The Journal of Foot & Ankle Surgery 58 (2019) 674–678

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Long-Term Results for Treatment of Chronic Ankle Instability With Fibular Periosteum Ligamentoplasty and Extensor Retinaculum Flap

Eric Dromzée, MD[1], Benjamin Granger, MD[2], Romain Rousseau, MD[3], Camille Steltzlen, MD[3], Hadrien Stolz, MD[1], Frédéric Khiami, MD, PhD[3]

[1] *Surgeon, Department of Orthopedic Surgery and Sport Trauma, University Hospital of Geneva, Geneva, Switzerland*
[2] *Biostatician, Department of Biostatistics, Public Health and Medical Information, Groupe Hospitalier Pitié-Salpêtrière-Charles Foix, Assistance Publique-Hôpitaux de Paris, Paris, France*
[3] *Surgeon, Department of Orthopedic Surgery and Sport Trauma, Groupe Hospitalier Pitié-Salpêtrière-Charles Foix, Assistance Publique-Hôpitaux de Paris, Paris, France*

ARTICLE INFO

Level of Clinical Evidence: 4

Keywords:
chronic ankle instability
extensor retinaculum flap
periosteum ligamentoplasty

ABSTRACT

Long-term results of anatomic reconstruction for chronic ankle instability are good, but no study has shown the results of fibular periosteum ligamentoplasty associated with extensor retinaculum flap at long-term follow-up. To demonstrate the efficacy of fibular periosteum ligamentoplasty and extensor retinaculum flap in chronic lateral instability, 40 patients underwent surgery for ankle instability. Thirty-three (82.5%) patients were reviewed, with a median follow-up duration of 8.2 (range 4 to 13) years. Functional results were assessed using the Karlsson score. Static and dynamic x-ray images were realized to measure varus tilt and anterior drawer, and osteoarthritis was evaluated with the van Dijk classification. The median Karlsson score was 95 (range 80 to 100). The mean decrease in varus laxity was 11° (range 0 to 18) and in anterior drawer was 1 (range −8 to 4) mm. At the last follow-up visit, 3 (7.5%) patients showed an evidence of osteoarthritis according to the preoperative criteria of the van Dijk classification (grade 2) and 6 (15%) patients had radiologic changes, without narrowing of the joint space (grade 1). Studies that have a follow-up time >5 years are rare. This study shows that despite the excellent control of ankle laxity, severe radiographic changes (grade 2) continue to evolve in the long term. This study indicates a good long-term outcome but suggests the need to monitor the occurrence of osteoarthritis over the long term.

Chronic instability of the ankle joint is a common complication of sprains. Although a functional treatment is currently the standard reference in acute situations, it can become ineffective in 10% to 30% of cases, where the instability becomes a chronic problem (1,2). In patients with a significant degree of residual laxity, this treatment may not be effective, and surgery may be required to stabilize the ankle joint, especially in young or active patients (3). Numerous surgical techniques for the repair of ankle instability, including anatomic reconstructions that involve the use of capsular retention, with or without augmentation (4–7), and nonanatomic reconstructions that involve the use of an autogenous tendon (8–10), allograft tendon (11), or synthetic ligament (12), have been described in the literature. These techniques offer good results, both in the short term and in the mid-term, but there are few studies that describe long-term (minimum of 5 years) follow-up results (13). To our knowledge, no study has described the long-term results of periosteum ligamentoplasty associated with an extensor retinaculum flap for the treatment of chronic lateral ankle instability. The purpose of this study was to evaluate this procedure.

Patients and Methods

This was a retrospective, monocentric study. All of the 40 patients were enrolled consecutively and treated between February 2001 and February 2010 (a period of 9 years). Potentially eligible patients were identified in the medical records by using the keyword “ankle ligamentoplasty” in our informatic. The inclusion criteria included chronic lateral ankle instability, with the failure of previous conservative treatments (strapping, cast immobilization, or rehabilitation). Chronic instability refers to the condition in which a patient complains subjectively of suffering repeated ankle sprains, despite adequate rehabilitation, at least 6 months after the initial acute injury. The exclusion criteria included the abnormalities that can cause instability, such as syndesmotic injuries, medial laxity, tarsal coalition, neuromuscular deficiency, and cavovarus foot. Physical examination included the anterior drawer test and the talar tilt test to evaluate the anterior talofibular ligament and the calcaneofibular ligament, respectively. Laxity was confirmed on stress radiographs, performed bilaterally by manual technique. Anterior drawer of 3 mm (14) or talar tilt of 5° (14) were considered indicative of instability.

Financial Disclosure: None reported.
Conflict of Interest: None reported.
Address correspondence to: Frédéric Khiami, MD, PhD, Department of Orthopedic and Sport Trauma, Groupe Hospitalier Pitié-Salpêtrière-Charles Foix, 47-83 Boulevard de l'Hôpital, 75651 Paris Cedex 13, France.
E-mail address: frederic.khiami@psl.aphp.fr (F. Khiami).

1067-2516/$ - see front matter © 2018 by the American College of Foot and Ankle Surgeons. All rights reserved.
https://doi.org/10.1053/j.jfas.2018.11.011

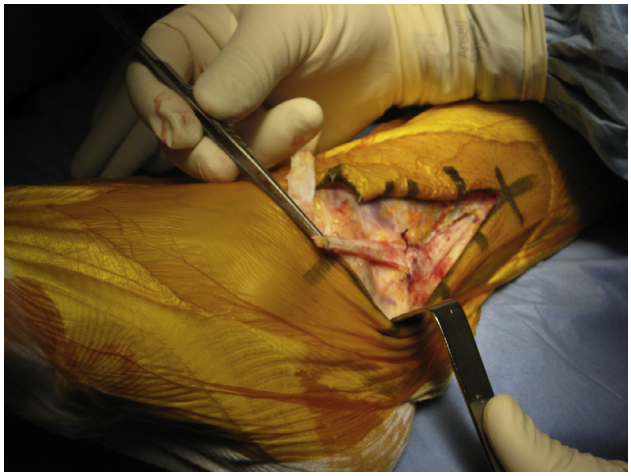

Fig. 1. Periosteum flap is cleared of subcutaneous tissue.

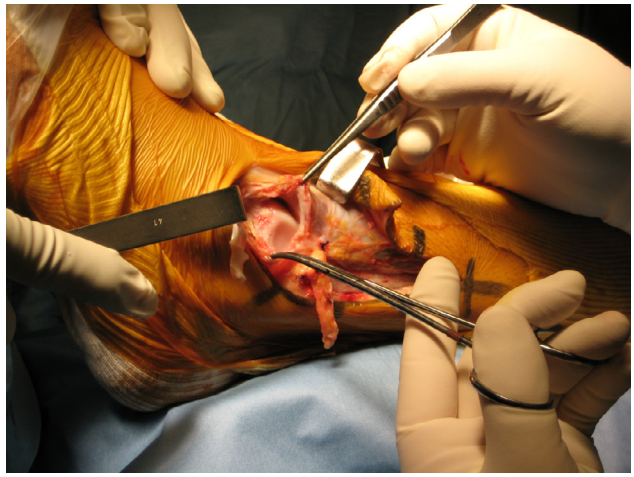

Fig. 3. Ankle articulation exploration after capsulotomy.

Assessors

One author (F.K.) performed all surgeries but did not review the patient-related data. Two authors (C.S. and R.R.) served as outcome assessors. Two authors (E.D. and H.S.) abstracted the data from the medical records. The statistical analyses of the data were performed by a statistician (B.G.).

Surgical Technique

All operations were performed by the senior surgeon (F.K.). The skin incision extended from the center of the lateral malleolus to the neck of the talus. The superficial fibular nerve was located and protected. The lateral malleolus periosteum and the extensor retinaculum were cleared of the subcutaneous tissue. The periosteal flap (Fig. 1) and the extensor retinaculum band (Fig. 2) were made 8 cm long and 1 cm wide, respectively. The subtalar joint was then tested in the varus position to determine the evidence of laxity. The anterolateral joint capsule was opened vertically, to expose the talar neck (Fig. 3). The tibiotalar joint was then examined for loose bodies and cartilaginous or bony lesions. Osteochondral procedures were performed, if necessary. The foot was positioned in the neutral position, and the joint capsule was closed and tensioned with separate sutures (Fig. 4). The periosteal strip was fixed on the talar neck and the retinaculum was fixed on the lateral malleolus (Fig. 5) by using anchoring sutures (Mitek GII® Anchor; DePuy Synthes, Norwood, MA). The ankle was immobilized in a resin cast for 6 weeks, with no weightbearing. Rehabilitation was started 6 weeks after the surgery.

Outcome Assessment

Epidemiologic data included sex, age at the time of surgery and at the follow-up visit, contralateral limb status, initial sprain etiology, sprain-to-surgery interval, reason for surgery, and sports activities. Physical examination evaluated the ankle range of motion and laxity. Radiographic outcomes were evaluated in terms of stability, arthrosis, and hindfoot morphotype.

Functional results were measured using the Karlsson ankle function score (15), a validated disease-specific measure that was developed for individuals who have sustained a lateral ankle injury. This scale contains 8 items covering the content related to instability, pain, swelling, stiffness, functional activities (i.e., stair climbing, running, and work activities), and need for support. Values for each of these items are summed, with a higher score representing a higher level of function. Results are classified with 4 different outcomes: excellent (90 to 100 points), good (80 to 89 points), fair (61 to 79 points), and poor (≤60 points). Radiographic assessment of the operated and contralateral ankles comprised loaded anteroposterior (20° internal rotation) and lateral views, weightbearing hindfoot alignment view, and dynamic radiographs in forced varus and anterior drawer taken manually. The evolution of arthritis was classified into 4 grades by using the van Dijk classification (16) (Table 1). Hindfoot morphotype and residual laxity were also assessed.

Statistical Analyses

The quantitative data were presented as median (first quartile, third quartile, or range of 95% CI), and the qualitative data were presented as frequency and percentage. To compare laxity and mobility between the healthy side and the affected side, we used a Wilcoxon rank-sum test. To test the evolution of laxity on the healthy side, we used a Wilcoxon rank-sum test for paired data. We used a Wilcoxon rank-sum test or a Kruskal-Wallis test to analyze the association between the Karlsson score and baseline characteristics, including sex, cartilaginous lesion found during surgery, reason for surgery, radiographs before and after surgery, complications, dysesthesia, and talar osteochondral

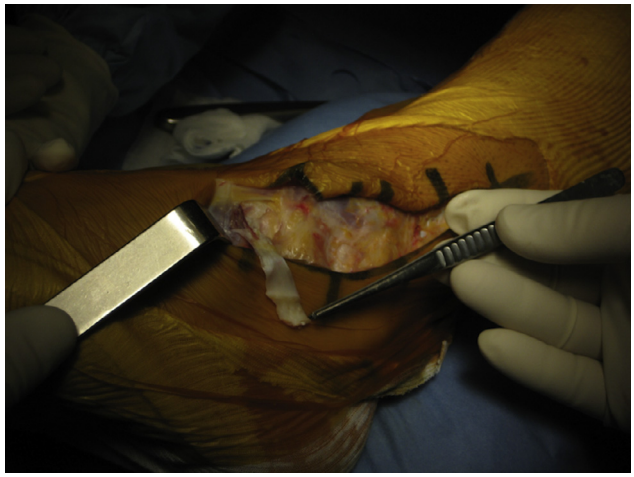

Fig. 2. Inferior extensor retinaculum band.

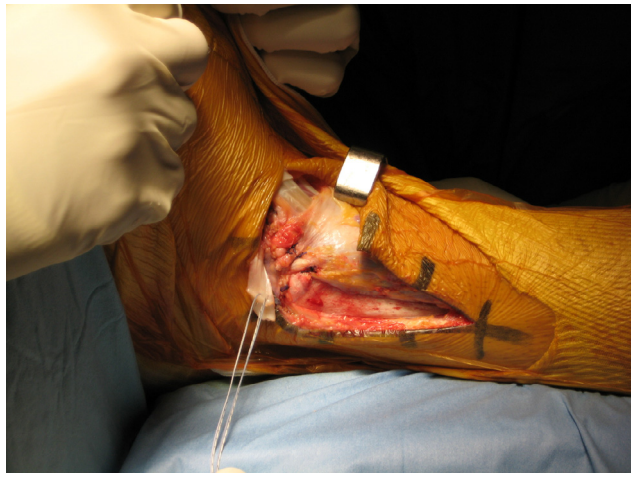

Fig. 4. Capsule retention and periosteum band fixation on the talar neck.

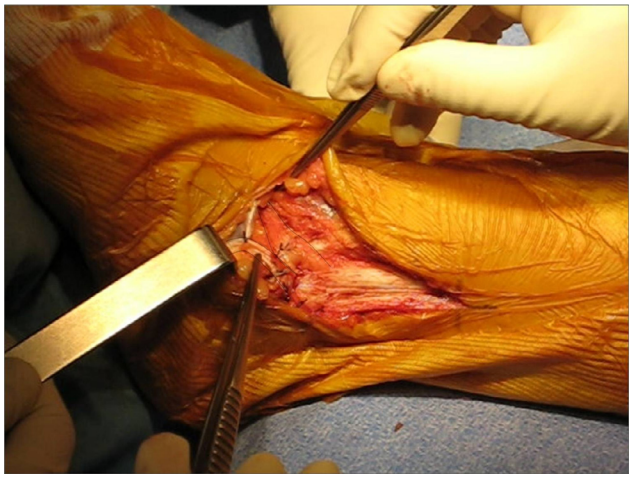

Fig. 5. Inferior extensor retinaculum fixation.

Table 1
van Dijk radiologic classification

Grade	Tibiotalar Joint Line
G0	Normal
G1	Osteophytes without impingement
G2	Impingement with or without osteophytes
G3	Complete impingement

lesions before and after surgery (Table 2). To test the correlation between various delays in patient management and the control of laxity and mobility, we computed Spearman's rho. We used the Wilcoxon rank-sum test or the Fisher's exact test to assess the association between the radiologic changes and baseline characteristics, control of laxity, mobility, and delay variables. All tests involved the use of R 2.14.1 software (R Foundation, Vienna, Austria).

Results

All patients were reviewed independently by the surgeon. Forty consecutive patients were enrolled between February 2001 and February 2010. Seven patients were lost during the follow-up, leaving 33 patients, including 16 females and 17 males, who were reviewed at a median follow-up duration of 8.2 (first quartile [Q1] 5 to third quartile [Q3] 11.5) years. Their median age at the time of surgery was 29 (Q1 24 to Q3 42) years, and it was 38 (Q1 33 to Q3 53) years at the final follow-up. In 19 cases, the initial sprain was owing to a sports injury, whereas in all other cases, the initial sprain was owing to domestic accidents. The mean period of instability prior to surgery was 132 ± 96.5 months. Clinically, all ankles were subjectively considered unstable, 17 were considered unstable and painful, and 3 were considered essentially painful.

Preoperative radiologic analysis confirmed the increase in drawer and varus laxity, with a 2-mm difference in drawer with respect to the healthy side and a 10° difference in varus. Radiographs revealed 4 grade 1 lesions and 1 grade 2 lesion, according to the van Dijk radiologic classification. Talar osteochondral lesions (2 laterals and 1 medial) were present in 3 patients. The hindfoot morphotype was neutral in 26 cases, and otherwise it was moderate varus.

Complications

Nine patients developed ≥1 postoperative complications: 1 postoperative hematoma, which healed unremarkably; 1 delayed wound healing, treated locally, with an unremarkable recovery; 7 partial lesions of the superficial fibular nerve, which were regressive and totally tolerable but which caused minor complications such as areas of hypoanesthesia.

Table 2
Factors associated with the Karlsson score (N = 33 patients)

	Levels	Count, n (%)	Karlsson Score (95% Confidence Interval)	*p* Value
Sex	Male	17 (52)	94 (85 to 95)	.94
	Female	16 (48)	95 (80 to 100)	
Reason for surgery	Pain (essentially)	3 (9)	82 (82 to 90)	.55
	Instability and pain	17 (52)	95 (90 to 100)	
	Instability	13 (39)	90 (85 to 100)	
Cartilaginous lesions found during surgery	No	27 (82)	94.5 (81.3 to 100)	.64
	Yes	6 (18)	95 (88.5 to 96)	
Complications	No	24 (73)	95 (90 to 100)	.03
	Yes	9 (27)	80 (74 to 95)	
Dysesthesia	No	26 (79)	95 (85 to 100)	.04
	Yes	7 (21)	80 (60 to 85)	
Preoperative radiologic alterations (van Dijk)	G0	28 (85)	94 (82 to 97)	.06
	G1	4 (12)	100 (100 to 100)	
	G2	1 (3)	29 (29 to 29)	
Postoperative radiologic alterations (van Dijk)	G0	24 (73)	95 (80 to 100)	.04
	G1	6 (18)	95 (92 to 100)	
	G2	3 (9)	80 (60 to 82)	
Postoperative laxity (>5 mm or >5°)	No	30 (91)	93.5 (83.8 to 100)	.75
	Yes	3 (9)	94 (81 to 96)	

Quantitative Results

Twenty-one (63.6%) patients were very satisfied with their result, 9 (27.3%) were satisfied, and 3 (9.1%) were disappointed. The median Karlsson score was 95 (95% confidence interval [CI] 82 to 100), and this was divided into 17 (51.5%) excellent, 12 (36.4%) good, 3 (9.1%) fair, and 1 (3.03%) poor. The poor Karlsson score was statistically significantly associated with the occurrence of a complication ($p = .03$), especially dysesthesia ($p = .04$), and with the occurrence of postoperative radiologic osteophytes and joint space narrowing ($p = .04$). The Karlsson score decreased significantly as the preoperative time period (the duration of symptoms) increased ($r = -0.53$, $p = .01$). We were not able to demonstrate a relationship between a long preoperative time period and poor results regarding the postoperative pain ($p = .52$) and osteoarthritis ($p = .32$).

At the last follow-up visit, the range of motion was not reduced significantly, with the difference in dorsiflexion and plantarflexion between the operated side and the contralateral side of −2° (95% CI −4° to 0°; $p = .005$) and −4° (95% CI −10° to 0°; $p = .001$), respectively.

The reduction of anterior drawer before and after surgery was 1 mm (95% CI 0 to 3; $p = .006$) and that for varus tilt was 11° (95% CI 8° to 15°; $p < .001$). Three patients showed recurring radiologic laxity (>5 mm of varus tilt). Detailed analysis of these patients showed that the patients with postoperative laxity had a longer delay between the first sprain and surgery in comparison with the patients without postoperative laxity (18.6 ± 7.4 years vs. 7.8 ± 3.6 years; $p < .02$). Interestingly, these patients were not aware of any clinical instability and showed good clinical results, without any functional consequences. Their recurring radiologic laxity was not associated with clinical instability or a poor Karlsson score ($p = .75$).

Six patients, including the 3 patients who presented with radiologic lesions, had superficial cartilaginous lesions (4 lateral and 2 medial) of the talus that were found during surgery. The age of these patients (41.7 [95% CI 34 to 44.5] years) was not statistically significantly greater

than the age of the rest of the patients (29.3 [95% CI 23.3 to 42.1] years) in the study ($p = .5108$), and their Karlsson score (95 [95% CI 88.5 to 96]) was not statistically significantly different from the Karlsson score for the group without a cartilaginous lesion (94.5 [95% CI 81.3 to 100]) ($p = .64$).

Postoperatively, 4 additional patients developed radiologic changes: 2 grade 1 and 2 grade 2. We did not find any factor (baseline variable, mobility and control of laxity factors, cartilaginous lesion, follow-up time, time of surgery, or Karlsson score) statistically significantly associated with a radiologic change. Furthermore, 17 (51.52% of the overall group and 89.5% of 19 athletes in the study) patients were able to return to the same sports activities at the same level at which they carried out these activities before their injury. One patient, with a Karlsson score of 74 of 100, decreased his sports level owing to the recurrence of ankle instability, and another patient admitted to using an ankle sleeve for comfort and security during athletic activities.

Discussion

This study showed good long-term results, with a median Karlsson score of 95 (range 80 to 100) and 91% of excellent or good results. Our review of the literature showed that the results of our investigation were, at face, comparable to those described by other investigators using a variety of repair technique. The subjective and objective short-term results of ligamentoplasty showed 80% to 90% good or very good results in 1 report (8), and the short-term results for the technique using periosteum showed good or very good results in 79% to 82% of cases (4,17). Studies describing a duration of follow-up >5 years are rare. Our search of the literature revealed good or very good results, ranging from 57% to 90% in studies that described the duration of follow-up to be ranging from 13 years to 26 years (18–21). One report (22), which described a repair technique that employed an extensor retinaculum flap without periosteum, showed an incidence of satisfaction of 93% and a mean Karlsson score of 94.8, after 11 years of follow-up.

It is often suggested that ligamentoplasties that involve the use of tendon decrease ankle mobility (6,23,24) and anatomic ligamentoplasties have little influence on tibiotalar or subtalar joint mobility. Some authors have reported minor alterations of all movements (25), in particular inversion of the foot (18). In our study, dorsiflexion and plantarflexion were not decreased significantly, and this factor was not associated with the functional result.

The success of a ligamentoplasty can be determined by the control of radiologic varus tilt and anterior drawer. In the present study, the reduction in median varus tilt was 11° (95% CI 8° to 14°] and in anterior drawer was 1 (95% CI 0 to 3] mm. Interestingly, these results are also comparable to those found in other published reports, which vary from 3.9° to 7° and from 2 mm to 3 mm for median varus tilt and anterior drawer, respectively (4,19).

Only 3 osteochondral lesions of the talus were observed preoperatively on radiologic analysis, whereas 7 cartilaginous lesions were found during surgery. This suggests that preoperative arthroscopy, or an arthro-computed tomography, could be informative with regard to determining the state of the cartilage prior to definitive surgical intervention. It is common to find the degeneration of cartilage when a talar osteochondral lesion is associated with instability, and it is rare for this to be well tolerated. When a cartilaginous lesion is present, the relative risk of a poor outcome is 8.5 (26). The etiology of cartilaginous lesions is usually traumatic, and these can occur when the ankle ligaments are sprained. Varus deformity of the hindfoot and residual ankle laxity can worsen the outcome, and a strong correlation has been shown between osteoarthritis and a varus deformity of the hindfoot (27). In a study of 37 patients with an average age of 26 years and an average follow-up duration of 24 years, De Vries et al (19) showed that 57% of patients had postoperative osteoarthritis and only 62% of the results were good or excellent according to the Karlsson score. In another study (18), which described 23 patients with an average age of 32 years and an average follow-up duration of 13 years, 25% had preoperative osteoarthritis, and at the time of the last follow-up visit, 60% were determined to have osteoarthritis. Nonetheless, 81% of the patients experienced good or excellent results, and they theorized that the poor results were owing to the development of osteoarthritis.

In our study, 5 patients showed preoperative radiologic alterations, with only 1 patient showing preoperative evidence of osteoarthritis according to the criteria of the van Dijk classification (1 grade 2 lesion = 3%). At the last follow-up, 9 patients had radiologic changes, including 6 grade 1 and 3 grade 2 lesions. Grade 2 lesions were associated significantly ($p = .04$) with the poorest functional evolution.

In conclusion, the major strengths of this study come from the long duration of the follow-up and the dynamic radiologic analysis. Each patient was operated on by the same surgeon, using the same reconstructive procedure, and was reviewed independently from the operator. Only 7 (17.5%) patients were lost to the follow-up. The main weaknesses come from the retrospective nature of the series and from our comparisons to historical controls (prior published results). The results of our investigation led us to modify our practices and our surgical technique. The authors now systematically isolate the superficial fibular nerve during the surgical approach to reduce neurologic complications. Finally, preoperative detection of cartilaginous lesions of the talus are considered by the routine use of an arthroscan. Our understanding of the literature and our experience with the patients described in this report lead us to conclude that fibular periosteum ligamentoplasty associated with an extensor retinaculum flap provides good results and should be evaluated in the very long term to check whether the rate of osteoarthritis increases over time and, incrementally, in association with similar procedures.

References

1. Chan KW, Ding BC, Mroczek KJ. Acute and chronic lateral ankle instability in the athlete. Bull NYU Hosp Jt Dis 2011;69:17–26.
2. Lynch SA, Renström PA. Treatment of acute lateral ankle ligament rupture in the athlete. Conservative versus surgical treatment. Sports Med Auckl NZ 1999;27:61–71.
3. McCriskin BJ, Cameron KL, Orr JD, Waterman BR. Management and prevention of acute and chronic lateral ankle instability in athletic patient populations. World J Orthop 2015;6:161–171.
4. Jarde O, Bouzigues P, Trinquier-Lautard JL, Havet E, Vives P. Chronic lateral ankle instability: surgical treatment with periosteum ligamentoplasty and capsular ligament tension. 34 cases. Rev Chir Orthopédique Réparatrice Appar Mot 1999;85:51–57.
5. Duquennoy A, Fontaine C, Gougeon F, Delcour JP. Treatment of chronic laxity of the ankle by retightening of the external ligaments. A propos of 37 cases. Acta Orthop Belg 1983;49:736–744.
6. Krips R, Brandsson S, Swensson C, van Dijk CN, Karlsson J. Anatomical reconstruction and Evans tenodesis of the lateral ligaments of the ankle. Clinical and radiological findings after follow-up for 15 to 30 years. J Bone Joint Surg Br 2002;84:232–236.
7. Rudert M, Wülker N, Wirth CJ. Reconstruction of the lateral ligaments of the ankle using a regional periosteal flap. J Bone Joint Surg Br 1997;79:446–451.
8. Mabit C, Pécout C, Arnaud JP. Ligamentoplasty using the peroneus tertius in the correction of lateral laxity of the ankle. Surgical technique. Rev Chir Orthopédique Réparatrice Appar Mot 1996;82:70–75.
9. Baray AL, Philippot R, Neri T, Farizon F, Edouard P. The Hemi-Castaing ligamentoplasty for chronic lateral ankle instability does not modify proprioceptive, muscular and posturographic parameters. Knee Surg Sports Traumatol Arthrosc 2016;24:1108–1115.
10. Welstin NE, Vogler HW, Albertsson MP, Arvidsson T, Montgomery F. Treatment of lateral ankle instability with transfer of the extensor digitorum brevis muscle. J Foot Ankle Surg 2003;42:183–192.
11. Ventura A, Terzaghi C, Legnani C, Borgo E. Lateral ligament reconstruction with allograft in patients with severe chronic ankle instability. Arch Orthop Trauma Surg 2014;134:263–268.
12. Jones AP, Sidhom S, Sefton G. A minimally invasive surgical technique for augmented reconstruction of the lateral ankle ligaments with woven polyester tape. J Foot Ankle Surg 2007;46:416–423.
13. Mabit C, Tourné Y, Besse JL, Bonnel F, Toullec E, Giraud F, Proust J, Khiami F, Chaussard C, Genty C. Sofcot (French Society of Orthopedic and Traumatologic Surgery). Chronic lateral ankle instability surgical repairs: the long term prospective. Orthop Traumatol Surg Res 2010;96:417–423.

14. Maestro M. Biomechanics of the talo-crural and the sub-talar joints. Foot Med Surg 2004;20:6.
15. Karlsson J, Peterson L. Evaluation of ankle joint function: the use of a scoring scale. Foot 1991;1:15–19.
16. van Dijk CN, Tol JL, Verheyen CC. A prospective study of prognostic factors concerning the outcome of arthroscopic surgery for anterior ankle impingement. Am J Sports Med 1997;25:737–745.
17. Roy-Camille R, Saillant G, Gagna G, Benazet JP, Feray C. Chronic external instability of the ankle. Surgical treatment by a periosteum ligamentoplasty. Rev Chir Orthopédique Réparatrice Appar Mot 1986;72:121–126.
18. Muijs SPJ, Dijkstra PDS, Bos CFA. Clinical outcome after anatomical reconstruction of the lateral ankle ligaments using the Duquennoy technique in chronic lateral instability of the ankle: a long-term follow-up study. J Bone Joint Surg Br 2008;90:50–56.
19. De Vries J, Struijs PA, Raaymakers EL, Marti RK. Long-term results of the Weber operation for chronic ankle instability: 37 patients followed for 20-30 years. Acta Orthop 2005;76:891–898.
20. Bell SJ, Mologne TS, Sitler DF, Cox JS. Twenty-six-year results after Broström procedure for chronic lateral ankle instability. Am J Sports Med 2006;34:975–978.
21. Nimon GA, Dobson PJ, Angel KR, Lewis PL, Stevenson TM. A long-term review of a modified Evans procedure. J Bone Joint Surg Br 2001;83:14–18.
22. Tourné Y, Mabit C, Moroney PJ, Chaussard C, Saragaglia D. Long-term follow-up of lateral reconstruction with extensor retinaculum flap for chronic ankle instability. Foot Ankle Int 2012;33:1079–1086.
23. Castaing J, Falaise B, Burdin P. Ligamentoplasty using the peroneus brevis in the treatment of chronic instabilities of the ankle. Long-term review. Orthop Traumatol Surg Res 2014;100:33–35.
24. Krips R, van Dijk CN, Halasi PT, Lehtonen H, Corradini C, Moyen B, Karlsson J. Long-term outcome of anatomical reconstruction versus tenodesis for the treatment of chronic anterolateral instability of the ankle joint: a multicenter study. Foot Ankle Int 2001;22:415–421.
25. Broström L. Sprained ankles. VI. Surgical treatment of “chronic” ligament ruptures. Acta Chir Scand 1966;132:551–565.
26. Choi WJ, Lee JW, Han SH, Kim BS, Lee SK. Chronic lateral ankle instability: the effect of intra-articular lesions on clinical outcome. Am J Sports Med 2008;36:2167–2172.
27. Valderrabano V, Hintermann B, Horisberger M, Fung TS. Ligamentous post traumatic ankle osteoarthritis. Am J Sports Med 2006;34:612–620.