is usually technically difficult to suture the ends of the ligaments directly and have suggested several modifications of the original technique.
In theory, anatomical reconstruction has the following advantages over a tenodesis procedure:

- the normal anatomy is restored
- the peroneus brevis tendon, an active stabilizer of the ankle joint is not sacrificed
- less scarring
- less extensive soft tissue dissection
- shorter rehabilitation time
- no or minimal restriction of subtalar motion.

The procedures have been reported to produce satisfactory long-term results in a large proportion of patients\(^{22,29,30,33,47}\).

The simplicity and the high success rate of anatomical reconstruction, in addition to its superior biomechanical ability to restore mechanical stability while preserving normal motion, makes it nowadays the operative treatment of choice for chronic anterolateral ankle instability. In the present paper the different methods of anatomical reconstruction, their advantages and disadvantages and their results in the literature are described in six groups:

- direct anatomical repair
- shortening and reinsertion
- periosteal plasty
- capsular shift procedure
- Weber plantaris plasty
- other and future procedures.
Direct anatomical repair (Figure 1)

In 1966, Broström reported the results in a series of 60 patients in whom he had performed direct anatomical repair of the lateral ankle ligaments. He stated that even in patients with old ligament ruptures the torn ends could be freed and sutured. During surgical exploration in his series he found that the ends of the ligaments were clearly separated and as a rule were well preserved with normal thickness and length. Histological examination showed in most cases normal ligamentous tissue without degenerative changes or some fibrosis. In two cases only insignificant remnants of the anterior talo-fibular ligament were present, in four cases the freed ends of the torn ligament were thin and weaker than normal and three cases showed partial ossification of the ligament substance. In about every fourth case there was an area of scarring in the calcaneo-fibular ligament, denoting old, healed rupture, and in two cases the ligament was notably elongated.

Figure 1: Direct repair of the anterior talo-fibular ligament
Technique: In 25% of cases the anterior talo-fibular ligament is ruptured near its mid-portion. The torn ends are united with continuous sutures. In 65% of cases the anterior talo-fibular ligament has ruptured near the lateral malleolus with or without avulsion of bone fragments. The proximal end is anchored to the anterior margin of the inferior tip of the fibula with four to six solitary synthetic sutures which are drawn through drill holes in the lateral malleolus. The anterior malleolar margin is trimmed beforehand with a chisel in order to improve the probability of union between bone and ligament. In 10% of cases only insignificant remnants of the anterior talo-fibular ligament can be identified, making it insufficient for direct repair. The anterior talo-fibular ligament is then reconstructed with a flap from the lateral talocalcaneal ligament. The calcaneo-fibular ligament was sutured in only one case.

Advantages: The technique is simple, does not require extensive surgical exposure and local structures are preserved.

Disadvantages: Reconstruction of the calcaneo-fibular ligament is difficult to perform by direct suturing and Broström subsequently advised not to reconstruct this ligament routinely. In patients with generalized hyperlaxity, long-standing ligamentous insufficiency, or in patients who had previous ligamentous surgery to the lateral ankle ligaments, the quality of the damaged ligaments is poor. In these cases direct suturing of the lateral ankle ligaments is not possible.

Results: Broström found that his method of direct repair yielded 85% good and excellent results. Other investigators have found 86% to 95% good and excellent results with the Broström repair. In these studies, however, Broström’s concept was modified because the authors found it impossible to reconstruct the lateral ankle ligaments by direct suturing. Results were generally unaffected by the interval from injury to repair, and did not deteriorate or show progression of osteoarthritis over time. Several authors have found that results improved when both ligaments are routinely reconstructed. The Broström procedure has been subjected to experimental studies. Liu and Baker tested 40 cadaver ankles to compare the Broström, Watson-Jones, and Chrisman-Snook procedures with intact ankles and after excision of the anterior talofibular and calcaneo-fibular ligaments. Anterior drawer and talar tilt stress testing were performed using the TELOS equipment, and laxity was measured from radiographs. They found that all procedures reduced anterior drawer and talar tilt when compared with ankle after excision of the anterior talo-fibular and calcaneo-fibular ligament. However, the Broström technique produced a greater mechanical restraint than either of the
other procedures. Other biomechanical studies showed that the procedure successfully restores joint stability and does not result in a restricted range of ankle motion.

Discussion: The Broström technique is a simple technique that has proven to lead to satisfactory functional results in numerous studies. However, the major limitation of this procedure is that patients may lack the necessary amount of local ligamentous tissue to perform the reconstruction. In his original report, Broström stated that it is possible to repair the torn ends of the lateral ankle ligaments by midsubstance suturing. He might have meant imbrication of the lateral ankle ligaments.

Shortening and reinsertion (Figure 2)
In contrast to Broström’s findings, who stated that even after several years suture of the attenuated ligamentous ends is possible in most patients, Karlsson and co-workers found intact, but macroscopically elongated ligaments with scar formation in the vast majority of patients. They found direct suture of the attenuated ligaments difficult or impossible in these patients. The modified technique they developed, is based on the same concept as Broström described.

Technique: The incision is made posterior to the lateral malleolus, as this gives easier access to the calcaneo-fibular ligament. The peroneus tendon sheath is opened and both the anterior talofibular and calcaneo-fibular ligament are identified. The ligaments and capsule are divided about 1 to 2 mm from the anterior and inferior fibular border. A bone block shaped like an inverted L is chiselled away from the anterior and inferior fibular border. Five or six drill holes are made in the fibula and the ligaments and the joint capsule are attached with mattress sutures with the foot in pronation and dorsiflexion. Finally a duplication is performed with a periosteal flap and the proximal end of the ligament(s). Both the anterior talofibular and calcaneo-fibular ligaments can be reconstructed using the same method.

Advantages: Shortening and reinsertion is a safe and simple method. The technique can be used in the vast majority of patients with primary chronic instability. Reconstruction of both the anterior talofibular and calcaneo fibular ligament can be performed.

Disadvantages: The procedure provides not enough mechanical restraints in patients with generalized hyperlaxitiy and long-standing ligament insufficiency. The ligaments must be
identifiable. When the ligaments are severely attenuated or even absent, this procedure cannot be performed.

**Results:** Very few complications are reported with the use of this technique. The overall functional results were satisfactory in 88% of patients. Mechanical stability is well restored without causing any deficit in ankle function. Karlsson and co-workers found that the functional results were better if both ligaments were reconstructed at the same time, than if only the anterior talo-fibular ligament was reconstructed. Therefore, they advised standard reconstruction of both ligaments.

![Figure 2: shortening, imbrication and reinsertion of the anterior talo-fibular ligament and calcaneo-fibular ligament.](image)

**Figure 2:** shortening, imbrication and reinsertion of the anterior talo-fibular ligament and calcaneo-fibular ligament.
Discussion: In a large number of patients with chronic ankle instability the lateral ankle ligaments are elongated with scar formation. Midsubstance duplication of the ligaments is possible, but shortening and reinsertion is a simple and safe alternative. Routine reconstruction of the calcaneo-fibular ligament is well possible and leads to better functional results.

**Periosteal flap plasty (Figure 3)**

Periosteal flap plasty is an anatomical reconstruction which preserves the lateral active stabilizers of the ankle joint. The procedure was first described by Kuner in 1978 and later by Duquennoy\(^{17,34}\). The success of this type of reconstruction relies on the quality of the periosteal graft, which varies according to age, sex and morphotype\(^{40}\).

![Figure 3: Periosteal plasty](image-url)
Technique: The skin incision is anterior to the distal fibula and curved posteriorly at the lateral malleolus. Two periosteal flaps from the fibula, approximately 10 cm x 5 mm, are elevated from proximal to distal. At the tip of the fibula, two drill holes are made in the direction of the anterior talofibular and the calcaneo fibular ligaments. The sharp edges of the drill holes are smoothed with a rongeur, and the periosteal flaps pulled through the drill holes. The site of the distal insertion of the calcaneo fibular ligament is exposed distal to the peroneal tendon sheath and a 10 x 10 mm square piece of cortical bone is removed. The capsule of the ankle is then incised in the line of the anterior talofibular ligament, the site of its insertion is exposed, and a small cortical bone block is removed. The dorsal periosteal flap is then directed deep to the peroneal tendons and pushed under tension into the bony bed at the site of the insertion of the calcaneo-fibular ligament with the foot in slight equinus. The bone fragment is then replaced and fixed by a staple or a screw. For fixation of the anterior periosteal flap the foot is returned to the neutral position with the hindfoot in valgus at the subtalar joint. The flap is placed under tension in the prepared bed and the bone fragments are fixed in a similar fashion.

Advantages: Periosteum is a reliable substance to harvest. The periosteal tissue serves as a template for the formation of fibroblastic and scar tissue, and histological evaluation of the periosteal tissue has shown that it transforms into ligament and the donor site recovers rapidly. Furthermore, the operation does not require precise identification of the attenuated ligaments, which may not always be possible long after the initial injury.

Disadvantages: The technique is less simple than direct repair or shortening and reinserstion of the lateral ankle ligaments. During surgery, the periosteum must be prepared carefully because its initial strength is low. Furthermore, screws or staples may be necessary for fixation of the flaps. Some authors have reported an increased risk for superficial wound infection after the procedure. Another disadvantage of the technique is that it can not be used during adolescence because of the risk of bony transformation of the periosteal tissue; this does, however, not occur in adults.

Results: Good short-term results and effective restoration of mechanical laxity with the periosteal flap technique have been reported by a number of authors. Ahlgren and Larsson proposed a subperiosteal release at the lateral malleolus, including the insertions of the anterior talo-fibular and the calcaneo-fibular ligaments. The released flap was reattached.
to the malleolus more proximally. In 78 patients, the subjective results were excellent or good in 95%, with a mean follow-up of two years.

**Discussion:** The periosteal flap plasty technique allows anatomical reconstruction of both the anterior talo-fibular and calcaneo-fibular ligaments and does not sacrifice other ligaments or tendons in the foot. Due to the vulnerability of the periosteum, the technique may be difficult and screws or staples can be necessary for fixation. This technique should not be used during adolescence because of the risk of ossification of the periosteal tissue.

**Capsular shift procedure (Figure 4)**
Gould et al., in 1980, described a modification of the Broström technique with a repair of the lateral talo-calcaneal ligament and reefing of the lateral ankle retinaculum to the fibula in addition to repair of the anterior talo-fibular and calcaneo-fibular ligament. The procedure was originally designed to reduce subtalar instability and includes an augmentation with the inferior extensor retinaculum.

![Figure 4: Capsular shift procedure](image_url)
Technique: An incision is made in the skin and subcutaneous tissue along the anterior border of the lateral malleolus, curving posteriorly along the tip of the distal fibula. The inferior extensor retinaculum is incised to expose the attenuated lateral ligaments beneath. The peroneal tendons are retracted posteriorly to expose the calcaneo-fibular ligament. When the ligament ends are present, they are repaired. When they are in continuity by scar tissue, the capsule-ligament shift is performed. The anterior talo-fibular and calcaneo-fibular ligaments and the anterolateral capsule are divided near their insertion to the fibula. The incision through the anterolateral capsule extends to the tibiotalar articulation, with care not to incise the anterior talo-fibular ligament. The foot is then held in neutral dorsiflexion and slight eversion during the ligament reconstruction. This begins with reattachment of the calcaneo-fibular ligament which is plicated to the periosteum on the anteroinferior part of the lateral malleolus. After the repair of the calcaneo-fibular ligament, four non-absorbable sutures are placed in the anterior talo-fibular ligament-lateral capsule complex, and the flap is advanced as a unit to be sutured to the periosteum of the midportion of the lateral malleolus under appropriate tension. The lateral talo-calcaneal ligament is then advanced proximally, and attached adjacent to the calcaneo-fibular ligament at the anteroinferior distal fibula. Finally, the inferior extensor retinaculum is advanced proximally and sutured to the anterior talo-fibular-lateral capsule complex. The stability of the ankle, the range of motion, and adequacy of the reconstruction are then assessed. If required, the ligament-capsule complex is shifted further laterally.

Advantages: The procedure can be used when ligamentous tissue is attenuated, especially in ankles with very long-standing instability. The lateral shift of the lateral ligament-capsule complex restores normal tension in the lax lateral structures. The technique is simple and easy to perform.

Disadvantages: The procedure does not entirely preserve the local anatomy. The talocalcaneal ligament and inferior extensor retinaculum are sacrificed for augmentation. In comparison with other methods of anatomical reconstruction more soft tissue exposure is needed. This leads to a higher risk of nerve injuries and wound infection.

Results: Functional results vary from 75% to 96% good or excellent results. Karlsson et al. found that intraoperative nerve injuries were more frequent in these procedures than in reconstructive procedures without capsular shift. This may be due to the more extensive soft
tissue exposure which is needed for this procedure. Other authors report that mechanical stability is well restored by correcting lateral capsule-ligament tension. Furthermore, they feel that the procedure improves proprioception which helps to achieve better functional stability. However, they did not objectify this assumption.

Discussion: The capsular shift procedure is, in strict sense, not an anatomical reconstruction. It provides, however, restoration of the lateral ligaments while retaining the unity of the lateral capsule-ligament complex. Especially in patients with severely attenuated ligamentous tissue the procedure is a good alternative to other procedures.

Anatomical reconstruction with a plantaris tendon graft (Weber) (Figure 5)
Using this procedure the plantaris tendon is sacrificed as a free tendon graft. Reconstruction using the plantaris tendon was first described by Weber in 1968. The plantaris repair is regarded as a method of choice when the ligaments are absent or remnants of the existing ligaments cannot be used. The difference compared with other tenodesis procedures is that the tendon is used as a free graft in order to restore the anatomy of the anterior talo-fibular ligament only.

Technique: The plantaris tendon is detached with a stripper. The tendon is well suited for this purpose. Holes are drilled on the original insertions of the anterior talo-fibular ligament at the fibula and the talus. The graft is then pulled through the drillholes in a plain fashion, or if it is long enough, in a figure-of-eight loop. The ends of the graft are sutured to the graft itself, or to the periosteum.

Advantages: A firm reconstruction of the anterior talo-fibular ligament is possible in absence of the remnants of the anterior talo-fibular ligament. Proprioception and hence the dynamic stabilization of the lateral foot remains unimpaired. The technique is less difficult than using a classic tenodesis. The local anatomy is not severely disrupted which subsequently leads to better functional results.

Disadvantages: A disadvantage is that the plantaris tendon is present in only 93% of people. Some authors warn for the theoretical risk of weakening the triceps surae, although no studies support this.
Figure 5: Weber plantaris plasty

*Results:* Based on the results of several studies, restoration of mechanical laxity has been reported to be effective and 88% to 95% good or excellent functional results are reported after this procedure \(^7,50\). Brunner and Gaechter compared plantaris tendon plasty with peroneal tenodesis. They found superior functional outcomes after plantaris tendon plasty and the number of reoperations was significantly lower after this procedure \(^7\).

*Discussion:* Plantaris tendon plasty affords better results than peroneal tenodesis. Plantaris grafting can therefore be considered as the method of choice when the lateral ankle ligaments are absent or when the remnants cannot be used for reconstruction.
Other and future procedures

Carbon fiber repair

The use of carbon fibres for the repair of the lateral ankle ligaments is an unusual procedure which has not gained much popularity. Burri and Neugaber were the first to describe the replacement of the anterior talo-fibular and the calcaneo-fibular ligament by a carbon fibre ligament\(^\text{11}\). Patients with carbon fibre replacement of the anterior cruciate ligaments have shown early breakage and littering of the operative field with debris\(^\text{63}\). Becker et al. advised to use the implants in the extraarticular environment of the ankle complex, to avoid this problem\(^\text{4}\). The same authors reported 50% of patients experiencing pain during activity and a residual sense of instability after the procedure. Long-term follow-up reports after carbon fiber replacement are not available.

Arthroscopic stapling repair (figure 6)

With the advent of better technique and smaller equipment and surgical tools, chronic ankle instability can be treated arthroscopically, avoiding traditional open incision methods. Its place in the orthopaedic armamentarium is not yet known, because well documented follow-up studies of large numbers of patients are not available. In 1987, Hawkins was the first to describe arthroscopic stapling repair of the anterior talo-fibular ligament\(^\text{25}\). With use of a four-portal system the anterior talo-fibular and contiguous capsule are plicated. The foot is brought to the neutral position to tighten the lateral structures. Thereafter, the staple is inserted with a mallet. The staple is placed around the anterior talo-fibular ligament with an inserter-extractor device. Hawkins reported greatly improved stability in 24 patients until 5 years after the procedure. In one patient, however, the staple was inadvertently placed at an angle so that the tines entered the subtalar joint. Another patient developed an inability to extend his little toe after the stapling repair. One patient experienced recurrent instability that required a conventional reconstructive procedure. The major limitation of arthroscopic stabilization is that this technique makes it possible to reconstruct only the anterior talo-fibular ligament. Furthermore, the technique is technically demanding. Future development might make this procedure more useful, but further studies are necessary to define the role of arthroscopy in the treatment chronic ankle instability.
Figure 6: Arthroscopic stapling repair

Capsular shrinkage
Capsular shrinkage is a novel way of using low power radio-frequency current in a bi-polar configuration in order to volumetrically ablate soft tissue without generating significant thermal lesions to the underlying tissues. It is possible to perform an arthroscopic (thermal) capsular shrinkage. At first, this was performed with laser (LACS: Laser Assisted Capsular Shift), but nowadays the thermal probe seems to be more appropriate (ETACS: Electro Thermally Assisted Capsular Shift), because of a better controlled way of application of the heat. Although the exact mechanism of the changes in collagen and the long-term effect are not well known, this appears to be a promising alternative for surgical intervention. In shoulder instability capsular shrinkage has been demonstrated to be successful.\textsuperscript{27,42,48} Arthroscopy, as a minimal invasive procedure, has been proven to be a valuable diagnostic and therapeutic tool in the ankle joint. Analogue to the use of capsular shrinkage for shoulder instability, this method could be useful in the treatment of chronic ankle instability. The anterior talo-fibular ligament is a capsular ligament and therefore well accessible by the electrocoagulation device under arthroscopic vision. Experimental studies are necessary to determine the efficacy of shrinkage of the anterior talo-fibular ligament. Potential advantages of shrinkage procedure are minimally invasive surgical technique, reduced operating time, out-patient procedure, less postoperative morbidity, fast recovery and fast return to work and sports.
References


