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Isolated Anterior Talofibular Ligament Broström Repair for Chronic Lateral Ankle Instability

9-Year Follow-up

Nicola Maffulli,*† MS, MD, PhD, FRCS (Orth), Angelo Del Buono,‡ MD, Gayle D. Maffulli,* MD, Francesco Oliva,§ MD, PhD, Vittorino Testa,‖ MD, Giovanni Capasso,¶ MD, and Vincenzo Denaro,‡ MD
Investigation performed at Barts and The London School of Medicine and Dentistry, London, United Kingdom

Background: Lateral ankle sprains may result in pain and disability in the short term, decreased sport activity and early retirement from sports in the mid term, and secondary injuries and development of early osteoarthritis to the ankle in the long term.

Hypothesis: This combined approach to chronic lateral instability and intra-articular lesions of the ankle is safe and in the long term maintains mechanical stability, functional ability, and a good level of sport activity.

Study Design: Case series; Level of evidence, 4.

Methods: We present the long-term outcomes of 42 athletes who underwent ankle arthroscopy and anterior talofibular Broström repair for management of chronic lateral ankle instability. We assessed in all patients preoperative and postoperative anterior drawer test and side-to-side differences, American Orthopaedic Foot and Ankle Society (AOFAS) score, and Kaikkonen grading scales. Patients were asked about return to sport and level of activity. Patients were also assessed for development of degenerative changes to the ankle, and preoperative versus postoperative findings were compared.

Results: Thirty-eight patients were reviewed at an average of 8.7 years (range, 5-13 years) after surgery; 4 patients were lost to follow-up. At the last follow-up, patients were significantly improved for ankle laxity, AOFAS scores, and Kaikkonen scales. The mean AOFAS score improved from 51 (range, 32-71) to 90 (range, 67-100), and the mean Kaikkonen score improved from 45 (range, 30-70) to 90 (range, 65-100). According to outcome criteria set preoperatively, there were 8 failures by the AOFAS score and 9 by the Kaikkonen score. Twenty-two (58%) patients practiced sport at the preinjury level, 6 (16%) had changed to lower levels but were still active in less demanding sports (cycling and tennis), and 10 (26%) had abandoned active sport participation although they still were physically active. Six of these patients did not feel safe with their ankle because of the occurrence of new episodes of ankle instability. Of the 27 patients who had no evidence of degenerative changes preoperatively, 8 patients (30%) had radiographic signs of degenerative changes (5 grade I and 3 grade II) of the ankle; 4 of the 11 patients (11%) with preexisting grade I changes remained unchanged, and 7 patients (18%) had progressed to grade II. No correlation was found between osteoarthritis and status of sport activity ($P = .72$).

Conclusion: Combined Broström repair and ankle arthroscopy are safe and allow most patients to return to preinjury daily and sport activities.

Keywords: chronic ankle instability; Broström repair; ankle arthroscopy; return to sport; degenerative changes

Very common in athletes, lateral ankle sprains may result in pain and disability in the short term, decreased sport activity and early retirement from sports in the mid term,[2,3] and secondary injuries and development of early osteoarthritis to the ankle in the long term.[21,22] The initial approach is nonoperative, usually effective in sedentary patients, but often unsatisfying in athletes: 15% to 20% of athletes have to reduce sport participation, and 80% report a new injury.[22] Nonanatomic reconstructions using local tendons have been proposed, but some concerns arise from their invasiveness, related risks of neurovascular injuries, postoperative subtalar and tibiotalar joint stiffness, and long-term degenerative joint disease in the ankle and subtalar joint.[8,9,14] On the other hand, anatomic repairs, more frequently performed in athletes, provide long-term stability without any impairment of range of motion.[10,31,38]

The Broström technique modified by Gould et al[24] is often considered as the standard. Nevertheless, the original procedure described by Broström[12,13] is anatomic, minimally disruptive of local anatomy, and biomechanically advantageous. Care should be taken to spare the superficial sensory nerves in the area, the injury of which may cause loss of sensation distal to the skin incision and neuromas.

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The original work by Broström[12,13] showed that in most patients, only the anterior talofibular ligament (ATFL) could be repaired with excellent results, and recent clinical and biomechanical studies have confirmed this impression. We present the long-term outcomes of 38 of 42 patients who had undergone ankle arthroscopy and anatomic repair of the ATFL only, hypothesizing that this combined approach to chronic lateral instability and intra-articular lesions of the ankle is safe and guarantees in the long term biomechanical stability, functional ability, and good level of sport activity.

MATERIALS AND METHODS

All procedures described in the present investigation were approved by the local ethics committee. Patients were operated on after they had signed a written consent. In the period from 1997 to 2001, we had operated on 49 patients, 7 of whom were excluded because of the presence of large (>2 cm) severe cartilage lesions (3 patients) and axial deformities (2 patients). The remaining 2 patients did not have enough good-quality tissue to undertake a Broström repair; in these 2 patients, we performed a gracilis autograft reconstruction of the lateral compartment of the ankle.

We present the retrospective clinical and functional analysis of 42 physically active patients (32 men and 10 women) who had been prospectively enrolled in a database of individuals who had undergone ankle arthroscopy and anatomic repair of the ATFL for the management of symptomatic lateral ankle instability. Four patients were lost to follow-up as they had moved and no forwarding address had been made available. The remaining 38 underwent surgery at an average age of 25.3 years (range, 18-41 years) and after an average period of 12.5 months from the first traumatic episode (range, 7-23 months) of inversion injury of their ankle. All patients were secondary and tertiary referrals from other health care professionals.

Inclusion criteria were mechanical laxity greater than grade 2 at clinical anterior drawer test, more than 2 episodes of functional instability (giving way) of the ankle, and unresponsiveness to a minimum of 3 months of appropriately conducted nonoperative management, which included rest, bracing, use of anti-inflammatory drugs, proprioceptive and balance training, strengthening of the peroneals, and physical therapy. We excluded patients with systemic diseases, neuromuscular disorders, peroneal tendon subluxation or tears, body mass index greater than 28, anatomic deformities (pes cavus and excessive hindfoot varus requiring other corrective procedures in addition to the ones described in the present study), hyperlaxity, posttraumatic sinus tarsi syndrome, peroneal tendon tears or subluxation, and previous surgery on the affected ankle or the ipsilateral foot. Also, patients with tibial and/or talar lesions greater than Outerbridge grade 1 at arthroscopy and patients with osteochondral injuries of the articular surface of the tibia and/or talus at arthroscopy were excluded. Finally, we excluded patients in whom the ATFL repair was considered unsound by the end of the operation. In these instances, an anatomic reconstruction was performed using the tendon of gracilis or semitendinosus.

The senior author (N.M.) performed all clinical investigations in all patients involved in the present study. At the final assessment, a clinical research fellow who had not been involved in the original management of the subjects involved in the present study examined the patients, administered all the tests, and examined and classified all the images. The clinical research fellow has a specialist degree in trauma and orthopaedic surgery and was undertaking a fellowship in lower-limb sports injuries. The senior author was available to supervise each examination and investigation but did not examine the patient.

Preoperative Assessment

Patients were asked to classify their activity level. At preoperative clinical examination, we examined the presence of swelling and tenderness over and around the lateral malleolus and the anterolateral aspect of the ankle, and all patients referred pain and discomfort to the ankle: all had pain on the anterior talofibular ligament, and 28 had pain on the anterior talofibular ligament and the calcaneofibular ligaments. In addition, 6 patients also reported pain over the peroneal tendons and 4 over the anterior aspect of the ankle. Eleven patients had clinical signs of anterior impingement and at arthroscopy had various degrees of footballer's ankle, which was addressed arthroscopically. A football player's ankle was defined as a chronic condition resulting from repeated minor strains of the anterior ligaments of the ankle joint, generally characterized by pain and tenderness localized to the area of strain.[37] The anterior drawer test was evaluated bilaterally clinically to exclude hypermobility. With the patient supine and the ankle in neutral position, a <5-mm side-to-side difference in tibiotalar translation was considered normal (grade 0), 5- to 10-mm side-to-side difference was classified as grade 1, 10 to 15 mm as grade 2, and >15 mm as grade 3. We considered the anterior drawer test as normal when a hard stop could be appreciated and pathologic when the stop was soft. At anterior drawer test, 23 patients received the diagnosis of grade 2 laxity and 15 patients of grade 3. All patients underwent plain anteroposterior and lateral ankle and foot radiographs. Magnetic resonance imaging (MRI) scans were performed to investigate associated cartilage injuries and ligament damages, and for the objective evaluation, the American Orthopaedic Foot and Ankle Society

†Address correspondence to Nicola Maffulli, MS, MD, PhD, FRCS (Orth), The Royal London Hospital (Mile End), 275 Bancroft Road, London, UK (e-mail: n.maffulli@qmul.ac.uk).
*Centre for Sports and Exercise Medicine, Barts and The London School of Medicine and Dentistry, Mile End Hospital, London, United Kingdom.
‡Department of Orthopaedic and Trauma Surgery, Campus Biomedico University of Rome, Via Alvaro del Portillo, Rome, Italy.
§Department of Orthopaedic and Trauma Surgery, University of Rome, Tor Vergata, Rome, Italy.
||Department of Sports Traumatology, Dynamic Center, Angri, Italy.
¶Department of Orthopaedics and Traumatology, University of Napoli, Napoli, Italy.
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Figure 1. After removal of all the adhesions to the surrounding soft tissues, the anterior talofibular ligament is exposed.

Figure 2. Repair with strong absorbable sutures in a vest-over-pant fashion.

(AOFAS) ankle-hindfoot scale[32] and the Kaikkonen et al ankle scoring scale[28] were administered to each patient.

Operative Technique

All patients were operated on by a single fellowship-trained orthopaedic surgeon (N.M.), under general anesthesia, in the supine position, without any distraction devices. After exsanguination, a thigh tourniquet was inflated to 300 mm Hg. We used a standard knee arthroscope and 2 standard anteromedial and anterolateral portals, switching to a 2.7-mm 30°-angled arthroscope if needed. We palpated with a probe all structures to assess osteochondral and bony features and the presence of soft tissue impingement. We performed appropriate bony and soft tissue debridement for management of anterior impingement and footballer's ankle lesions as appropriate. Shaving of the distal fibula allowed us to expose the ATFL remnant and remove ATFL adhesions and scar tissues when indicated.

After the arthroscopy, we made a slightly curvilinear 2- to 2.5-cm incision anterior to the anterior border of the lateral malleolus, 2 cm distal to the tip of the fibula, to avoid injury to the medial dorsal cutaneous nerve and/or the intermediate dorsal cutaneous nerve. After removal of all the adhesions to the surrounding soft tissues, we exposed the anterior talofibular ligament (Figure 1) and proceeded to repair it using the anatomic Broström technique with strong absorbable sutures in a vest-over-pant fashion (Figure 2). We did not use transosseous sutures or bone anchors. With the patient under anesthesia, the tension of the construct and the clinical stability were tested with the ankle in slight eversion, flexed at 90°. After thorough irrigation with normal saline, the skin incisions were sutured with 3.0 Biosyn (Tyco Health Care, Norwalk, Connecticut) and Steri-strips (3M Health Care, St Paul, Minnesota) were applied.

A below-knee weightbearing synthetic cast was applied with the foot in neutral, and weightbearing was allowed as able for the first 2 postoperative weeks. Progressive weightbearing was allowed thereafter. At 4 weeks, the cast was removed and physical therapy, including proprioceptive training, active ankle extension, and eversion exercises, were started, with the ankle in a semirigid brace. Stationary cycling was allowed from postoperative week 6. Running and swimming were introduced by 3 months and return to high-contact sports at 6 months. Patients were assessed thereafter at 6-month intervals for 2 years and discharged at that stage.

Follow-up

At the last examination, a mean of 8.7 years after surgery (range, 5-13 years; standard deviation, 2.71 years), all patients underwent conventional anteroposterior and lateral radiographs; bilateral varus–valgus ankle stress and anterior drawer test were performed and compared.

Immediately before the operation and at the latest follow-up, all patients completed the AOFAS score, which was considered as excellent (90-100), good (80-89), fair (70-79), or poor (<70).[16] We considered failure an AOFAS score of <80.

Also, patients completed the Kaikkonen scoring system,[28] which was considered as excellent (85-100), good (70-80), fair (55-65), or poor ($\leq$50). We considered failure a Kaikkonen score of <70.

In addition, patients were asked about their activity level. We considered as elite those athletes competing at national and international levels and professional as all those who competed at least at county level and whose sole or main source of income was derived from the sport played.

The development of osteoarthritis (OA) was assessed from weightbearing anteroposterior and lateral radiographs of both ankles, obtained preoperatively and at the final follow-up, assessed by an independent observer not involved in the study. Osteoarthritis was defined using the system described by Krips et al,[33] which classifies the joint as grade 0 (normal), grade I (in the presence of osteophytes without joint space narrowing), grade II (when the joint space is narrowed), and grade III (if the space is markedly reduced or deformed). Radiographs were assessed by the senior author.

In more demanding cases, the diagnosis was confirmed by a radiologist not involved in the study and experienced in muscle, tendon, and ligament disorders in athletes.

Statistics

After assessment of the distribution with the Kolmogorov-Smirnov test, the Mann-Whitney test was used to compare the anterior drawer test and talar tilt measures to the injured and contralateral side; the Wilcoxon signed-rank test was used to compare preoperative and postoperative clinical and radiological findings. Dependent-sample t tests were used to compare preoperative versus postoperative AOFAS scores and the clinical findings between ankles with and without secondary lesions injuries. A χ^2 test was used to correlate the status of postoperative sport activity with the development of ankle OA and recurrence of ankle instability. A P value of $<.05$ was considered to be statistically significant. Analysis was performed by a statistician using SPSS software, version 13.0 (SPSS, Chicago, Illinois).

RESULTS

Thirty-eight of 42 patients included in our original cohort returned to our clinic at the average final follow-up of 8.7 years. The right ankle was involved in 25 (66%) patients and the left in 13 (34%) patients. The AOFAS significantly improved from an average preoperative score of 51 (range, 32-71) to 90 (range, 67-100) at the last follow-up ($P < .0001$). Postoperatively, the AOFAS scores were graded as excellent in 19 (50%), good in 11 (29%), fair in 5 (13%), and poor in 3 (8%) patients.

The Kaikkonen score significantly improved from an average preoperative score of 45 (range, 30-70) to 90 (range, 65-100) at the last follow-up ($P < .0001$). Postoperatively, the Kaikkonen score was graded as excellent in 20 (52%), good in 9 (24%), fair in 5 (13%), and poor in 4 (11%) patients.

The anterior drawer test showed grade 0 laxity in 19 patients, grade 1 in 11 patients, and grade 2 in the remaining 8 patients, with a significant improvement compared with baseline ($P < .0001$). At the last appointment, 22 (58%) patients practiced sport at the preinjury level (national, international, and county levels); 6 (16%) changed from weightbearing to nonweightbearing sport activities (cycling and swimming), but they were still highly competitive in their new sport; and 10 (26%) abandoned altogether any sport. Six patients did not feel safe with their ankle because of the occurrence of new episodes of ankle instability; 4 felt too old to continue. However, all 10 were still continuing to keep fit in nonweightbearing occasional activity (cycling, swimming, and cross-training; see the Appendix, available in the online version of this article at http://ajs.sagepub.com/supplemental/).

Surgical complications were seen in 4 patients (11%): 1 superficial wound infection occurred, but this healed uneventfully without any influence on the final result, and 3 patients reported sensory disturbance on the lateral aspect of the foot, but at the last follow-up, they were completely asymptomatic, pain free, and stable. At the last follow-up, 5 patients (13%) had limitation in eversion or inversion. Twelve patients (32%) had experienced another traumatic inversion injury of the ankle, and in 6 of these patients (16%), the procedure had been judged to have failed and had developed mechanical and functional instability. Three of these 6 patients (8%) did not want to undergo another procedure and were managed with self-administered proprioceptive training and an ankle support. The remaining 3 patients (8%) underwent reconstruction of the anterior talofibular ligament and of the calcaneofibular ligament using an ipsilateral minimally invasive gracilis autograft.[19] At the last follow-up, all of these 6 patients reported fair or poor scores and had stopped practicing sport ($P = .02$; odds ratio [OR], 5.5).

Imaging Outcomes

At operation, 27 of 38 patients had no signs of degenerative changes in the ankle, and the remaining 11 had grade I changes in the talus and/or the lower aspect of the tibia. At final follow-up, of the 27 patients who had no evidence of degenerative changes, plain radiographs revealed that 5 patients had radiographic signs of grade I degenerative changes of the ankle and 3 had radiographic signs of grade II degenerative changes of the ankle. Two of these 8 patients (25%) had abandoned sport activity, and 2 (25%) had changed to low-impact sports such as swimming and cycling.

Of the 11 patients who had preexisting grade I changes, 4 remained unchanged and 7 had progressed to grade II; 3 of them (27%), all with grade II OA, changed to low-impact sports and 2 (18%) declined any sport. No correlation was found between the presence of degenerative osteoarthritic changes and change or withdrawal from sport (χ^2; $P = .72$). Three of the 12 patients who had experienced new episodes of ankle instability had developed osteoarthritis ($P = .08$; OR, 0.2).

DISCUSSION

The main finding of the present study is that isolated repair of the anterior talofibular ligament according to the technique described by Broström is easy, fast to perform, inexpensive, and provides a high rate of good to excellent outcomes in the long term, allowing most patients to be still active at the preinjury level of sport activity at almost 9 years after surgery. However, in 6 of our patients (16%), the procedure had been judged to have failed and the patients developed mechanical and functional instability; 8 to 9 patients (21%-24%) had fair or poor outcome scores. Patients with recurrent ankle instability are more likely to quit sport.[11] Loss of subtalar motion, sacrifice of peroneal tendons, damage to the local sensory nerve, and concerns for long-term deterioration have favored a preference for anatomic[4,25,39,46] over nonanatomic reconstructions.[7,42,43] Also, in the case of tendon graft reconstructions, the peroneus brevis tendon graft may reduce the eversion strength of the ankle,[44] the plantaris tendon may be absent in 19% of patients,[40] the gracilis tendon may induce donor site morbidity,[18,47] and toe

extensor tendons can be technically demanding to harvest.[1,5] Anatomic repairs may improve the long-term results, with the advantage of most closely restoring normal ankle and subtalar motion, rotational stability,[27] and greater mechanical restraints than either the Chrisman-Snook or the Watson-Jones procedure,[36] without any donor site morbidity. The Broström technique significantly reduces pathologic ankle joint laxity, with lower motion restriction compared with more invasive reconstructions, and reproduces loading patterns similar to those recorded in normal ankles.[6]

We repaired the anterior talofibular ligament using simple stitches, without using transosseous tunnels or suture anchor systems, with minimal dissection and irritation of soft tissues, and great accuracy in restoring the ligament to its normal anatomic position, without bone exposure. The simplicity and minimal invasiveness of this procedure decrease operating time and the risk of potential fractures secondary to multiple drill holes. Suture anchors may successfully reattach the lateral ligament tissue to an anatomically normal position, but they may disadvantageously result in malpositioning, breakage, pullout, and additional costs.[17,23] According to the original procedure described by Broström, we repaired the ATFL only. Clinical symptoms and talocrural joint motion measured on stress radiographs are similar when comparing singular ATFL and combined ATFL and calcaneofibular ligament repairs,[34,35] and therefore, it is not necessary, in primary procedures, to repair the calcaneofibular ligament as well.

In the long term, the Watson-Jones procedure provides encouraging functional outcomes, at the price of early degenerative changes.[9] The modified Evans procedure is satisfactory for 50%[29] to 85%[7] of patients, but no validated scores have been used. Indeed, as reported by Bell et al,[10] the effectiveness of Broström anatomic repair is still valuable at 26 years after surgery, with a mean functional ROOS[41] score of 92 points (of 100), a mean ankle function score of 91.2 (of 100), and more than 90% of patients with good functional results.

In this study, the rate of good and excellent outcomes at an average follow-up of 8.7 years was lower than that reported by Karlsson et al[30] (87%) at a follow-up of 6 years. In a randomized controlled study, Karlsson et al[31] compared outcomes of patients undergoing 2 different repairs: the Karlsson (group 1) and Broström-Gould (group 2) technique. At an average follow-up of 3 years, 25 of 30 (83%) patients in group 1 and 23 of 30 (77%) in group 2 were still active at the same preinjury activity level. In the present study, at the last appointment, 22 (58%) patients practiced sport at the preinjury level, 6 (16%) had changed to lower levels, and 10 (26%) had abandoned active sport participation, although they still were physically active in low-weightbearing sports. Our results are less good, probably because of the worsening of the long-term outcome and because our sample included patients who were older and not motivated to continue to practice sport.

Intra-articular lesions such as loose bodies, synovitis, and osteochondral lesions should be thoroughly assessed and managed arthroscopically at the time of ligament stabilization.[20] Secondary lesions, if unmanaged, may induce occurrence and persistence of symptoms and impair long-term functional status, even in stable repaired ankles.[1] Intra-articular osteochondral lesions of the talus are strong indicators for poor clinical outcomes,[26] with long-term impairment,[38] whereas ATFL deficiency increases anterior translation, internal rotation, and superior translation of the talus, with high risk to develop osteoarthritis.[15]

Early radiographic degenerative changes have been observed in patients undergoing Watson-Jones procedure, but these findings did not correlate with functional outcomes.[45] In a 26-year follow-up study, more than 90% of the patients had good functional outcomes, regardless of their imaging results, but the authors did not perform any clinical or radiographic investigation.[10] In our series, postoperative imaging findings were significantly worse than at baseline, but they did not correlate with functional outcomes and return to sport activity, explaining decreased levels of sport activity more because of aging than of ankle problems.

We outline that recurrent instability was not predisposing for development of degenerative changes ($P = .08$; OR, 0.2), but it was a negative prognostic factor for poor outcomes in terms of functional scores (AOFAS and Kaikkonen), and it may negatively condition the motivational status of the patients, making them less confident to return to sport ($P = .02$; OR, 5.5). We are aware that the association between functional instability and degenerative changes would have been better assessed on computed tomography or MRI scans, but we used radiographic imaging because it is more available, less expensive, and contextually allows us to assess joint laxity.

To the best of our knowledge, this is one of the longest follow-up studies that reports on clinical and imaging outcomes of patients with chronic lateral ankle instability undergoing isolated ATFL Broström repair. We have recently reported the long-term results of arthroscopic-assisted Broström repair, with results superior to what was described in the present study.[38] Specifically, at an average postoperative follow-up of 9.8 years, almost all patients (94.7%) had good or excellent AOFAS scores, and 87% of patients who used to practice sport were still active at the same preinjury activity level.[38] Even though the arthroscopic Broström-Gould procedure may seem to be more effective in the long term,[38] we believe that the results we have shown in the present study are apparently less exciting as a consequence of the high preinjury activity level at which these athletes used to compete. In addition, we further underline that this approach is less invasive, using a limited, selective ATFL repair through a small incision. Theoretically, if appropriate imaging can definitely exclude intra-articular lesions, arthroscopy can be avoided. In such instances, the isolated ATFL repair described in the present study would be an even simpler and less time-, equipment-, and cost-intensive procedure, with results comparable to more technically demanding operations. Appropriately powered randomized controlled trials could be performed to ascertain whether this is indeed the case. The relatively small sample size made statistical analysis of the data difficult. Although the retrospective design of the study and the absence of a control group do not allow us to draw definitive conclusions, an isolated ATFL Broström repair compares well with the long-term follow-up results of other studies.[10,38]

In conclusion, isolated anatomic repair of the ATFL for the management of ankle instability is safe, effective, and low cost and allows safe return to preinjury sport activity. In this series, recurrent instability occurred in 16% of patients, fair to poor outcome scores were observed in 21% to 24% of patients, and radiographic degenerative changes progressed in 39% of patients at 8.7 years of follow-up. Studies with longer follow-up could better assess the association between imaging findings and functional/clinical outcomes.

REFERENCES

1. Ahn JH, Choy WS, Kim HY. Reconstruction of the lateral ankle ligament with a long extensor tendon graft of the fourth toe. *Am J Sports Med*. 2011;39:637-644.
2. Ajis A, Maffulli N. Conservative management of chronic ankle instability. *Foot Ankle Clin*. 2006;11:531-537.
3. Ajis A, Younger AS, Maffulli N. Anatomic repair for chronic lateral ankle instability. *Foot Ankle Clin*. 2006;11:539-545.
4. Anderson ME. Reconstruction of the lateral ligaments of the ankle using the plantaris tendon. *J Bone Joint Surg Am*. 1985;67:930-934.
5. Attarian DE, McCrackin HJ, Devito DP, McElhaney JH, Garrett WE. A biomechanical study of human lateral ankle ligaments and autogenous reconstructive grafts. *Am J Sports Med*. 1985;13:377-381.
6. Bahr R, Pena F, Shine J, Lew WD, Tyrdal S, Engebretsen L. Biomechanics of ankle ligament reconstruction: an in vitro comparison of the Brostrom repair, Watson-Jones reconstruction, and a new anatomic reconstruction technique. *Am J Sports Med*. 1997;25:424-432.
7. Barnum MJ, Ehrlich MG, Zaleske DJ. Long-term patient-oriented outcome study of a modified Evans procedure. *J Pediatr Orthop*. 1998;18:783-788.
8. Baumhauer JF, O'Brien T. Surgical considerations in the treatment of ankle instability. *J Athl Train*. 2002;37:458-462.
9. Becker HP, Ebner S, Ebner D, et al. 12-year outcome after modified Watson-Jones tenodesis for ankle instability. *Clin Orthop Relat Res*. 1999;358:194-204.
10. Bell SJ, Mologne TS, Sitler DF, Cox JS. Twenty-six-year results after Brostrom procedure for chronic lateral ankle instability. *Am J Sports Med*. 2006;34:975-978.
11. Bridgman SA, Clement D, Downing A, Walley G, Phair I, Maffulli N. Population based epidemiology of ankle sprains attending accident and emergency units in the West Midlands of England, and a survey of UK practice for severe ankle sprains. *Emerg Med J*. 2003;20:508-510.
12. Broström L. Sprained ankles. V. Treatment and prognosis in recent ligament ruptures. *Acta Chir Scand*. 1966;132:537-550.
13. Broström L. Sprained ankles. VI. Surgical treatment of ''chronic'' ligament ruptures. *Acta Chir Scand*. 1966;132:551-565.
14. Caprio A, Oliva F, Treia F, Maffulli N. Reconstruction of the lateral ankle ligaments with allograft in patients with chronic ankle instability. *Foot Ankle Clin*. 2006;11:597-605.
15. Caputo AM, Lee JY, Spritzer CE, et al. In vivo kinematics of the tibiotalar joint after lateral ankle instability. *Am J Sports Med*. 2009; 37:2241-2248.
16. Chen CY, Huang PJ, Kao KF, et al. Surgical reconstruction for chronic lateral instability of the ankle. *Injury*. 2004;35:809-813.
17. Cho BK, Kim YM, Kim DS, Choi ES, Shon HC, Park KJ. Comparison between suture anchor and transosseous suture for the modified-Brostrom procedure. *Foot Ankle Int*. 2012;33:462-468.
18. Coughlin MJ, Schenck RC Jr, Grebing BR, Treme G. Comprehensive reconstruction of the lateral ankle for chronic instability using a free gracilis graft. *Foot Ankle Int*. 2004;25:231-241.
19. Espinosa N, Smerek J, Kadakia AR, Myerson MS. Operative management of ankle instability: reconstruction with open and percutaneous methods. *Foot Ankle Clin*. 2006;11:547-565.
20. Ferkel RD, Scranton PE Jr. Arthroscopy of the ankle and foot. *J Bone Joint Surg Am*. 1993;75:1233-1242.
21. Ferran NA, Maffulli N. Epidemiology of sprains of the lateral ankle ligament complex. *Foot Ankle Clin*. 2006;11:659-662.
22. Ferran NA, Oliva F, Maffulli N. Ankle instability. *Sports Med Arthrosc*. 2009;17:139-145.
23. Giza E, Nathe R, Nathe T, Anderson M, Campanelli V. Strength of bone tunnel versus suture anchor and push-lock construct in Brostrom repair. *Am J Sports Med*. 2012;40:1419-1423.
24. Gould N, Seligson D, Gassman J. Early and late repair of lateral ligament of the ankle. *Foot Ankle*. 1980;1:84-89.
25. Horibe S, Shino K, Taga I, Inoue M, Ono K. Reconstruction of lateral ligaments of the ankle with allogeneic tendon grafts. *J Bone Joint Surg Br*. 1991;73:802-805.
26. Hua Y, Chen S, Li Y, Chen J, Li H. Combination of modified Brostrom procedure with ankle arthroscopy for chronic ankle instability accompanied by intra-articular symptoms. *Arthroscopy*. 2010;26:524-528.
27. Javors JR, Violet JT. Correction of chronic lateral ligament instability of the ankle by use of the Brostrom procedure: a report of 15 cases. *Clin Orthop Relat Res*. 1985;198:201-207.
28. Kaikkonen A, Kannus P, Jarvinen M. A performance test protocol and scoring scale for the evaluation of ankle injuries. *Am J Sports Med*. 1994;22:462-469.
29. Karlsson J, Bergsten T, Lansinger O, Peterson L. Lateral instability of the ankle treated by the Evans procedure: a long-term clinical and radiological follow-up. *J Bone Joint Surg Br*. 1988;70:476-480.
30. Karlsson J, Bergsten T, Lansinger O, Peterson L. Reconstruction of the lateral ligaments of the ankle for chronic lateral instability. *J Bone Joint Surg Am*. 1988;70:581-588.
31. Karlsson J, Eriksson BI, Bergsten T, Rudholm O, Sward L. Comparison of two anatomic reconstructions for chronic lateral instability of the ankle joint. *Am J Sports Med*. 1997;25:48-53.
32. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. *Foot Ankle Int*. 1994;15:349-353.
33. Krips R, van Dijk CN, Halasi PT, et al. 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.
34. Lee KT, Lee JI, Sung KS, et al. Biomechanical evaluation against calcaneofibular ligament repair in the Brostrom procedure: a cadaveric study. *Knee Surg Sports Traumatol Arthrosc*. 2008;16:781-786.
35. Lee KT, Park YU, Kim JS, Kim JB, Kim KC, Kang SK. Long-term results after modified Brostrom procedure without calcaneofibular ligament reconstruction. *Foot Ankle Int*. 2011;32:153-157.
36. Liu SH, Baker CL. Comparison of lateral ankle ligamentous reconstruction procedures. *Am J Sports Med*. 1994;22:313-317.
37. McMurray TP. Footballer's ankle. *J Bone Joint Surg Br*. 1950;32:68-69.
38. Nery C, Raduan F, Del Buono A, Asaumi ID, Cohen M, Maffulli N. Arthroscopic-assisted Brostrom-Gould for chronic ankle instability: a long-term follow-up. *Am J Sports Med*. 2011;39:2381-2388.
39. Okuda R, Kinoshita M, Morikawa J, Jotoku T, Abe M. Reconstruction for chronic lateral ankle instability using the palmaris longus tendon: is reconstruction of the calcaneofibular ligament necessary? *Foot Ankle Int*. 1999;20:714-720.
40. Pagenstert GI, Hintermann B, Knupp M. Operative management of chronic ankle instability: plantaris graft. *Foot Ankle Clin*. 2006;11:567-583.
41. Roos EM, Brandsson S, Karlsson J. Validation of the foot and ankle outcome score for ankle ligament reconstruction. *Foot Ankle Int*. 2001;22:788-794.
42. Rosenbaum D, Becker HP, Sterk J, Gerngross H, Claes L. Functional evaluation of the 10-year outcome after modified Evans repair for chronic ankle instability. *Foot Ankle Int*. 1997;18:765-771.
43. Ross G, Regan KJ, McDevitt ER, Wilckens J. Rupture of the peroneus longus tendon in a military athlete. *Am J Orthop (Belle Mead NJ)*. 1999;28:657-658.

44. Sammarco GJ, Idusuyi OB. Reconstruction of the lateral ankle ligaments using a split peroneus brevis tendon graft. *Foot Ankle Int*. 1999;20:97-103.
45. Sugimoto K, Takakura Y, Akiyama K, Kamei S, Kitada C, Kumai T. Long-term results of Watson-Jones tenodesis of the ankle: clinical and radiographic findings after ten to eighteen years of follow-up. *J Bone Joint Surg Am*. 1998;80:1587-1596.
46. Takahashi T, Nakahira M, Kaho K, Kawakami T. Anatomical reconstruction of chronic lateral ligament injury of the ankle using pedicle tendon of the extensor digitorum longus. *Arch Orthop Trauma Surg*. 2003;123:175-179.
47. Takao M, Oae K, Uchio Y, Ochi M, Yamamoto H. Anatomical reconstruction of the lateral ligaments of the ankle with a gracilis autograft: a new technique using an interference fit anchoring system. *Am J Sports Med*. 2005;33:814-823.